Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/4270
DOI URL: http://dx.doi.org/10.21474/IJAR01/4270
ISSN NO. 2320-5407

RESEARCH ARTICLE

EFFECT OF THREE VENEERING TECHNIQUES ON MARGINAL ACCURACY AND FRACTURE RESISTANCE OF ZIRCONIA BASE FIXED RESTORATION (IN-VITRO STUDY).

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Manuscript Info

Manuscript History

Received: 27 March 2017
Final Accepted: 30 April 2017
Published: May 2017

Key words:-
Veneering , Zirconia , Fracture resistance , Marginal accuracy.

Abstract

Statement of the problem. Veneered zirconia restorations are frequently used for esthetic demands , however marginal accuracy and fracture resistance are among the critical factors that determine longevity and success of these restorations. These two items may be affected by veneering procedures.

Purpose. The aim of this systematic review was to identify from in vitro studies the effect of veneering techniques on the marginal accuracy and fracture resistance of zirconia restorations.

Materials and methods. The articles identified were screened by two reviewers according to inclusion and exclusion criteria. The reference lists of articles advanced to second round screening were hand searched to identify additional potential articles. **Sources:** An electronic search was conducted on PubMed/Medline, Cochrane, Google scholar, Sciencedirect and Springerlinnk databases with no limitations.

Results . Study selection: 387 articles were identified, of which, nine met the inclusion criteria and formed the basis of this systematic review. Factors investigated in the selected articles included the sample size, type of restoration , die material ,preparation criteria , veneering technique , cementation , method of measuring fracture resistance , method of measuring marginal accuracy , results of fracture and results of marginal accuracy.

Conclusions. Based on the currently available scientific evidence, The zirconia veneering technique significantly influences the fracture resistance of zirconia-based crowns, the layering veneering technique crowns recorded the highest failure loads, while the digital veneering technique crowns recorded the lowest failure loads, the combination

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of the CAD /CAM and the press-over techniques for the veneering process improves thestability after artificial ageing relative to the layeringtechnique, Anatomical framework design increased the fracture resistance when alayering veneering technique was employed , No articles were found studying effect of veneering technique on marginal accuracy of zirconia restorations.

Recommendations. Before they can be recommended for daily application, the effect of newly introduced veneering techniques on the long-term stability of Y-TZP-based zirconia fixed dental prosthesis must be verified in well-designed, randomized clinical trials. Further studies should study effect of veneering technique on marginal accuracy of zirconia restorations.

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Introduction:-

Despite several systems are available to provide metal-free restorations, the dental profession continues to look for the ideal, which would combine optimum esthetic with excellent strength and marginal adaptation properties together with ease of fabrication. Many all-ceramic systems were strong enough to be used in anterior teeth. However, few all ceramic systems were strong enough to perform well on posterior teeth. However these all ceramics are brittle and need to be supported by stronger frameworks, especially when used in high stress bearing areas as the posterior region.

For esthetical reasons the zirconia frameworks have to be veneered with an appropriate veneering ceramic. In clinical application the veneering ceramic revealed to be the weakest link in such reconstructions. Chipping of the veneer is described to be the most frequent reason for failure. Fracture toughness is the first step in predicting the clinical performance of all ceramic material. [1] Unfortunately, against all efforts, chipping of the veneering ceramic is still one of the most common critical clinical failure types with zirconia FDPs. Fracture of veneering ceramics or dental porcelains could be separated into two groups, fracture of a veneering itself and fracture originated from the interfaces between the core and veneering porcelains. This phenomenon presents a clinical challenge, as replacement of such FDPs may cause iatrogenic damage such as abutment teeth or ceramic fracture, discomfort to the patient, and loss of time [2] .In addition to fracture resistance and esthetics, marginal fit is one of the most important criteria for the long-term success of ceramic restorations. It is necessary to minimize the marginal gap, since a significant space between the tooth and the restoration exposes the luting material to the oral environment, thus resulting in a more aggressive rate of cement dissolution caused by oral fluids and chemo mechanical forces. The consequent micro leakage may result in inflammation of the periodontal tissues, secondary caries, and subsequent failure of the prosthesis. Thus, for all-ceramic restorations to be successful and durable, they must have good marginal adaptation as well as high strength [3]. A conventional condensation and sintering technique used in fabricating a veneer can also contribute in low fracture resistance of veneering materials because it can produce a great number of porosity that can lower the strength and can create a critical flaw for fracture to occur.[2] Data in the literature about effect of different veneering techniques on marginal accuracy and fracture resistance of zirconia restorations has been found to be scarce and rare.

Whether different veneering techniques would affect the marginal accuracy and fracture strength of zirconia, is a question to be answered throughout this study.

Materials and Methods:-

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement was used as a reporting template as much as possible.

Search strategy PRISMA flow diagram downloaded as a separate file.
Data collection:

A systematic search of electronic databases was conducted using five databases: PubMed (NLM—National Library of Medicine), Cochrane Library (Wiley), Google scholar ,Sciencedirect and Springerlink up to November 2016.

The terms used were "Veneering technique", "Zirconia," "Marginal accuracy," and "Fracture strength". Specific search strategies for each electronic database are outlined in Table (1). No limits were applied during the electronic searches.

Criteria for selection of studies:-Table 1
All titles revealed by the electronic search were screened according to the following **inclusion criteria**:
1. Articles written in English
2. Posterior zirconia crowns or bridges
3. Veneered zirconia restorations
4. Studies measuring fracture strength
5. Studies measuring marginal accuracy

In addition to the inclusion criteria, the following **exclusion criteria** were applied:
1. Zirconia posts
2. Studies measuring bond strength
3. Comparing zirconia with metal
4. Zirconia implants and abutments
5. Comparing alumina and zirconia
6. Measuring light transmission
7. In vivo clinical studies
8. Measuring shear strength
9. Anterior crowns

The initial PubMed search resulted in 268 articles while that of Cochrane resulted in 19 articles while that of Googlescholar resulted in 100 articles while that of ScienceDirect resulted in zero articles while that of SpringerLink resulted in zero articles (total 387 articles).

After removal of duplicates the final search resulted in 386 articles. A search of the related titles/abstracts was conducted. Where a potentially relevant title without a listed abstract was available, the full article was later assessed to select the studies. The total selected articles for full text screening were fifteen articles. According to inclusion and exclusion criteria seven articles were excluded and eight articles were included.

In addition to one article obtained from manual searching in references of the included studies.

Screening and selection:-
Search results with abstracts were transferred into an excel sheet and duplicates were deleted. Next, initial screening of the titles was conducted to exclude irrelevant articles. The remaining studies were further reviewed by reading their abstracts. Screening the titles and abstracts was performed. If the abstract did not provide enough information to include or exclude a paper, it was selected for full-text reading. Finally, the remaining papers were examined further for their relevance against the inclusion criteria by reading them in full text. Papers that met the eligibility criteria were included in this study.

Data extraction (summary of findings table)
The studies were analyzed with regard to the data mentioned in Table 2

Results:-

Study selection: justified through PRISMA flow chart
Nine laboratory studies were included in the systematic review . Among the 15 studies initially considered in the second selection stage, a few studies were eliminated after inclusion and exclusion criteria were applied. In vitro studies that did not analyze the veneering technique and its effects on zirconia restorations were excluded. The initial search resulted in 387articles (). De duplication reduced this number to 386 studies. Then 371 papers were excluded after screening of titles. Abstracts and full texts of the remaining 15 articles were reviewed and led to more exclusion of the non-relevant articles. Seven articles were excluded and 8 were included. In addition an article was added by manual searching. Not all data presented in the accepted 9 papers were included in the present study, because some data did not meet the scope of the study. In total, 7 papers were excluded after a full-text reading, for the following reasons: Although they studied the bilayered zirconia restorations they didn`t mention effect of

veneering technique which was the scope of this study. Moreover, a study by Stawarzyk et al 2011[21] was done on anterior teeth which was one of the exclusion criteria.

Table 1:- Inclusion and Exclusion criteria.

Inclusion criteria	Exclusion criteria
Articles in English	Zirconia posts
Posterior zirconia crowns or bridges	Studies measuring bond strength
Veneered zirconia restorations	Comparing zirconia with metal
Studies measuring fracture strength	Zirconia abutments and implants
Studies measuring marginal accuracy	Comparing alumina and zirconia
	Measuring light transmission , contact ,wear
	In-vivo clinical studies
	Measuring shear strength
	Anterior crowns

Table 2:- Summary of findings table

Study	Sample size	Type of restoration	Die material	Preparation criteria	Veneering technique	Cementation
Al Wahdani et al 2016[4]	45	Crowns	Cobalt chromium	1.2 mm heavy chamfer finish line, 1 to 1.5 mm reduction, 8° taper & Cement space 50 µm	-Layering -Overpressing -Digital	Glass ionomer
Chaar et al 2013[5]	48	3units F.P.D	Human teeth	Circumferential chamfer of 0.8 mm in depth, a convergence angle of 10°and a wall height of 5 mm.	1-layering technique with leucite-strengthened feldspathic porcelain (group LV). 2- layering technique 3- CAD⁄CAM and press-over techniques	self-adhesive resin cement
Choi et al 2012[6]	45	Crowns	Titanium	1.2 mm, 360˚chamfer preparation and occlusal reduction of 2 mm, 8˚tapered angle,spacer thickness 10 µm	Layering ,press on and sintering(CAD/CAM)	Resin modified glass ionomer cement
Kanat et al 2014[7]	90	Crown Bar Disc shape	Stainless steel	Crowns 1 mm standard circumferential chamfer, spacer thickness 10 µm Bar- (length: 25 mm, width: 5 mm, height: 1.5 mm) and square- (4 × 4	File splitting, layering & over-pressing	Glass ionomer

				mm 2)		
Kanat et al 2015[8]	60	Crowns blocks	Stainless steel	1 mm circumferential chamfer,die spacer 10µm	Layering , overpressing , CAD on	resin moodified glass ionomer cement
Larsson et al 2011[9]	80	Crowns	inlay pattern resin	120 ° chamfer preparation and 15˚ angle of convergence	Layering and press on	Panavia F2
Sundh et al 2005[10]	15	Bridges(frameworks)	Stainless steel	120˚chamfer, 6˚tapering	Layering and press on , heat treatment similar to veneering	Zinc phosphate
Sundh et al 2004 [11]	40	Crowns	Steel	120˚chamfer, 6˚tapering	Press on	Zinc phosphate
Aboushleib et al 2008[12]	36	Crowns	Natural teeth	Round margin &thickness 0.5mmn	Pressing+CADon,Layering	Light polymerized adhesive resin

Table 3:- Methods of measuring outcomes.

Study	Method of measuring fracture resistance	Method of measuring marginal accuracy
Al Wahdani et al 2016[4]	Universal testing machine	Not measured in this study
Chaar et al 2013[5]	Universal testing machine	Not measured in this study
Choi et al 2012[6]	Universal testing machine	Not measured
Kanat et al 2014[7]	Universal testing machine	Not measured
Kanat et al 2015[8]	Universal testing machine	Not measured
Larsson et al 2011[9]	Universal testing machine	Not measured
Sundh et al 2005[10]	Universal testing machine	Not measured
Sundh et al 2004[11]	Universal testing machine	Not measured
Aboushleib et al 2008[12]	Universal testing machine	Not measured

Table 4:- Table of results.

Study	Fracture resistance results
Al Wahdani et al 2016[4]	1]LV0 2034 +- 401) , 2]LV1 1625 +-291), 3]LZ0 2373 +-718) 4]LZ1 1769 +- 136); 5]PP0 1959 (+- 453) 6]PP1 1897 (+-329).
Chaar et al 2013[5]	1]4263.8±1110.8 N for Group Layering Tech. 2]5070.8±1016.4 for Group Heat pressing tech. 3] 6242.0±1759.5 N for Group Sintering tech.
Choi et al 2012[6]	CD (4408 ± 608) , L (4323 ± 462) and Pressing (2507 ± 594)
Kanat et al 2014[7]	L (6102 ± 1519) and P (4117 ± 1083) than with of OCF (1900 ± 254)
Kanat et al 2015[8]	Emaxceram 1814-3005 SD 436 Triceram 1874-2326SD 346
Larsson et al 2011[9]	Three-unit frameworks veneered with

	Eris2237(363) Three-unit frameworks veneered with Vita D 1973(175)
Sundh et al 2005[10]	1]Single veneering technique 3486 _ 1067 N for the 10 crowns with an 'adapted Denzir core' veneered with IPS Empress 2 veneer ceramic, 2]2226 _ 553 N for the 10 crowns with a 0.5 mm Denzir core veneered with IPS Empress 2 veneer ceramic, 3]4114 _ 321 N for the 10 crowns with an 'adapted Denzir core' veneered with IPS Eris veneer ceramic, 4]2740 _ 272 N for the 10 crowns with a 0.5 mm Denzir core veneered with IPS Eris veneer ceramic, 5]2346 _ 371 N for the 10 IPS Empress 2
Sundh et al 2004 [11]	442.8+-25NCAD on, 346+-24N Layering
Aboushleib et al 2008[12]	442.8+-25NCAD on, 346+-24N Layering

Table 5:- List of excluded studies.

Study	Reason for exclusion
DeyarJelal et al 2016[17]	Not studying veneering technique
Jalali et al2016[18]	Not studying veneering technique
Nakamura et al 2015[19]	Not studying veneering technique
Preis et al 2014[20]	Not studying veneering technique
Saurez et al 2015[21]	No mentioning of veneering techniques
Stawarzyk et al 2011[22]	Anterior teeth
Preis et al 2012[23]	Not studying veneering technique

Discussion:-

The aim of this systematic review was to study the effect of different veneering techniques on the marginal accuracy and fracture resistance of zirconia base fixed restorations. Good esthetics and acceptable biocompatibility are important considerations of dental restorations. All-ceramic crowns have recently been popular and frequently used in dental clinics. Actually high quality, all-ceramic restorations are not easily distinguished from adjacent natural teeth. [13] Among the many ceramic systems that have been developed, Yttria-stabilized polycrystalline tetragonal zirconia has become a common form of dental restoration; mostly because of having good characteristics including esthetics, excellent biocompatibility, low plaque accumulation, and high strength [14]. In addition to esthetics, marginal fit and fracture strength are essential criteria for clinical success. Increased marginal discrepancies increase the incidence of cement dissolution, microleakage, recurrent caries, periodontal problems, and finally failure of the restoration. The majority of studies proved the marginal fit and fracture resistance to be important for the long-term success of restorations [15]. Long term clinical evaluation of zirconia based all-ceramic crowns showed high success rate. However, chipping of the veneering material was one of the most important and disastrous complications, loss of retention of the restoration and presence of secondary caries as well. Some of the problems may be related to the marginal and internal accuracy of the restorations. Thus an adequate fit is an important factor in the restorative treatment prognosis. [15.]

Clinical studies are the best experiment to test the actual performance of dental restorations; however, they consume money, time and involve ethical approvals. That`s why laboratory testing is essential to provide scientific basic data to assess the failure risk and offer clinically relevant results and produce failure modes similar to those reported in clinical studies [16.]In vitro tests attempt to simulate clinical failures and it is therefore desirable to create an in vitro model that resembles the clinical situation as closely as possible. Many clinical situations are difficult to be resembled in the laboratory. Laboratory tests can only offer limited predictions about the expected clinical performance of tested restorations, however they are useful when studying and comparing specific factors in a controlled environment [17.]

The preparation criteria were variable among different studies.

1.2 mm heavy chamfer finish line by two studies[4,6],0.8 mm circumferencial chamfer, one study 1mm[8] , 120 chamfer and 0.5 mm chamfer finish line[10].
The die spacer thickness ranged from 10 µm in articles as Choi et al 2012[6],Kanat et al2015[7] to 50 µm in one study by Alwahdani et al 2016[4] .

The die material used during fracture resistance testing was either cobalt chromium[4].,Titanium[6] , stainless steel[8,10,11] , natural teeth[12] and inlay pattern resin[9] Ideally it should have been epoxy resin to simulate the modulus of elasticity of the natural teeth.

Factors affecting failure loads were listed as :1-Mechanical factor of material used, 2-cementation technique,3-anatomic difference in shape,4-loading method. Aboushleib 2008[12]. The occlusal surface was non-anatomic in a study by Al-wahdani et al 2016[4] which gave reduced failure load results.

The causes of veneer chipping were listed by Al-wahdani et al 2016[4]as :design of zirconia core, support and thickness of veneering layer, firing protocol , stiffness of zirconia core, morphology of circular finish line ,core veneer adhesive forces ,mismatch in thermal expansion coefficient ,type of veneering ceramic and technique of veneering.Chaaret al2013[5], Al wahdani et al2016.[4]

Three veneering techniques were mentioned in the listed articles. The layering technique , the press on technique in addition to the cad on technique which was also called the sintering technique or the over cemented file splitting technique.Choi et al 2012[6], Kanat et al 2015[8]. However, Larsson et al 2011[9] and Sundh et al 2004[11] used different veneering ceramics but one veneering technique. Effect of veneering technique was not mentioned or studied.

The layering technique had some limitations including:Lack of shade uniformity, formation of bubbles and human variable with varying technician skills. That`s why novel veneering techniques were introduced aiming at overcoming variable human performance, improving quality and reducing costs. However , factors affecting over-pressing technique were mentioned as:

Flask attatchment, cleanness of modeling wax , quality of pressing material ,furnace caliberation and air abrasion performed during divestment procedures. Advantages of press on technique include: improve homogeneity and reduced thermal stresses. Chaaret a 2013[5].

Failure of the veneered zirconia crowns was described as occurrence of visible cracks. Alwahdaniet al2016[4].

The direct view technique using the microscope is used frequently followed by cross sectioning and the impression replica techniques. The direct viewing technique using microscope is nondestructive, more cost effective, time saving and more accurate as it does not involve replication of cement space layer. However, this method is restricted to in-vitro use as it requires direct examination of the marginal gap under magnification. Regarding our search no articles were found concerning the effect of veneering technique on marginal accuracy of zirconia base fixed restorations, which means the need for further studies regarding this issue [16].

Conclusions:-

Within the limitations of this systematic review it was found that:

1. The zirconia veneering technique had a significant influence on the fracture resistance of zirconia-based crowns.
2. The layering veneering technique crowns recorded the highest failure loads, while the digital veneering technique crowns recorded the lowest failure loads.
3. The combination of the CAD/CAM and the press-over techniques for the veneering process improves the stability after artificial ageing relative to the layering technique.
4. Anatomical framework design increased the fracture resistance when a layering veneering technique was employed.
5. No articles were found studying effect of veneering technique on marginal accuracy of zirconia restorations.

Recommendations:-

Before they can be recommended for daily application, the effect of newly introduced veneering techniques on the long-term stability of Y-TZP-based zirconia fixed dental prosthesis must be verified in well-designed, randomizedclinical trials. Further studies should study effect of veneering technique on marginal accuracy of zirconia restorations.

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