IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 7 Ser.15 (July. 2020), PP 28-39
www.iosrjournals.org

Assessment of Marginal Discrepancies In Zirconia Fixed Dental Prosthesis Fabricated Using Various Cad Cam Milling Systems – A Systematic Review

M.Keerthna[1,] Deepak Nallaswamy[2,] Marian Anand Bennis[3]
[1](*Department of Prosthodontics and Implantology, Saveetha Dental College/ Saveetha UniversitySIMATS, India)*
[2](*Director of Academics, Saveetha Dental College/Saveetha University, SIMATS, India)*
[3] (*Senior Lecturer, Department of Prosthodontics and Implantology, Saveetha Dental College/ Saveetha University, SIMATS, India)*

STRUCTURED ABSTRACT
Aim*The aim of this systematic review is to assess the studies on the marginal discrepancy of zirconia based fixed dental prosthesis reproduced by various CAD CAM milling systems and to evaluate which CAD CAM milling system produced zirconia based fixed dental prosthesis with least marginal discrepancy.*
Data sources and search methods
A comprehensive electronic search was done in online databases, 'Pubmed'and 'Google Scholar' and 'Cochrane' based on pre-determined eligibility criteria. In-vitro studies assessing the marginal discrepancy of zirconia based fixed dental prosthesis were selected after thorough screening. The search strategy covered all studies published until February 2019 and yielded a total of 7 articles out of which 4 studies were determined to fulfil the inclusion criteria and were selected for this review.
Review methods
Data extraction from the included studies was conducted by the primary author and reviewed by the second author. The information collected included sample size and population, study design, intervention, vertical marginal discrepancy, horizontal marginal discrepancy and absolute marginal discrepancy and measurement methods to determine marginal discrepancy.
Results *Out of 1348 articles obtained after the search, 4 studies were determined to fulfil the inclusion criteria and were selected for this review. Out of which only 1 article revealed measurements of vertical, horizontal and absolute marginal discrepancies while 3 studies revealed the vertical marginal discrepancy values and 2 studies revealed measurements of absolute marginal discrepancy. Study heterogeneity made it impossible to perform a meta-analysis of the research findings and to compare the rank of various systems that are discussed in this systematic review.*
Conclusion
Despite the limitations this study, it can be concluded that conclude that Zirkonzahn milling unit M 1 CAD CAM system produced the least vertical and absolute marginal discrepancy and Everest Kavo Biberach CAD CAM milling system produced the least horizontal marginal discrepancy. However, longer clinical trials are required to provide a stronger level of evidence to validate the results of this systematic review.
Key words: Computer aided design, Computer aided manufacturing, optical scanning, marginal discrepancy, Zirconia based fixed dental prosthesis

---

Date of Submission: 15-07-2020 Date of Acceptance: 30-07-2020

I. Introduction

Computer aided design and Computer aided manufacturing (CAD CAM) technology is truly revolutionizing the way dentistry is practiced. It has enabled both the dentists and labs to fabricate esthetic and durable restorations. CAD CAM technology in dentistry has been pursued worldwide since 1980's. A variety of CAD CAM systems have been applied for reproducing dental restorations. The three pioneers of CAD CAM in dentistry are Dr.Duret, developer of Sopha system.[1] Dr.Moermann developer of CEREC system, the chair side milling machines.[2] The third being Dr.Anderson, developer of Procera system who also attempted to fabricate titanium copings by spark erosion. He also introduced CAD CAM made composite veneered restorations which later developed as a processing center networked with satellite digitizers around the world for fabrication of all ceramic frameworks.[3] A CAD CAM system utilizes a process chain consisting of scanning, designing and milling phases. The scanning device converts the shape of the prepared teeth into three dimensional units of information (**voxels**). The computer translates this information into 3D map (**point cloud**). The operator will then be able to design a restoration shape using the computer which generates a tool path, which is used by the milling device to create the shape from a restorative material.[4]

Commonly when newer materials are introduced in the field of dentistry, they are tested against conventional technology. But in case of high strength ceramics invented for fabricating FPD frameworks, the conventional technology did not work well as expected.[5] Therefore the advent of CAD CAM at processing centres proved to be very effective in compensating for dimensional changes that occur along with processing and obtaining accurate fit of crowns to the abutment teeth.[6] Having the following advantages such as reduced labour involvement, reduced working time, providing good quality control of dental devices by designing, reducing the residual strain with the total processing time much shorter than conventional technique.[7]

All the CAD CAM systems generally consists of three components, the Digitalisation Tool/ Scanner, Software and a Production Technology Scanner. There are two types of scanners available for CAD CAM technology one being the Optical scanners and the second being the mechanical scanners. The basis of Optical scanner is the collection of three dimensional structures in a 'triangulation procedure'. Here, the source of light that is the laser and the receptor unit are in a definite angle in their relationship to one another. Through this angle the computer can calculate a three-dimensional data set from the image on the receptor unit. Examples are Lava Scan ST (3M ESPE, white light projections) and es1 (etkon, laser beam). The second type is the mechanical scanner, in this scanner variant, the master cast is read mechanically line-by-line by means of a ruby ball and the three-dimensional structure is measured. This type of scanner is distinguished by a high scanning accuracy, whereby the diameter of the ruby ball is set to the smallest grinder in the milling system, with the result that all data collected by the system can also be milled. Example is Procera Scanner. The drawbacks are complicated mechanics, very expensive apparatus and long processing times compared to optical systems.[8]

Processing devices are distinguished by means of the number of milling axes namely the 3-axis devices, 4-axis devices and 5-axis devices. The 3-axis milling devices has degrees of movement in the three spatial directions. Thus, the mill path points are uniquely defined by the X -, Y -, and Z – values. All 3-axis devices used in dentistry can also turn the component by 180° in the course of processing the inside and the outside with the advantages of short milling times and simplified control and cost effective. Examples are In Lab (Sirona), Lava (3M ESPE), Cercon brain (Degu Dent). In addition to the three spatial axes, in 4 axis devices the tension bridge for the component can also be turned infinitely variably. As a result it is possible to adjust bridge constructions with a large vertical height displacement into the usual mould dimensions and thus save material and milling time. Examples are Zeno (Wieland-Imes). With a 5-axis milling device there is also, in addition to the three spatial dimensions and the rotatable tension bridge (4th axis), the possibility of rotating the milling spindle (5th axis). This enables the milling of complex geometries with subsections. Example is Everest Engine (KaVo).

Various CAD CAM milling machines used in dentistry include Cercon, Everest, Lava, Procera, DCS Precident, CICERO system, Cerec 1, Cerec 2, Cerec 3 Cerec In Lab and E 4 dentist system . Cercon CAM milling machine does not have a CAD component and scans the wax pattern and mills a zirconia bridge coping.[9] Everest CAD CAM system consists of a scanning unit, a reflection free gypsum cast is fixed to the turntable and scanned by a CCD camera in a 1:1 ratio with an accuracy of measurement of 20 µm. Its machining unit has 5-axis movement which gives a detailed morphology and precise margins. Lava system uses a laser optical system to digitize information and its CAD software automatically finds the margin and suggests a pontic so the framework is designed to be 20% larger to compensate for sintering shrinkage.[7] Procera system has combined pantographic reproduction with electrical discharge (spark erosion) machining. It uses an innovative concept for generating its alumina and zirconia copings having excellent clinical longevity and strength.[8] DCS Precident can scan 14 dies simultaneously and mill up to 30 framework units in 1 fully automated operation. CICERO method for production of ceramic restorations uses official scanning, ceramic sintering, and computer assisted milling techniques to fabricate restorations with maximal static and dynamic occlusal contact relations. CEREC (computer-assisted CERamic REConstruction) system is used for electronically designing and milling restorations. In CEREC 1 the ceramic block could be turned on the block carrier with a spindle and feed against the grinding wheel, which grinds the ceramic block to a new contour with a different distance from the axis at each feed step. In CEREC 2 the introduction of an additional cylinder diamond enables the grinding of partial and full crowns. It introduced the design of the occlusion in three modes: extrapolation, correlation and function but the design still was displayed two-dimensionally. With CEREC 1 and CEREC 2, an optical scan of the prepared tooth is made with a couple charged device (CCD) camera, and a 3-dimensional digital image is generated on the monitor. The restoration is then designed and milled.[9] The most significant factor for three-dimensional scanning with the Cerec 3 intraoral camera is that tooth preparations for crowns and inlays have a unique characteristics of having all points of interest that can be seen from a single viewing line, representing the preparation and insertion axes, respectively.[1] CEREC in Lab is a laboratory system in which working dies are laser-scanned and a digital image of the virtual model is displayed on a screen. E4D Dentist System is presently the only system besides CEREC that permits same day in-office restorations. This system includes a laser scanner (Intraoral digitizer), a design center and a milling unit. The scanner is placed near the target tooth, and has 2 rubber feet that hold it to specific distance from the area being scanned. As each picture is taken, the software gradually creates a 3D image. The design system automatically detects the finish lines and marks them on the screen. As soon as the restoration is approved, the data are transmitted to either the in-house milling machine or a dental laboratory. The office milling machine will then manufacture the restoration from the chosen blocks of ceramic or composite.[10]

These CAD CAM milling machines overcome the shortcomings of the conventional fabrication techniques such as more time consumption, more number of labor involved, patient discomfort and processing of high strength ceramics for fabrication of fpd was not possible by conventional techniques. The marginal adaptation of FPD to the abutment is one of the determining factors for long term success of the dental prosthesis.[12] McLean and Von Fraunhofer proposed that an acceptable marginal discrepancy for full coverage restorations should be less than 120 µm. Christenson suggested a clinical goal of 25 µm to 40 µm for the marginal adaptation of cemented restorations. However, most clinicians agree that the marginal gap should be no greater than 50 µm to 100 µm.[13] The purpose of this systematic review is to analyse the available evidence on the marginal discrepancy of zirconia based fixed dental prosthesis reproduced by various CAD CAM milling systems and to evaluate which among the CAD CAM milling machines produces zirconia based fixed dental prosthesis with least marginal discrepancy.

II. Materials And Methodology

Which is the most accurate CAD CAM milling system that produced zirconia based fixed dental prosthesis with least marginal discrepancy?

PICO (Population, Intervention, Comparison, and Outcomes)

- P – Teeth requiring zirconia based fixed dental prosthesis
- I – Various CAD CAM milling systems
- C - Nil
- O – Marginal discrepancies of zirconia based fixed dental prosthesis reproduced by CAD CAM milling machines.

Outcome Variables

The outcomes of interest in this systematic review are

***Vertical marginal discrepancy*:** The vertical misfit between the outermost portions of the frameworks margin and the preparation edge of the abutment teeth measured parallel to the path of draw of the restoration.

Horizontal marginal discrepancy: The horizontal misfit between the outermost portions of the frameworks margins and the preparation edge of the abutment teeth measured perpendicularly to the path of draw of the restoration.

Absolute marginal discrepancy: The vectorial sum of these distances defines the absolute marginal discrepancy.

Literature Search Protocol

Publications of interest within the scope of this focused systematic review were searched in

- The electronic database National Library of Medicine (MEDLINE/PubMed)
- Google scholar
- Cochrane

Search Terms

P – Partially edentulous, missing teeth, teeth requiring crowns, fixed partial denture, fixed dental prosthesis, endodontically treated teeth, fixed prosthesis, bridge, tooth supported fpd, missing abutment teeth, long span edentulous arch, multiunit fixed prosthesis, abutments, cantilever fpd, multiple missing abutments, tooth supported cantilever fpd, lost natural teeth, retainer, pontic, cantilever pontic, missing anterior teeth, missing posterior teeth, replacements of missing teeth, fpd serving as abutments, replacement of missing teeth, single missing tooth, edentulous space, three unit fpd, four unit fpd, long span bridge.

I – CAD CAM, computer aided design, computer aided manufacturing, lava 3M ESPE, Procera, Everest, Wieland, Ceramill, scanning, milling, designing,CEREC1, CEREC 2, CEREC3, Cerec In Lab, Cicero, DCS Precident, Cercon.

O – Marginal fit, marginal integrity, monolithic restorations, fully contoured crowns, clinically acceptable marginal gap, marginal misfit, vertical marginal discrepancy, horizontal marginal discrepancy, absolute marginal discrepancy, lithium disilicate ceramic crowns, marginal gap, and post sintered zirconia.

Article Eligibility Criteria

Inclusion Criteria:
- Invitro studies
- Articles written in English

Exclusion Criteria:
- Animal studies
- Case reports, reviews, systematic reviews
- Studies comparing digital and conventional methods
- Invivo studies
- Randomized control trials
- Articles written in other languages than English

Search statergy:

The search strategy included searching MEDLINE / PubMed, Google scholar, Cochrane library from January 1965 to February 2019. A hand search was also performed on European Journal of Oral sciences, American college of Prosthodontists, Journal of Prosthetic dentistry, Quintessence International. This research was supplemented by cross checking the reference articles of selected studies to locate additional papers that meet the eligibility criteria fixed for this study.

Selection of studies:

The review process consists of two phases. In the first phase, titles and abstract of the search were initially screened for relevance and full text of relevant abstract were obtained and accessed. The hand search of the selected articles as well as search of references in the selected articles was also done. The articles that were obtained after the first step of review process using the following inclusion and exclusion criteria were screened in the second phase and relevant and suitable articles were isolated for further processing and data extraction.

Article selection:

Search results

A total of 1348 articles were obtained using keywords in a Boolean search operator in the PubMed search engine. The remaining articles were subjected to a title analysis which yielded a total of 14. Further analysis of the article's abstracts lead to an exclusion of 7 articles. The remaining 7 articles were subjected to full text analysis which yielded a total of 4 articles.

III. Results

Search strategy

PubMed

#28	Add	Search **three unit fpd**	118	03:00:47
#27	Add	Search **edentulous space**	569	03:00:33
#26	Add	Search **single missing tooth**	657	03:00:16
#25	Add	Search **replacement of missing teeth**	1302	03:00:02
#24	Add	Search **fpd serving as abutments**	2	02:59:45
#23	Add	Search **missing posterior teeth**	571	02:59:31
#22	Add	Search **missing anterior teeth**	830	02:59:20
#21	Add	Search **cantilever pontic**	289	02:59:04
#20	Add	Search **pontic**	10300	02:58:50
#19	Add	Search **retainer**	1323	02:58:43
#18	Add	Search **lost natural teeth**	874	02:58:37
#17	Add	Search **tooth supported cantilever fpd**	4	02:58:26
#16	Add	Search **multiple missing abutments**	25	02:58:09
#14	Add	Search **cantilever fpd**	44	02:57:48
#15	Add	Search **abutments**	9465	02:57:35
#13	Add	Search **multiunit fixed prosthesis**	33	02:54:10
#12	Add	Search **long span fpd**	13	02:53:52
#11	Add	Search **long span edentulous arch**	14	02:53:41
#10	Add	Search **missing abument teeth**	0	02:53:28
#9	Add	Search **tooth supported fpd**	66	02:53:07
#8	Add	Search **bridge**	62747	02:52:46
#7	Add	Search **fixed prosthesis**	23913	02:46:37
#6	Add	Search **endodontically treated teeth**	3575	02:46:27
#5	Add	Search **fixed dental prosthesis**	14452	02:46:11
#4	Add	Search **fixed partial dentures**	10363	02:45:58
#3	Add	Search **teeth requiring crowns**	162	02:45:45
#2	Add	Search **missing teeth**	22156	02:45:27
#1	Add	Search **partially edentulous**	5338	02:45:15

Figure 1: PubMed search showing terms for population

#50	Add	Search ((((((((((((((CAD CAM) OR computer aided manufacturing) OR Lava 3 M ESPE) OR everest) OR wieland) OR ceramill) OR scanning) OR designing) OR cerec 1) OR cerec 2) OR cerec 3) OR cerec in lab) OR cicero) OR dcs precident) OR cercon	574802	03:12:09
#49	Add	Search **cercon**	196	03:08:39
#48	Add	Search **dcs precident**	6	03:07:44
#47	Add	Search **cicero**	1758	03:07:32
#46	Add	Search **cerec in lab**	15	03:07:18
#45	Add	Search **cerec 3**	327	03:07:01
#44	Add	Search **cerec 2**	348	03:06:56
#43	Add	Search **cerec 1**	349	03:06:48
#42	Add	Search **designing**	59499	03:05:55
#41	Add	Search **milling**	6688	03:05:46
#40	Add	Search **scanning**	490156	03:05:39
#39	Add	Search **ceramill**	44	03:04:58
#38	Add	Search **wieland**	3609	03:04:43
#37	Add	Search **everest**	1147	03:04:36
#36	Add	Search **Procera**	824	03:04:29
#35	Add	Search **Lava 3 M ESPE**	12	03:04:17
#34	Add	Search **computer aided manufacturing**	21083	03:03:53
#33	Add	Search **computer aided design**	21676	03:03:39
#32	Add	Search **CAD CAM**	21908	03:03:23

Figure 2: PubMed search showing search terms for intervention and Boolean for intervention

#66	Add	Search (((((((((((((((((((((((((((((missing teeth) OR fixed partial dentures) OR fixed dental prosthesis) OR endodontically treated teeth) OR fixed prosthesis) OR bridge) OR tooth supported fpd) OR missing abument teeth) OR long span edentulous arch) OR multiunit fixed prosthesis) OR abutments) OR cantilever fpd) OR multiple missing abutments) OR tooth supported cantilever fpd) OR lost natural teeth) OR retainer) OR pontic) OR cantilever pontic) OR missing anterior teeth) OR missing posterior teeth) OR fpd serving as abutments) OR replacement of missing teeth) OR single missing tooth) OR edentulous space) OR three unit fpd) OR four unit fpd) OR long span bridge)) AND (((((((((((((((CAD CAM) OR computer aided manufacturing) OR Lava 3 M ESPE) OR everest) OR wieland) OR ceramill) OR scanning) OR designing) OR cerec 1) OR cerec 2) OR cerec 3) OR cerec in lab) OR cicero) OR dcs precident) OR cercon)) AND ((((((((((((((marginal fit) OR marginal integrity) OR monolithic restorations) OR monolithic restorations) OR fully contoured crowns) OR clinically acceptable marginal gap) OR marginal misfit) OR vertical marginal discrepancy) OR horizontal marginal discrepancy) OR absolute marginal discrepancy) OR lithium di silicate ceramic crowns) OR marginal gap) OR yttrium stabilized tetragonal zirconia) OR post sintered zirconia)	409	03:35:11
#65	Add	Search (((((((((((((marginal fit) OR marginal integrity) OR monolithic restorations) OR monolithic restorations) OR fully contoured crowns) OR clinically acceptable marginal gap) OR marginal misfit) OR vertical marginal discrepancy) OR horizontal marginal discrepancy) OR absolute marginal discrepancy) OR lithium di silicate ceramic crowns) OR marginal gap) OR yttrium stabilized tetragonal zirconia) OR post sintered zirconia	4731	03:32:51
#64	Add	Search **post sintered zirconia**	61	03:31:42
#63	Add	Search **yttrium stabilized tetragonal zirconia**	665	03:31:21
#62	Add	Search **marginal gap**	1401	03:30:52
#61	Add	Search **lithium di silicate ceramic crowns**	0	03:30:38
#60	Add	Search **absolute marginal discrepancy**	46	03:14:33
#59	Add	Search **horizontal marginal discrepancy**	29	03:14:20
#58	Add	Search **vertical marginal discrepancy**	84	03:14:08
#57	Add	Search **marginal misfit**	137	03:13:49
#56	Add	Search **clinically acceptable marginal gap**	112	03:13:39
#55	Add	Search **fully contoured crowns**	1	03:13:21
#54	Add	Search **monolithic restorations**	244	03:13:09
#53	Add	Search **marginal adaptation**	4254	03:12:51
#52	Add	Search **marginal integrity**	1068	03:12:39
#51	Add	Search **marginal fit**	1713	03:12:25

Figure 3: PubMed search showing search terms for outcome and Boolean for outcome also AND Boolean for population, intervention and outcome

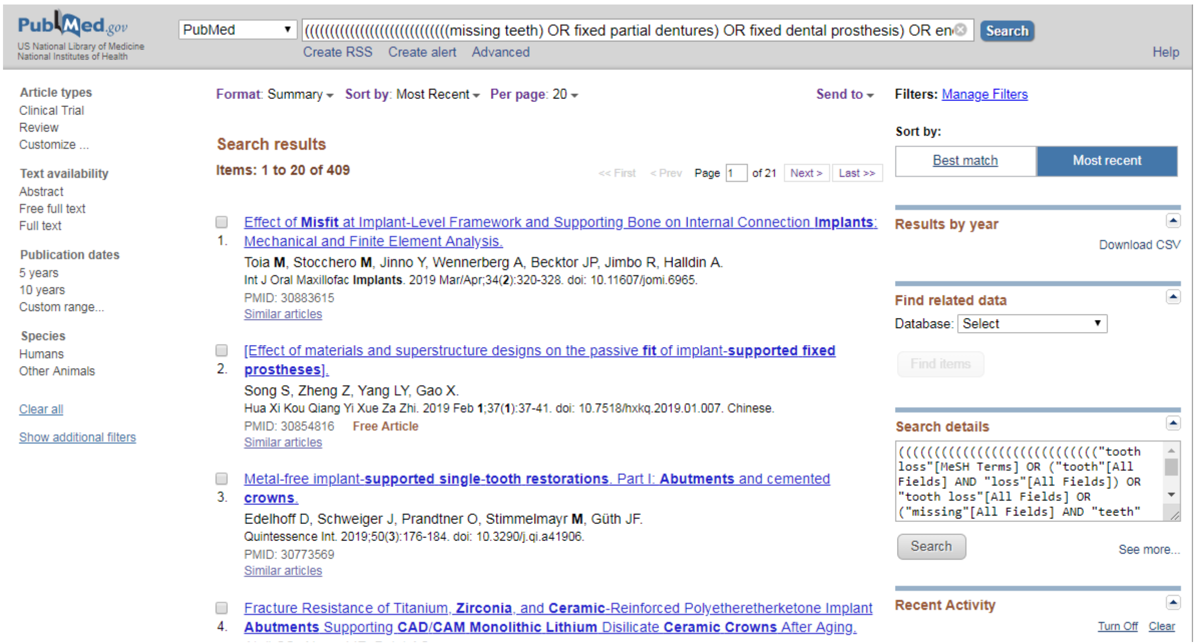

Figure 4: PubMed search showing search results for Pico search terms yielding 409 articles

Figure 5: Cochrane search resulted in 100 clinical trials and 1 systematic review

Data extraction

The data of the selected studies was extracted using customised data abstraction tables. Information extracted from each study included the following:

- Study design applied.
- Statistical test done.
- Groups and sample size.
- Outcome measures such as vertical marginal discrepancy, horizontal marginal discrepancy and absolute marginal discrepancy.
- Methods of measuring the marginal discrepancy.

Table 1: Characteristics and summary of included studies

S.NO	AUTHOR	JOURNAL /YEAR OF PUBLICATION	STUDY DESIGN	STATISTICAL DATA	GROUPS AND SAMPLE SIZE	VERTICAL MARGINAL DISCREPANCY (μm)	HORIZONTAL MARGINAL DISCREPANCY (μm)	ABSOLUTE MARGINAL DISCREPANCY (μm)	OUTCOME MEASURES (VMD , HMD AMD)	MEASUREMENT METHODS TO DETERMINE MARGINAL DISCREPANCY
1.	Paolo Vigolo et al	American College of Prosthodontists 2007	In Vitro	Two way ANOVA	Group A : Lava Group B : Everest Group C : Procera Sample size : 45	46.79 ± 4.7 65.34 ± 5.7 62.46 ± 5.2	- - -	- - -	Vmd = 63 μm	Light microscope (Axioskop, Zeiss, Oberkochen, Germany) at a magnification of ×50 equipped with digital camera
2.	Philipp Kohorst et al	European Journal of Oral Sciences 2009	In Vitro	One way ANOVA	Group A : Cerec in lab Group B : Everest Group C : Cercon Group D : Digident Sample size : 40	111.5 ± 34.2 197.3 ± 57 114.5 ± 32.1 23.8 ± 18.8	85.8 ± 27.1 37.6 ± 14.8 116.3 ± 31.1 51.1 ± 26.1	182.7 ± 26.1 206.3 ± 56.4 116.3 ± 31.1 57.9 ± 28.8	Vmd = 77.5 μm Hmd = 50.5 μm Amd = 98.5 μm	Light optical microscope (Orthoplan; Leitz, Wetzlar, Germany) at magnification of × 51.2 equipped with an analog camera
3.	Maria Jose et al	Revista Odontologica Mexicana 2015	In Vitro	T test	Group A = Cerec In Lab Group B = Zirkonzahn Sample size = 20	- -	- -	92.14 ± 38.59 38.71 ± 12.62	Amd = 61.75 μm	stereoscopic microscope Meiji Techno EMZ-13TR (Meiji Techno®) at a x50 magnifi cation
4.	Tamer A Hamza et al	Journal of Prosthetic Dentistry 2016	In Vitro	One way ANOVA	Group A = MCXL Group B = Ceramill motion 2 Group C = Wieland Group D = Zirkonzahn Group E = S 1 dental milling machine Sample size = 30	39.3 ± 2.3 25.1 ± 8.2 27.3 ± 11.4 19.4 ± 7.1 22.8 ± 8.9	- - - - - -	- - - - - -	Vmd = 39.3 μm	Binocular microscope (SZ – PT ; Olympus Corp) at a magnification of x100

Table 2: Characteristics for excluded studies

S.No	NAME OF THE AUTHOR / YEAR	STUDY DESIGN	CHARACTERISTICS OF EXCLUDED STUDIES
1.	Dominik L Buchi et al 2014	In Vitro study	Pre sintered zirconia used as the material of choice for milling influencing the outcome of the in vitro study
2.	Syed Rashid Habib et al 2018	In Vitro study	Poly wax CAD CAM zirconia blanks were used as the material of choice influencing the outcome of this in vitro study
3.	Futoshi Komine et al 2009	In Vitro study	Pre sintered zirconia used as the material of choice for milling influencing the outcome of the in vitro study.

Table 3: Shows the CEBM evidence level of selected articles

S.No	AUTHOR NAME	JOURNAL /YEAR OF PUBLICATION	STUDY DESIGN	LEVEL OF EVIDENCE
1.	Paolo Vigolo et al	American College of Prosthodontists 2007	In Vitro	3
2.	Philipp Kohorst et al	European Journal of Oral Sciences 2009	In Vitro	3
3.	Maria Jose et al	Revista Odontologica Mexicana 2015	In Vitro	3
4.	Tamer A Hamza et al	Journal of Prosthetic Dentistry 2016	In Vitro	3

(According to Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence)

Table 4: Shows the extraction of existing data regarding the outcome measures

S.NO	AUTHOR	GROUPS AND SAMPLE SIZE	VERTICAL MARGINAL DISCREPANCY (μm)	HORIZONTAL MARGINAL DISCREPANCY(μm)	ABSOLUTE MARGINAL DISCREPANCY(μm)
1.	**Paolo Vigolo et al**	Group A = Lava	46.79 ± 4.7	-	-
		Group B = Everest	65.34 ± 5.7	-	-
		Group C = Procera	62.46 ± 5.2	-	-
		Sample Size = 45			
2.	**Philipp Kohorst et al**	Group A = Cerec in Lab	111.5 ± 34.2	85.8 ± 27.1	182.7 ± 26.1
		Group B = Everest	197.3 ± 57	37.6 ± 14.8	206.3 ± 56.4
		Group C = Cercon	114.5 ± 32.1	116.3 ± 31.1	189.3 ± 10.5
		Group D = Digident	23.8 ± 18.8	51.1 ± 26.1	57.9 ± 28.8
		Sample Size = 40			
3.	**Maria Jose et al**	Group A = Cerec In Lab	-	-	92.14 ± 38.59
		Group B = Zirkonzahn	-	-	38.71 ± 12.62
		Sample Size = 20			
4.	**Tamer Hamza et al**	Group A = MCXL	39.3 ± 2.3	-	-
		Group B = Ceramill motion 2	25.1 ± 8.2	-	-
		Group C = Wieland	27.3 ± 11.4	-	-
		Group D = Zirkonzahn	19.4 ± 7.1	-	-
		Group E = S 1 dental milling machine **Sample Size = 30**	22.8 ± 8.9	-	-

Table 5: Shows the risk of bias for the included studies

	Paolo Vigolo et al	Philipp Kohorst et al	Maria Jose et al	Tamer Hamza et al
Random sequence generation	+	+	+	+
Blinding of outcome assessment	+	+	+	+
Selective reporting	-	-	-	-
Incomplete outcome data	-	-	-	-
Funding sources	-	+	-	-
Statistical analysis	+	+	+	+
Measurement Method standardization	+	+	+	+

IV. Discussion

The absolute marginal gap corresponds to the distance between the edge of the prosthetic restoration and the boundary of the tooth preparation. The horizontal gap is defined by the space measured along an axis parallel to the axis of the tooth, from the edge of the prosthesis to the border of the preparation. The vertical marginal gap is obtained by measuring the same space along an axis perpendicular to the axis of the tooth.[14]

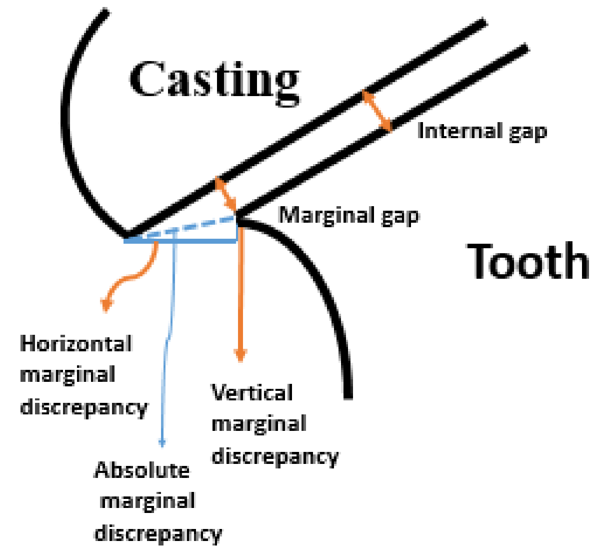

Figure 6: diagram showing method of measuring vertical, horizontal and absolute marginal discrepancy

Techniques thus were deemed more or less sensitive. Direct human intervention in the manufacturing of the crown could play a role according to the skill of the dental laboratory technician and the relative importance of his contribution. The number of steps involved inthe process was another important element because the probability of error increased with each additional step required.In addition, setting the steps of computer-aided manufacturing (CAM) is a source of variation in the precision machining of prosthetics.[14]

In an In vitro study by Paolo Vigolo et al who compared the three CAD CAM milling machines namely the Lava, Everest and Procera with a total sample size of 45, Lava group had lesser vertical marginal discrepancy (46.79 ± 4.7µm) than the Procera group (62.46 ± 5.2µm) and the Everest group (65.34 ± 5.7µm). Similarly in an In Vitro study by Philipp Kohorst et al who compared four CAD CAM milling machines ,the Cercon ,Cerec In Lab , Digident and Everest groups with a sample size of 40 in terms of vertical marginal discrepancy it was revealed that Everest CAD CAM milling machine produced the least vertical marginal discrepancy (23.8 ± 18.8µm). Tamer A Hamza et al in his In Vitro study compared five different CAD CAM milling machines MCXL Sirona, Ceramill Motion 2, Wieland, Zirkonzahn and S 1 dental milling machine with a samplesize of 30 which evaluated the vertical marginal discrepancy of the

monolithic zirconia restorations stated that Zirkonzahn CAD CAM milling machine proved to have the least vertical marginal discrepancy (19.4 ± 7.1µm) followed by S 1 dental milling machine (22.8 ± 8.9µm) , Ceramill Motion 2 CAD CAM milling system (25.1 ± 8.2µm) followed by Wieland CAD CAM milling machine (27.3 ± 11.4µm) and MCX milling machine (39.3 ± 2.3µm).

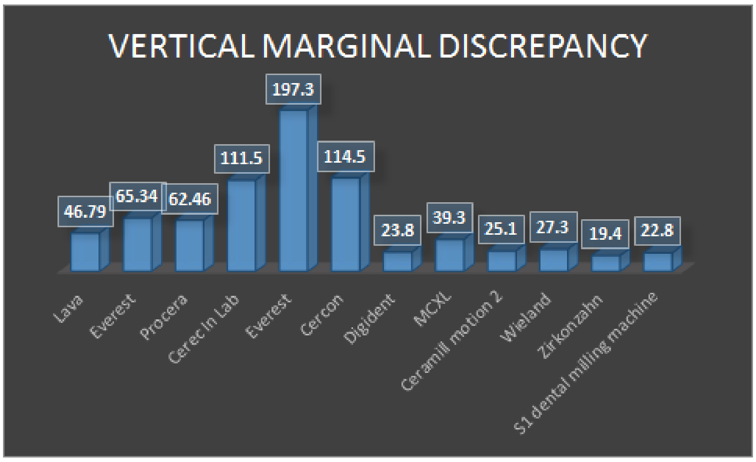

Figure 8: showing values of vertical marginal discrepancy inµm

With regard to measuring horizontal marginal discrepancy of zirconia based fixed dental prosthesis, Philipp Kohorst et al in his In Vitro study who compared four CAD CAM milling machines the Cerec In Lab, Everest, Cercon and Digident groups, Everest group reproduced the least horizontal marginal discrepancy (37.6 ± 14.8) followed by Digident group (51.1 ± 26.1), Cerec In Lab (85.8 ± 27.1) and Cercon (116.3 ± 31.1).

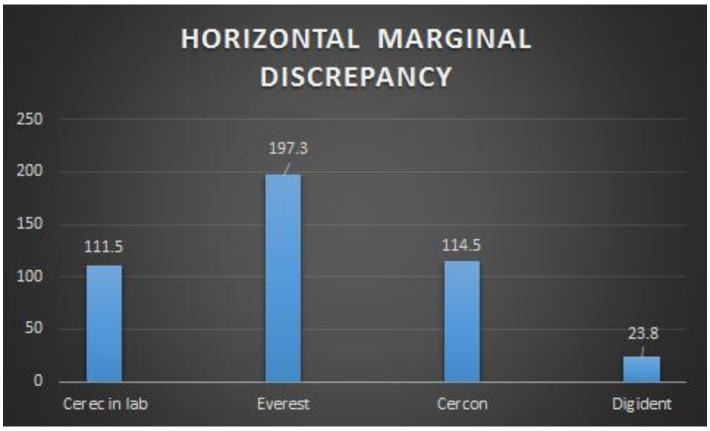

Figure 7: showing values of horizontal marginal discrepancy in µm

In the same study, absolute marginal discrepancy was also evaluated and found that the same Digident group (57.9 ± 28.8µm) followed by Cerec In Lab (182.7 ± 26.1µm), Cercon (189.3 ± 10.5µm) and Everest (206.3 ± 56.4µm) CAD CAM milling systems. Similarly in an In Vitro study performed by Maria Jose et al compared Cerec In Lab and Zirkonzahn CAD CAM milling machines with a sample size of 20 and found out that the absolute marginal discrepancy of Zirkonzahn group had the least value (38.71 ± 12.62µm). Several authors have reported that marginal discrepancies between 100 and 150 mm are clinically acceptable in regard to longevity of the restorations.

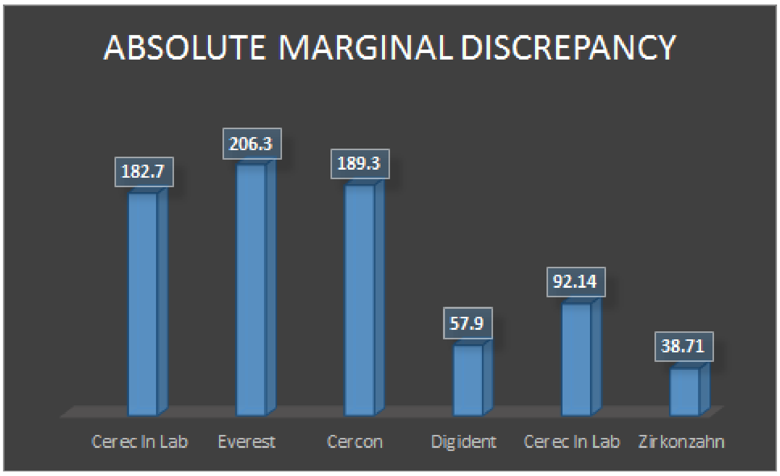

Figure 6: showing values of absolute marginal discrepancy in µm

Statistically significant differences between assessed CAD/CAM groups could be due to factors related to the digitization of each system. All the CAD CAM systems are subjected to limitations related to the scanning finite resolution**.** Influence of operator and dental clinician establish the high sensitivity of the CAD/CAM technique. Generally, CAM systems were at risk of more dimensional variations than CAD/CAM systems. In this systematic review also,in the included studies the same CAD CAM milling machines had varying vertical, horizontal and absolute marginal discrepancies.[17]

With respect to the measurement methods used to determine the marginal discrepancies vertically, horizontally and absolutely, one of the most accurate methods include viewing these zirconia based fixed dental prosthesis under microscopes for checking these marginal discrepancies. In a study by Paolo Vigolo et al, the vertical marginaldiscrepancy was devised and determined by a light microscope (Axioskop, Zeiss, Oberkochen, Germany) at a magnification of ×50 equipped with digital camera, in Philipp Kohorst et al study he had used the Light opticalmicroscope (Orthoplan; Leitz, Wetzlar, Germany) at magnification of × 51.2 equipped with an analog camera for determination all the three vertical, horizontal and Absolute marginal discrepancies. Maria Jose et al, measured the absolute marginal discrepancy under stereoscopic microscope Meiji Techno EMZ-13TR (Meiji Techno®) at a x50 magnification. Similarly Tamer Hamza et al viewed and measured the vertical marginal discrepancy through Binocular microscope (SZ – PT; Olympus Corp) at a magnification of x100.[16]

Study heterogeneity made it impossible to perform a meta-analysis of the research findings and to compare the rank of various systems that are discussed in this systematic review.[14] Direct CAD/CAM systems involved few steps. The coping, and sometimes even the crown, could be completed without the use of a die through intraoral impression. However, theaccuracy of data acquisition varied according to the systems various optical impression technologies. Software technology and milling accuracy also differed.[15] In addition, even for the same system, substantial variations among the measured values were noted, which was mainly due to the different experimental protocols used in each study. In this systematic review, we analyzed only in-vitro studies. The overall level of evidence is Level 3 hence we require well designed clinical trials with standardized outcomes to recommend the most accurate CAD CAM technology for reproducing zirconia based fixed dental prosthesis with least marginal discrepancies.

V. Conclusion

Despite the limitations of this study, we can conclude that Zirkonzahn milling unit M 1 CAD CAM system produced the least vertical and absolute marginal discrepancy and Everest KaVo Biberach CAD CAM milling system produced the least horizontal marginal discrepancy. However, longer clinical trials are required to provide a stronger level of evidence to validate the results of this systematic review.

References

[1]. Alghazzawi TF, Liu PR, Essig ME. The effect of different fabrication steps on the marginal adaptation of two types of glass-infiltrated ceramic crown copings fabricated by CAD/CAM technology. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2012 Apr; 21(3):167-72.

[2]. Andersson M, Carlsson L, Persson M, Bergman B. Accuracy of machine milling and spark erosion with a CAD/CAM system. The Journal of prosthetic dentistry. 1996 Aug 1; 76(2):187-93.

[3]. Aoki T, Kimura T, Momozaki K, Suzuki A. Graphical site simulation using an object oriented CAD model. PRISM. 1993 May; 1:i3.

[4]. Beuer F, Aggstaller H, Richter J, Edelhoff D, Gernet W. Influence of preparation angle on marginal and internal fit of CAD/CAM-fabricated zirconia crown copings. Quintessence International. 2009 Mar 1; 40(3).

[5]. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dental Clinics. 2011 Jul 1; 55(3):559-70.

[6]. Duret F, Blouin JL, Duret B. CAD-CAM in dentistry. The Journal of the American Dental Association. 1988 Nov 1; 117(6):715-20.

[7]. Bankoğlu Güngör M, Doğan A, Turhan Bal B, Karakoca Nemli S. Evaluation of marginal and internal adaptations of posterior all-ceramic crowns fabricated with chair-side CAD/CAM system: an in vitro study. Acta Odontol Turc. 2018; 35(1):1-8.

[8]. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. Journal of Prosthetic Dentistry. 1989 Oct 1; 62(4):405-8.

[9]. Iwai T, Komine F, Kobayashi K, Saito A, Matsumura H. Influence of convergence angle and cement space on adaptation of zirconium dioxide ceramic copings. Acta Odontologica Scandinavica. 2008 Jan 1; 66(4):214-8.

[10]. May KB, Russell MM, Razzoog ME, Lang BR. Precision of fit: the Procera All Ceram crown. The Journal of prosthetic dentistry. 1998 Oct 1; 80(4):394-404.

[11]. Mormann WH. The evolution of the CEREC system. The Journal of the American Dental Association. 2006 Sep 1; 137:7S-13S.

[12]. Mormann WH, Brandestini M, Lutz F, Barbakow F, Gotsch T. CAD-CAM ceramic inlays and onlays: a case report after 3 years in place. The Journal of the American Dental Association. 1990 May 1; 120(5):517-20.

[13]. Thaper S, Sengottaiyan V, Ganapathy D. A review on the prevalence of marginal discrepancy between lithium disilicate and zirconia crowns manufactured using dental cad cam. International Journal of Research in Pharmaceutical Sciences. 2019 Jan 5; 10(1):590-5.

[14]. Murugesan A, Sivakumar A. Comparison of accuracy of mesiodistal tooth measurements made in conventional study models and digital models obtained from intraoral scan and desktop scan of study models. Journal of Orthodontics. 2020 Mar 20:1465312520910755.

[15]. Sriram N, Jain AR. Computer aided design-computer aided manufacturing-A review. Drug Invention Today. 2018 Sep 1; 10(9).

M.Keerthna, et. al. “Assessment of Marginal Discrepancies In Zirconia Fixed Dental Prosthesis Fabricated Using Various Cad Cam Milling Systems – A Systematic Review.” *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(7), 2020, pp. 28-39.