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Clinical Performance of Ceramic Inlay Systems – A Systematic Review

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ABSTRACT

Purpose: To compare the clinical performance of ceramic inlays with other indirect restorations in posterior teeth and to analyze the influence of adhesive resins used for bonding ceramic inlays.

Methods

Search strategy: An electronic search was conducted of the PubMed and MEDLINE from January 1990 to 20th July 2011. Hand searching included relevant journals and bibliographies of all relevant papers and review articles from 1990 up to 2011.

Selection criteria: Randomized controlled trials and clinical trials, in which the clinical performance of ceramic inlays was compared with other indirect posterior restorations and the adhesive resins used for bonding ceramic inlays were included.

Data collection and Analysis: Data was searched independently and in duplicate. The primary outcome was presence or absence of the restorations. The secondary outcome was the presence or absence of postoperative pain/ discomfort, surface characteristics, colour, marginal adaptation, marginal integrity and recurrent caries.

Results: CAD/CAM (CEREC) inlays have better clinical performance when compared to other inlay systems but the durability of CEREC inlays is similar to gold inlays. The clinical performance does not differ based on the adhesive resin, but CAD/CAM (CEREC) inlays luted with chemically-cured resin have better clinical performance.

Clinical Significance: Ceramic inlays may be considered as viable esthetic alternatives to gold inlays in the restoration of permanent posterior teeth.

Keywords: Inlays, Clinical performance, Ceramics.

I. INTRODUCTION

Esthetics plays a major role in contemporary restorative dentistry. This has led to widespread application of composites and ceramics as intracoronal restorations. Dental restorations have to fulfill certain criteria when placed in the posterior teeth. Amalgam has been widely accepted as the material of choice for posterior restorations[1, 3]. The longevity of amalgam in lieu of its strength to withstand masticatory forces has been its primary advantage but the dark colour of amalgam restorations has paved the way to newer materials with enhanced esthetics.

The existence of composite resin began the trend in the aesthetic expectations of posterior restorations. They can be placed chair-side directly by the clinician or fabricated in the laboratory by the technician. The occurrence of post operative sensitivity and recurrence of caries are the disadvantages following composite restoration placement. The reduced longevity of composite restorations has led to the increased use of ceramic restorations [2].

Dental ceramics were introduced in dentistry in the late 1980s[3, 4]. Ceramic restorations include inlays, onlays, crowns and veneers. Dental Ceramic restorations are classified based on their firing temperatures and processing of the ceramics. CAD/CAM (computer-aided design computer-aided manufacturing) technique has come into existence in the late 1990s[5].

Ceramic inlays satisfy the aesthetic criteria to an extent for the patients but the actual clinical performing ability of ceramic inlays are uncertain. There are various criteria to evaluate the clinical performance of ceramic inlays. These include the loss of the restoration, surface characteristics, colour, anatomic form and marginal integrity[2]. Although the longevity of the restoration depends on various factors, the cementation of the ceramic inlays aids an additional support in the survival rate of these inlays. Adhesively bonded ceramic inlays demonstrate better strength than .... Adhesive resins could be dual-cured or self cured/ chemically cured. There does not appear to be any consensus on the durability of different types of ceramic inlays and on the adhesive resins used for cementation. Although two reviews have aimed at

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analyzing the clinical performance of ceramic inlays, these papers have not compared the different types of ceramics per se nor has the method of cementation been considered.

It was the aim of this systematic review to analyze the current literature on the clinical performances of ceramic inlay systems and also the influence of the adhesive resins used for bonding ceramic inlays.

II. METHODS

Structured questions

1. What is the clinical performance of ceramic inlays in comparison with other indirect restorations as a posterior restorative material?
2. What is the influence of adhesive resins on the longevity of ceramic inlays?

Pico analysis

- Population - Subjects requiring class I, II inlay restorations on the posterior teeth
- Intervention - Ceramic inlays for restorative treatment of permanent posterior teeth and adhesive resins used for bonding ceramic inlays
- Control - Gold inlays, indirect composite inlays, metal inlays
- Primary Outcome: Evaluation of failure of restoration
- Secondary Outcome: Evaluation of postoperative pain/discomfort, surface characteristics, colour, marginal adaptation, marginal integrity and recurrent caries.

Sources

For identification of studies included or considered for this review, detailed search strategies were developed for the database searched. The MEDLINE search used the combination of controlled vocabulary and free text terms.

Searched Databases

PubMed (from January 1990 to 20th July 2011)
PubMed Advanced Search (from January 1990 to 20th July 2011)
MEDLINE

Language

There were no language restrictions. Articles with translations of foreign language available were included.

Hand Searching

Relevant journals and bibliographies of all relevant papers from January 1990 to July 2011 were included.

- American Journal of Dentistry
- International Journal of Prosthodontics
- Journal of Adhesive Dentistry
- Journal of American Dental Association
- Journal of Conservative Dentistry
- Journal of Dentistry
- Journal of Esthetic and Restorative Dentistry
- Journal of Prosthetic Dentistry
- Operative Dentistry
- Quintessence International

Inclusion criteria

Criteria for considering studies for this review

Types of studies

Only randomized controlled trials and clinical trials were considered. These studies should have compared the longevity of ceramic inlays with other posterior restorations of adult permanent teeth or the influence of adhesive resins used for bonding the ceramic inlays were to be included in this review.

Types of interventions

- All types of ceramic inlays for restorative treatment of permanent posterior teeth.
- Adhesive resins used for bonding ceramic inlays
- Comparison with one of the controls (gold inlay, indirect composite resin inlay or cast metal inlays).

Types of outcome measures

Primary outcome:

- Longevity of the ceramic inlay restorations and the other posterior restorations were determined by the failure rate of the restorations.
- The failure rate of the restoration was characterized by the fracture of the restoration or loss of restoration.
- The restorations which receive a score unacceptable according to the USPHS (United States Public Health Service)/ modified USPHS criteria or the CDA (California Dental Association) criteria were considered as failed.

Secondary Outcome:

Postoperative pain/discomfort, surface characteristics, colour, marginal adaptation,

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marginal integrity and recurrent caries were evaluated.

Exclusion criteria

- Case reports and in vitro studies.
- Studies comparing onlays.
- Studies comparing direct restorations.

III. SEARCH METHODOLOGY

The search terms were:

Search	Most Recent Queries	Time	Result
#40	Search **(#35) AND #39**	15:13:25	59
#39	Search **(#37) OR #38**	15:13:01	459
#38	Search **(#34) AND #36**	15:12:29	204
#37	Search **(#33) AND #36**	15:11:46	322
#36	Search **(#31) AND #32**	15:11:17	1046
#35	Search **((((#26) OR #27) OR #28) OR #29) OR #30**	15:10:33	826583
#34	Search **(#24) OR #25**	15:09:40	10960
#33	Search **(((#20) OR #21) OR #22) OR #23**	15:09:16	1124
#32	Search **(((((((#9) OR #10) OR #11) OR #12) OR #13) OR #16) OR #17) OR #18) OR #19**	15:08:41	1046
#31	Search **((((((#2) OR #3) OR #4) OR #5) OR #6) OR #7) OR #8**	15:07:38	37935
#30	Search **double blinded trial**	15:04:26	107369
#29	Search **single blinded trial**	15:04:16	4454
#28	Search **clinical trial**	15:04:01	821050
#27	Search **controlled clinical trial**	15:03:54	165009
#26	Search **randomized controlled trial**	15:03:41	380888
#25	Search **bonding resin**	15:03:11	9440
#24	Search **adhesive resin**	15:02:58	6472
#23	Search **indirect composite resin inlays**	15:02:40	268
#22	Search **indirect composite resin inlay**	15:02:31	279
#21	Search **metal inlay**	15:02:11	806
#20	Search **gold inlay**	15:02:00	489
#19	Search **mirage ceramic inlays**	15:00:35	15
#18	Search **fired ceramic inlays**	15:00:19	20
#17	Search **glass ceramic inlays**	15:00:08	202
#16	Search **leucite reinforced ceramic inlays**	14:59:58	15
#13	Search **CAD/CAM inlays**	14:59:31	106
#12	Search **cerec inlays**	14:59:17	181
#11	Search **ips empress II inlays**	14:59:02	33
#10	Search **ips empress inlays**	14:58:49	113
#9	Search **ceramic inlays**	14:58:36	1016
#8	Search **inlays**	14:58:27	3095
#7	Search **indirect posterior dental restorations**	14:58:15	128
#6	Search **indirect dental restorations**	14:57:29	541

#5	Search **posterior permanent dental restorations**	14:57:14	2106
#4	Search **permanent dental restorations**	14:56:50	33230
#3	Search **dental restorations**	14:56:37	11835
#2	Search **restorations**	14:55:29	12601

IV. RESULTS

After performing the search 66 studies were found and screened for inclusion. 57 of the studies were excluded after examining the title and the abstract due to reasons cited in table 2. Full texts of 9 studies were retrieved for detailed evaluation. No studies were excluded. Therefore 9 studies were included in the review (Figure 1, Tables 1, 2).

Figure 1: SEARCH FLOW CHART

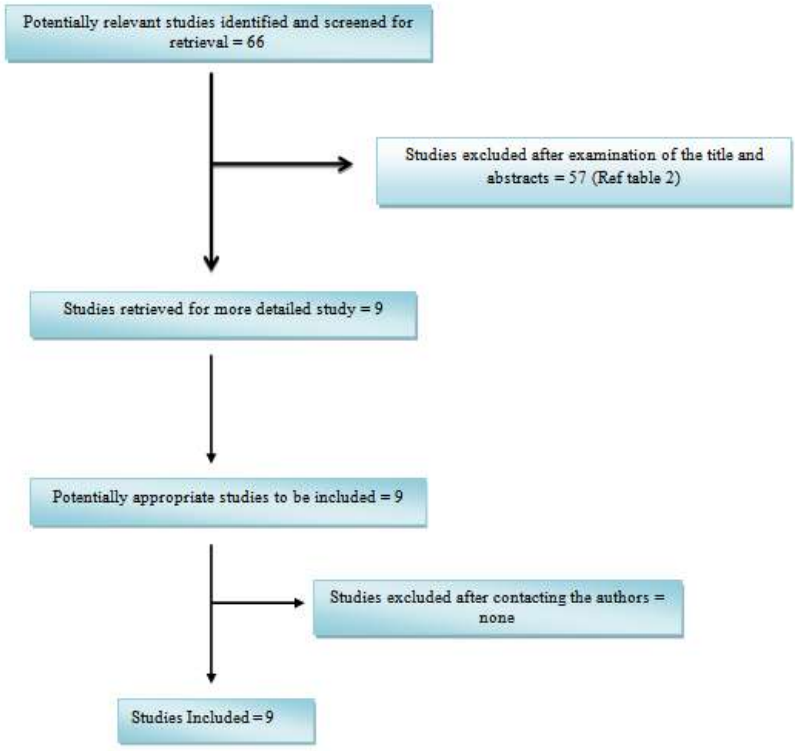

TABLE 1 - STUDY CHARACTERISTICS

S.No	Author	Materials	Method of evaluation	Observation time	Outcome
1.	Frankenberger et al 2009	Cergogold ceramic inlays and bonding adhesives – Definite Multibond/Definite; Syntac/Variolink ultra.	Modified USPHS criteria	Baseline, 6months, 1, 2, 4years.	Clinical behaviour of adhesively luted glass ceramic inlays
2.	Kramer et al 2009	Cergogold ceramic inlays and bonding adhesives – Definite Multibond/Definite; Syntac/Variolink ultra.	Modified USPHS criteria	Baseline, 1, 2,4 years	Clinical behaviour of adhesively luted pressed glass ceramic

					inlays
3.	Fabianelli et al 2006	IPS Empress ceramic inlays and bonding adhesives – dual-cured and self-cured resin cement	Modified USPHS criteria	1,7and 30 days – post operative sensitivity. 6,12,24 & 36 months evaluation	Clinical performance of Empress inlays cemented with self / dual cure adhesive system
4.	Sjogren et al 2004	CAD/CAM cerec inlays and bonding adhesives – dual-cured and self-cured resin cement	Modified USPHS criteria	10 year evaluation	Performance of cerec inlays after ten years
5.	Molin et al 2000	Cerec inlays, IPS Empress inlays, Mirage inlays and Gold inlays	CDA criteria	1 week baseline, 1, 3 and 5 years	Clinical quality and longevity of 3 ceramic inlay systems compared with Gold inlay
6.	Pallesen et al 2000	CAD/CAM inlays with two machinable ceramics (feldspathic and glass ceramic)	Modified USPHS criteria	Baseline, 8 months, 2,3,5,6 and 8 years	Durability of CAD/CAM ceramic inlays
7.	Thordrup et al 1999	Cerec inlays and Celay inlays	CDA criteria	1week, 1 and 3 years	Clinical performance of ceramic inlays made from machinable ceramic blocks
8.	Sjogren et al 1998	CAD/CAM cerec inlays , adhesives – dual-cured and self-cured resin .	Modified USPHS criteria	5 year evaluation	Performance of cerec inlays after ten years

9.	Sjogren et al 1995	CAD/CAM cerec inlays , adhesives – dual-cured and self-cured resin	Modified USPHS criteria	Baseline and 2 year evaluation	Performance of cerec inlays after ten years

TABLE 2: CHARACTERISTICS OF EXCLUDED STUDIES

S.No	AUTHOR/YEAR	REASON FOR EXCLUSION
1.	Atali et al, 2011	Onlays are considered in this study.
2.	Lohbauer et al, 2010	In vitro studies are excluded
3.	Harder et al, 2010	Inlay retained fixed dental prosthesis are excluded.
4.	van Dijken JW, Hasselrot L, 2010	Ceramic coverages are not included
5.	Dukic et al, 2010	Only indirect composite restorations are considered in the study
6.	Khairallah C, Hokayem A, 2009	In vitro ceramic is included in this study
7.	Peumans et al,2010	Ips empress inlays/onlays with or without etching.
8.	Rechenberg et al,2010	Evaluates the curing on marginal adaptation
9.	Khairallah et al, 2009	Onlays are considered in this study.
10.	Vailati F, Belser UC, 2008	Onlays are considered in this study.
11.	Lange RT, Pfeiffer P, 2009	Evopress inlays with filtek Z250 composite.
12.	Taschner et al, 2009	Onlays were considered in this study
13.	Behr et al, 2009	In vitro studies are excluded
14.	Galiatsatos AA, Bergou D, 2008	Onlays are considered in this study
15.	Frankenberger et al, 2008	Onlays are considered in this study
16.	Cobankara et al, 2008	In vitro studies are excluded.
17.	Krämer et al , 2008	Onlays are considered in this study
18.	Ohlmann et al, 2008	Inlay retained fixed partial dentures are excluded.
19.	Naeselius et al, 2008	Onlays are considered in this study
20.	Habekost et al, 2007	In vitro studies are excluded
21.	Soares et al, 2007	In vitro studies are excluded.
22.	Camacho et al, 2007	In vitro studies are excluded.
23.	Banditmahakun et al, 2006	In vitro studies are excluded
24.	Fasbinder et al, 2005	CAD/CAM generated composite and porcelain inlays.
25.	Kaytan et al, 2005	Onlay restorations are excluded.
26.	Santos MJ, Bezerra RB, 2005	In vitro studies are excluded.
27.	Krämer et al, 2006	Onlays are considered in this study
28.	Schmidlin et al, 2005	Direct restorations are excluded.
29.	Krämer N, Frankenberger R, 2005	Onlays are considered in this study
30.	Hofmann et al, 1998	In vitro studies are excluded
31.	Manhart et al, 2004	Reviews are excluded.

32.	Jung et al, 2004	Only the surface and margins were evaluated.
33.	Santos et al, 2004	Onlays are considered in this study
34.	Kükrer et al , 2004	No comparison is made with ceramic inlay.
35.	Soares et al , 2003	In vitro studies are excluded.
36.	Barghi N, Berry TG, 2002	Onlays are considered in this study.
37.	Mota et al, 2003	In vitro studies are excluded
38.	Ozturk N, Aykent F, 2003	In vitro studies are excluded
39.	Hayashi M, Yeung CA, 2003	Reviews are excluded
40.	de Freitas et al, 2002	In vitro studies are excluded.
41.	Otto T, De Nisco S, 2002	Onlays are considered in this study
42.	Monaco et al , 2001	Onlay restorations are excluded.
43.	Gemalmaz et al,2001	Only adhesive resins are included for bonding in the inclusion criteria
44.	Kuramoto et al, 2000	In vitro studies are excluded
45.	Hickel R, Manhart J, 2001	Reviews are excluded.
46.	Krämer N, Frankenberger R , 2000	Onlays are considered in this study
47.	Frankenberger et al, 2000	Onlays are considered in this study
48.	Brunton et al, 1999	In vitro studies are excluded.
49.	Krämer et al, 1999	Onlays are considered in this study
50.	Meijering et al, 1997	Veneer restorations are excluded.
51.	Long et al, 1997	Reviews are excluded.
52.	Stokholm R, Isidor F , 1996	Inlay retained fixed dental prosthesis are excluded.
53.	Isidor F, Brøndum K, 1995	Partial cuspal coverages are considered in this study
54.	Otogoto et al, 1994	In vitro studies and plaque assessment studies are excluded.
55.	Molin M, Karlsson S, 1993	In vitro studies are excluded.
56.	Haas et al, 1992	In vitro studies are excluded.
57.	Heymann et al, 1996	Cerec inlays and direct composites

Risk of bias in included studies

The assessments for the four main methodological quality items are shown in table 1. The study was assessed to have a "High risk" of bias if it did not record a "Yes" in three or more of the four main categories, "Moderate" if two out of four categories did not record a "Yes", and "Low" if randomization assessor blinding and completeness of follow – up were considered adequate (Tables 3,4).

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TABLE 3: RISK OF BIAS-MAJOR CRITERIA

Study	Randomization	Allocation Concealed	Assessor Blinding	Dropouts Described	Risk of Bias
Frankenberger et al, 2009	Yes	No	No	Yes	Moderate
Krämer et al, 2009	No	No	No	Yes	High
Fabianelli et al, 2006	No	No	No	yes	High
Sjögren et al, 2004	Yes	No	No	Yes	Moderate
Molin MK and Karlsson SL , 2000	Yes	No	No	None	Moderate
Pallesen U, van Dijken JW, 2000	Yes	No	No	None	Moderate
Thordrup et al, 1999	No	No	No	None	High
Sjögren et al,1998	Yes	No	No	None	Moderate
Sjögren et al, 1995	Yes	No	No	None	Moderate

TABLE 4: RISK OF BIAS-MINOR CRITERIA

Study	Sample Justified	Baseline comparison	I/E criteria	Method error
Frankenberger et al, 2009	No	Yes	Yes	No
Krämer et al, 2009	No	Yes	Yes	No
Fabianelli et al, 2006	No	Yes	Yes	No
Sjögren et al, 2004	No	No	No	No
Molin MK and Karlsson SL , 2000	No	Yes	Yes	No
Pallesen U, van Dijken JW, 2000	No	Yes	No	No
Thordrup et al, 1999	No	Yes	Yes	No
Sjögren et al,1998	No	No	No	No

Sjögren et al, 1995	No	Yes	No	No

Longevity of Ceramic Inlays

The data obtained from the included studies has been presented in tables 5 a, b, c, d.

TABLE 5: SUMMATION TABLES FOR INDIVIDUAL PARAMETERS

A) Longevity of Cergogold glass ceramic inlays

S. No	Author	Follow up	Total No. of restorations	Failure of restoration	Colour stability	Marginal integrity	Marginal adaptation	Surface characteristics	Secondary caries	Post-operative sensitivity
1.	Frankenberger et al 2009	4 years	98	21	1	4	3	1	Not mentioned	3
2.	Kramer et al 2009	4 years	57	4	2	17	4	2	Not mentioned	None

B) Longevity of IPS empress ceramic inlays

S. No	Author	Follow up	Total No. of restorations	Failure of restoration	Colour stability	Marginal integrity	Marginal adaptation	Surface characteristics	Secondary caries	Post-operative sensitivity
1.	Fabianelli et al 2006	3 years	33	None	None	3	4	3	None	None

C) Longevity of CAD/CAM Ceramic inlays

S. No	Author	Follow up	Total No. of restorations	Failure of restoration	Colour stability	Marginal integrity	Marginal adaptation	Surface characteristics	Secondary caries	Post-operative sensitivity
1.	Sjogren et al 2004	10 years	61	7	None	1	15	None	None	1
2.	Pallesen et al 2000	8 years	32	3	None	Not mentioned	None	None	None	1 restoration at 8months

3.	Thordrup et al 1999	3 years	30	3 (Celay)	10 (CEREC) 7 (Celay)	None	None	9	None	2 (CEREC) 2 (Celay)
4.	Sjogren et al 1998	5 years	66	3	9	25	12	2	1	None
5.	Sjogren et al 1995	5 years	66	1	5	7	10	None	None	None

D) Longevity of ceramic inlays with other indirect restorations

S. No	Author	Follow up	Total No. of restorations	Failure of restoration	Colour stability	Marginal integrity	Marginal adaptation	Surface characteristics	Secondary caries	Post-operative sensitivity
1.	Molin et al 2000	5 years	80	2 – gold inlays 1 – Mirage inlays 4 – IPS Empress inlays 2 – CEREC inlays	10-Mirage 8-CEREC 6-Empress	4-gold inlays 1-Mirage 14-CEREC	Not mentioned	6-gold inlay was rough	Absent	One gold inlay-2 months

V. DISCUSSION

This systematic review analyses the clinical performance of ceramic inlays and the influence of adhesive resins on the same. The analyses showed that the failure rate of all ceramic inlays ranges from 20% (IPS Empress inlays for 5 years) to 9.8% (CEREC inlays for 10 years). Adhesive resins do not play a role in longevity of Leucite reinforced and Glass ceramic inlays, but it does appear to increase the longevity of CAD/CAM (CEREC) inlays.

Longevity Of CEROGOLD Inlays

Two studies have compared the clinical performance of cergogold inlays bonded with two different adhesives. In both the trials a total of 155 inlay restorations were evaluated for a period of four years. Cergogold glass ceramic inlays had a failure rate of 16.1% for four years[4,6]. Both the studies compared Definite Multibond/Definite and Syntac/Variolink ultra. The differences in failure of ceramic inlays were due to the operator influence [4]. There were minimal differences between both the bonding adhesives in the clinical performance of cergogold inlays with Definite luted inlays having better clinical performance than Variolink adhesive bonded cergogold inlays[6].

Longevity Of IPS EMPRESS Inlays

Two different adhesive systems for luting of IPS Empress Ceramic inlays included Excite DSC dual curing adhesives and Multilink resin cement. In this study there were no failures in the inlay restorations but degradation in the marginal adaptation was reported. Both groups reported excellent aesthetic results[7].

Longevity Of CAD/CAM (CEREC) Inlays

Five studies were performed on CEREC inlays. Three trials were by the same author, published at different year intervals. The patients' received one dual- cured resin (vita cerec Duo

cement) and one chemically cured resin (Cavex clearfil F2) to lute the inlays. The marginal integrity was reported to be 85% in dual-cured luting adhesive and 88% in chemically cured adhesive[8]. Evaluation at 5 years reported that 89% of the inlay restorations were satisfactory and all the restorations that had to be replaced were luted with dual-cure adhesive resin[9]. At the ten year recall only 61 restorations were available for evaluation. The performances of the cerec inlays at the end of 10years were influenced by the adhesive resin used for bonding the inlays. Patient satisfaction was acceptable for chemically cured resin adhesive[5]. The comparison between CEREC and CELAY inlay gives a difference in the placement of the restorations. CEREC inlays are made for direct use whereas CELAY inlays are available for both direct and indirect technique[10]. CAD/CAM (CEREC) inlays that were processed by two industrially made machinable ceramics (sintered and glass ceramics) had a failure rate of 9.4% and the reason for failure being fracture of the CEREC inlays[11]. In the two trials concerning only CEREC inlays a total of 98 inlay restorations were placed in which three restorations failed at 8 years in one of the trials and seven restorations at 10 years[9'11]. Another trial comparing Celay inlays showed failure of three Celay restorations at 3 years. The failure rate of CEREC inlays at 10 years is 9.8% whereas for Celay inlays for 3 years it is 11%[10].

Longevity Of Ceramic Inlay In Comparison With Other Indirect Restorations

The longevity of 3 different ceramic inlay systems was compared with gold inlays. 92% of the 60 ceramic inlays and 100% of the 20 gold inlays were rated satisfactory 5years after luting. The gold inlays have a failure rate of 10% for 5 years when compared to Mirage inlays having 5%, IPS Empress Inlays having 20% and CEREC inlays having 10% of failure rate[12].

The trials included in this review have an evaluation period ranging from 3years to 10 years. The study including gold inlays has good interexaminer agreement, which minimizes the risk for evaluation bias. The studies pertaining to CEREC inlays have been long-term. This substantiates that CEREC inlays have acceptable performance and durability when luted with chemically-cured adhesive resin.

Influence Of Adhesive Resins On The Longevity Of Ceramic Inlays

Two studies have compared the clinical performance of cergogold inlays bonded with two different adhesives. Both the studies compared Definite Multibond/Definite and Syntac/Variolink ultra. There were minimal differences between both the bonding adhesives in the clinical performance of cergogold inlays with Definite luted inlays having better clinical performance than Variolink adhesive bonded cergogold inlays[6].

Two different adhesive systems for luting of IPS Empress Ceramic inlays included Excite DSC dual curing adhesives and Multilink resin cement. In this study there were no failures in the inlay restorations but degradation in the marginal adaptation was reported. Both groups reported excellent aesthetic results[7].

Report on Quality of Evidence Looked Upon

Articles referenced in this review are all randomized clinical trials and clinical trials. six trials were randomized clinical trials (Frankenberger et al 2009, Sjogren et al 1995, 1998, 2004, Molin et al 2000 and Pallesen et al 2000) which have a level of evidence 2 and moderate risk of bias and 3 trials were clinical trials (Kramer et al 2009, Fabianelli et al 2006 and Thordrup et al 1999) having a level of evidence of 3 and high risk of bias.

Report of Outlier Data

No outlier data obtained.

VI. CONCLUSION

With the available evidence this review concludes that the CAD/CAM (CEREC) inlays have better clinical

Performance when compared to other inlays but the durability of CEREC inlays is similar to gold inlays.

Adhesive resins did not elicit any difference in the clinical performance of Leucite reinforced and Glass

Ceramic inlays but increased the longevity of CAD/CAM (CEREC) inlays. Further studies must be performed

to give concrete evidence on the clinical performance of ceramic inlays with other indirectly placed restorations.

The clinical evidence in this review is inadequate to state that there is difference between

the clinical performances of ceramic inlay systems compared with other indirect

Restorations. Hence more long term good quality clinical trials comparing ceramic inlays

With other indirect restorations in the same respect will act as a valuable supplement to
the investigation of clinical performances of ceramic inlay systems.

REFERENCES

[1]. D.B.Mahler. The high copper dental amalgam alloys. J Dent Res, 1997; vol. 76: no. 1: 537-541.
[2]. Lange RT, Pfeiffer P. Clinical evaluation of ceramic inlays compared to composite restorations. Oper Dent. 2009; 34(3):263-72.
[3]. Krämer N, Ebert J, Petschelt A, Frankenberger R. Ceramic inlays bonded with two adhesives after 4 years. Dent Mater. 2006; 22(1):13-21.
[4]. Frankenberger R, Reinelt C, Petschelt A, Krämer N.Operator vs. material influence on clinical outcome of bonded ceramic inlays. Dent Mater. 2009; 25(8):960-8.
[5]. Sjögren G, Molin M, van Dijken JW. A 5-year clinical evaluation of ceramic inlays (Cerec) cemented with a dual-cured or chemically cured resin composite luting agent. Acta Odontol Scand. 1998; 56(5):263-7.
[6]. Norbert Kramer, Christian Reinelt, Gert Richter, Roland Frankenberger. Four – year clinical performance and marginal analysis of pressed glass ceramic inlays luted with ormocer restorative Vs. Conventional luting composite. J dent, 37, 2009, 813-819.
[7]. Fabianelli A, Goracci C, Bertelli E, Davidson CL, Ferrari M. A clinical trial of Empress II porcelain inlays luted to vital teeth with a dual-curing adhesive system and a self-curing resin cement. J Adhes Dent. 2006 ;8(6):427-31
[8]. Sjögren G, Molin M, van Dijken J, Bergman M. Ceramic inlays (Cerec) cemented with either a dual-cured or a chemically cured composite resin luting agent. A 2-year clinical study. Acta Odontol Scand. 1995 Oct; 53(5):325-30.
[9]. Sjögren G, Molin M, van Dijken JW. A 10-year prospective evaluation of CAD/CAM-manufactured (Cerec) ceramic inlays cemented with a chemically cured or dual-cured resin composite. Int J Prosthodont. 2004;17(2):241-6
[10]. Marianne Thordrup, Flemming Isidor, Preben Horsted-Bindslev. A3-year study of inlays milled from machinable ceramic blocks representing 2 different inlay syatems. Quintessence Int, 1999; 30: 829 – 836.
[11]. Pallesen U, van Dijken JW. An 8-year evaluation of sintered ceramic and glass ceramic inlays processed by the Cerec CAD/CAM system. Eur J Oral Sci. 2000; 108(3):239-46.
[12]. Molin MK, Karlsson SL. A randomized 5-year clinical evaluation of 3 ceramic inlay systems. Int J Prosthodont. 2000; 13(3):194-200.
[13]. Atali PY, Cakmakcioglu O, Topbasi B, Turkmen C, Suslen O. IPS Empress onlays luted with two dual-cured resin cements for endodontically treated teeth: a 3-year clinical evaluation. Int J of Prosthodont, 2011; 24 (1):40 - 42.
[14]. Banditmahakun S, Kuphausuk W, Kanchanavasita W, Kuphasuk C.The effect of base materials with different elastic moduli on the fracture loads of machinable ceramic inlays. Oper Dent. 2006; 31(2):180-7.
[15]. Barghi N, Berry TG.Clinical evaluation of etched porcelain onlays: a 4-year report. Compend Contin Educ Dent. 2002; 23(7):657-60.
[16]. Behr M, Hansmann M, Rosentritt M, Handel G.Marginal adaptation of three self-adhesive resin cements vs. a well-tried adhesive luting agent. Clin Oral Investig. 2009; 13(4):459-64.
[17]. Brunton PA, Cattell P, Burke FJ, Wilson NH.Fracture resistance of teeth restored with onlays of three contemporary tooth-colored resin-bonded restorative materials. J Prosthet Dent. 1999; 82(2):167-71.
[18]. Camacho GB, Gonçalves M, Nonaka T, Osório AB.Fracture strength of restored premolars. Am J Dent. 2007; 20(2):121-4.
[19]. Cobankara FK, Unlu N, Cetin AR, Ozkan HB.The effect of different restoration techniques on the fracture resistance of endodontically-treated molars. Oper Dent. 2008; 33(5):526-33.
[20]. Coelho Santos MJ, Mondelli RF, Lauris JR, Navarro MF.Clinical evaluation of ceramic inlays and onlays fabricated with two systems: two-year clinical follow up. Oper Dent. 2004; 29(2):123-30.
[21]. de Freitas CR, Miranda MI, de Andrade MF, Flores VH, Vaz LG, Guimarães C.Resistance to maxillary premolar fractures after restoration of class II preparations with resin composite or ceromer. Quintessence Int. 2002; 33(8):589-94.

[22]. Dukic W, Dukic OL, Milardovic S, Delija B. Clinical evaluation of indirect composite restorations at baseline and 36 months after placement. Oper Dent. 2010; 35 (2):156-64.
[23]. Fabianelli A, Goracci C, Bertelli E, Davidson CL, Ferrari M.A clinical trial of Empress II porcelain inlays luted to vital teeth with a dual-curing adhesive system and a self-curing resin cement. J Adhes Dent. 2006; 8(6):427-31.
[24]. Fasbinder DJ, Dennison JB, Heys DR, Lampe K.The clinical performance of CAD/CAM-generated composite inlays. J Am Dent Assoc. 2005; 136(12):1714-23.
[25]. Frankenberger R, Petschelt A, Krämer N.Leucite-reinforced glass ceramic inlays and onlays after six years: clinical behavior. Oper Dent. 2000 ; 25(6):459-65.
[26]. Frankenberger R, Taschner M, Garcia-Godoy F, Petschelt A, Krämer N.Leucite-reinforced glass ceramic inlays and onlays after 12 years. J Adhes Dent. 2008; 10(5):393-8.
[27]. Galiatsatos AA, Bergou D.Six-year clinical evaluation of ceramic inlays and onlays. Quintessence Int. 2008; 39(5):407-12.
[28]. Gemalmaz D, Ozcan M, Alkumru HN.A clinical evaluation of ceramic inlays bonded with different luting agents. J Adhes Dent. 2001; 3(3):273-83.
[29]. Haas M, Arnetzl G, Wegscheider WA, König K, Bratschko RO. Clinical results and material behavior of composite, ceramic and gold inlays.Dtsch Zahnarztl Z. 1992; 47(1):18-22. German.
[30]. Habekost Lde V, Camacho GB, Demarco FF, Powers JM. Tensile bond strength and flexural modulus of resin cements--influence on the fracture resistance of teeth restored with ceramic inlays. Oper Dent. 2007; 32(5):488-95.
[31]. Harder S, Wolfart S, Eschbach S, Kern M. Eight-year outcome of posterior inlay-retained all-ceramic fixed dental prostheses. J Dent. 2010 Nov; 38 (11):875-81.
[32]. Hayashi M, Yeung CA. Ceramic inlays for restoring posterior teeth. Cochrane Database Syst Rev. 2003 ;(1)
[33]. Hickel R, Manhart J. Longevity of restorations in posterior teeth and reasons for failure. J Adhes Dent. 2001; 3(1):45-64.
[34]. Hofmann N, Just N, Haller B, Hugo B, Klaiber B. The effect of glass ionomer cement or composite resin bases on restoration of cuspal stiffness of endodontically treated premolars in vitro. Clin Oral Investig. 1998; 2(2):77-83.
[35]. Isidor F, Brøndum K. A clinical evaluation of porcelain inlays. J Prosthet Dent. 1995; 74(2):140-4.
[36]. Jung M, Wehlen O, Klimek J. Finishing and polishing of indirect composite and ceramic inlays in-vivo: occlusal surfaces. Oper Dent. 2004; 29(2):131-41.
[37]. Kaytan B, Onal B, Pamir T, Tezel H. Clinical evaluation of indirect resin composite and ceramic onlays over a 24-month period. Gen Dent. 2005; 53(5):329-34.
[38]. Khairallah C, Hokayem A. Long-term clinical evaluation of 2 dental materials used for the preparation of esthetic inlays. Odontostomatol Trop. 2009; 32 (127):5-13. French.
[39]. Khairallah C, Sabbagh J, Hokayem A. Clinical study comparing at 5 years a ceramic and a ceromer used for making esthetic inlays. Odontostomatol Trop. 2009; 32(126):21-8. French.
[40]. Krämer N, Frankenberger R, Pelka M, Petschelt A. IPS Empress inlays and onlays after four years--a clinical study. J Dent. 1999; 27(5):325-31.
[41]. Krämer N, Frankenberger R. Clinical performance of bonded leucite-reinforced glass ceramic inlays and onlays after eight years. Dent Mater. 2005; 21(3):262-71.
[42]. Krämer N, Frankenberger R. Leucite-reinforced glass ceramic inlays after six years: wear of luting composites. Oper Dent. 2000; 25(6):466-72.
[43]. Krämer N, Taschner M, Lohbauer U, Petschelt A, Frankenberger R. Totally bonded ceramic inlays and onlays after eight years. J Adhes Dent. 2008; 10(4):307-14.
[44]. Kükrer D, Gemalmaz D, Kuybulu EO, Bozkurt FO. A prospective clinical study of ceromer inlays: results up to 53 months. Int J Prosthodont. 2004; 17(1):17-23.
[45]. Kuramoto M Jr, Matos AB, Matson E, Eduardo CP, Powers JM. Microleakage of resin-based composite restorations with ceramic inserts. Am J Dent. 2000; 13(6):311-4.
[46]. Lohbauer U, Pelka M, Belli R, Schmitt J, Mocker E, Jandt KD, Müller FA. Degree of conversion of luting resins around ceramic inlays in natural deep cavities: a micro-Raman spectroscopy analysis. Oper Dent, 2010; 35 (5): 579 - 86.

[47]. Manhart J, Chen H, Hamm G, Hickel R. Buonocore Memorial Lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. Oper Dent. 2004; 29(5):481-508. Review.
[48]. Meijering AC, Roeters FJ, Mulder J, Creugers NH. Patients' Satisfaction with Different Types of Veneer Restorations. J Dent. 1997; 25(6):493-7.
[49]. Molin M, Karlsson S. The fit of gold inlays and three ceramic inlay systems. A clinical and in vitro study. Acta Odontol Scand. 1993; 51(4):201-6.
[50]. Monaco C, Baldissara P, dall'Orologio GD, Scotti R. Short-term clinical evaluation of inlay and onlay restorations made with a ceromer. Int J Prosthodont. 2001; 14(1):81-6.
[51]. Mota CS, Demarco FF, Camacho GB, Powers JM. Microleakage in ceramic inlays luted with different resin cements. J Adhes Dent. 2003; 5(1):63-70.
[52]. Naeselius K, Arnelund CF, Molin MK. Clinical evaluation of all-ceramic onlays: a 4-year retrospective study. Int J Prosthodont. 2008; 21(1):40-4.
[53]. Ohlmann B, Rammelsberg P, Schmitter M, Schwarz S, Gabbert O. All-ceramic inlay-retained fixed partial dentures: preliminary results from a clinical study. J Dent. 2008; 36(9):692-6.
[54]. Otogoto J, Ebashi S, Tanaka K, Fujikawa K, Ito K, Murai S. Subgingival plaque formation on single and polycrystal aluminum ceramics. J Nihon Univ Sch Dent. 1994; 36(3):209-15.
[55]. Otto T, De Nisco S. Computer-aided direct ceramic restorations: a 10-year prospective clinical study of Cerec CAD/CAM inlays and onlays. Int J Prosthodont. 2002; 15(2):122-8.
[56]. Ozturk N, Aykent F. Dentin bond strengths of two ceramic inlay systems after cementation with three different techniques and one bonding system. J Prosthet Dent. 2003; 89(3):275-81.
[57]. Peumans M, De Munck J, Van Landuyt K, Poitevin A, Lambrechts P, Van Meerbeek B. Two-year clinical evaluation of a self-adhesive luting agent for ceramic inlays. J Adhes Dent. 2010; 12(2):151-61.
[58]. Rechenberg DK, Göhring TN, Attin T. Influence of different curing approaches on marginal adaptation of ceramic inlays. J Adhes Dent. 2010; 12 (3):189-96.
[59]. Roland Frankenberger, Christian Reinelt, Anselm Petschelt, Norbert Kramer. Operator Vs material influence on clinical outcome of bonded ceramic inlays. Dent Mater, 25, 2009, 960 – 968.
[60]. Santos MJ, Bezerra RB. Fracture resistance of maxillary premolars restored with direct and indirect adhesive techniques. J Can Dent Assoc. 2005; 71(8):585.
[61]. Schmidlin PR, Zehnder M, Schlup-Mityko C, Göhring TN. Interface evaluation after manual and ultrasonic insertion of standardized class I inlays using composite resin materials of different viscosity. Acta Odontol Scand. 2005; 63(4):205-12.
[62]. Soares CJ, Martins LR, Fernandes Neto AJ, Giannini M. Marginal adaptation of indirect composites and ceramic inlay systems. Oper Dent. 2003; 28(6):689-94.
[63]. Soares CJ, Santana FR, Fonseca RB, Martins LR, Neto FH. In vitro analysis of the radiodensity of indirect composites and ceramic inlay systems and its influence on the detection of cement overhangs. Clin Oral Investig. 2007; 11(4):331-6.
[64]. Stokholm R, Isidor F. Resin-bonded inlay retainer prostheses for posterior teeth. A 5-year clinical study. Int J Prosthodont. 1996; 9(2):161-6.
[65]. Taschner M, Frankenberger R, García-Godoy F, Rosenbusch S, Petschelt A, Krämer N. IPS Empress inlays luted with a self-adhesive resin cement after 1 year. Am J Dent. 2009; 22(1):55-9.
[66]. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 3.Eur J Esthet Dent. 2008; 3(3):236-57.
[67]. Van Dijken JW, Hasselrot L. A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages. Dent Mater, 2010; 26 (9): 929 - 39.