Eur. J. Prosthodont. Rest. Dent., Vol.22, No. 3, pp 117-124
Printed in Great Britain

doi:10.1922/EJPRD_1345Grivas08

Composite inlays: a systematic review

E. Grivas* , R.V. Roudsari† and J.D. Satterthwaite‡

Abstract - *The purpose of this study is to review the available literature related to composite inlays. Electronic databases published up to November 2013 were searched. Studies that evaluate composite resin inlays for the restoration of posterior teeth were selected. The studies should compare composite inlays against gold inlays, ceramic inlays and direct composite fillings regarding longevity, aesthetic quality and postoperative sensitivity or comparing the clinical effectiveness of them on premolars versus molars or on 1-2 surface preparations versus multi-surface preparations. Despite the heterogeneity of the available clinical trials composite inlays seem to be an effective method for the restoration of posterior teeth*

KEYWORDS: Composite inlays, systematic review, clinical effectiveness

INTRODUCTION

For many decades gold and amalgam were the only available materials for the restoration of carious teeth but the demand for more aesthetic options led to the use of porcelain and composite resins in dentistry. Nowadays the restoration of severely damaged teeth can be a real challenge for dentists who want to follow the rules of the contemporary conservative dentistry and preserve as much tooth structure as possible. The provision of inlays and onlays are a unique ally in this effort.

Gold and porcelain have been the first materials to be used for the construction of inlays(1) but with improving properties, composite resins seem to be a promising substitute for the traditional materials. The continuous evolution of composite resins since 1963(2) have led to modern materials that have high strength, good aesthetics and optimal fit that can be used for the construction of posterior restorations.(3, 4)

Resin composites come in different compositions, filler shapes, and matrix specifications. Laboratory composite resins are very similar to direct composite resins in terms of composition but the extraoral curing by heat ,pressure or light seems to improve their physical and mechanical properties (5, 6).

Some of the major advantages of composite inlays against ceramic and gold inlays are:

Advantages

- Aesthetic appearance, especially if this is combined with various shades and multiple translucencies (Layering technique) can be equal or superior to porcelain.
- Repairable, easy to maintain and refurbish (Can be modified by adding new material to old).
- Low cost compared to porcelain and gold alloys.
- Bonding to dental tissue compared to gold.
- Minimal wear to occluding enamel compared to porcelain.
- Can be constructed either in the lab or chairside (indirect, semi-direct technique or even direct and recurred extraorally).
- Easily polishable outside or inside mouth.
- Similar mechanical properties to dentine compared to ceramic (7).
- Ability to absorb forces make them an ideal restoration for cracked teeth (8).

Disadvantages

- Inferior longevity compared to ceramics and amalgams.
- Lower strength especially when used in limited space restorations compared to gold.
- Colour is changing during time.
- Possible release of toxic substances (9).
- Microleakage
- Secondary caries

Additionally the major advantages and disadvantages of indirect composite inlays versus direct composite restorations are:

Advantages

- Lower polymerization shrinkage due to more in-depth curing.
- Superior wear resistance and strength due to additional heat or light curing.
- Potential for better surface characteristics, details, polishability and subsequently better aesthetics.
- Better occlusal anatomy can be achieved.
- Improved proximal contacts

* DDS, MSc
† DDS, MSc, PGDip, MFDS RCPS
‡ BDS, MSc, PhD, PGDip, MFDS, FDSRCS, FDS (Rest Dent), FHEA, FADM

Disadvantages

- More time and skill demanding.
- More destructive to tooth tissue as a preparation prior to impression needed.
- Lab or extra instruments in practice needed.
- Temporary restoration needed.
- Extra cost
- Extra appointments and more clinical steps.
- More technique-sensitive due to sensitive luting procedure.

Some of the limitations of the composite inlays are:

a) Minor cavities

b) If lab cost must be avoided and necessary equipment for their fabrication is not available in the practice

c) Dentist does not have the knowledge and the special skills needed

d) Minor residual dental tissue

e) If tooth has to serve as an abutment

f) Lack of enamel circumferentially (if resin cements will be used), although modern resin cements can partially overcome this problem.

g) Bruxists or other parafunctional patients. However, clinical studies on recently introduced composite materials (Ceromers) have been shown great results when used in bruxists (10).

The aim of this study is to evaluate the clinical effectiveness of indirect composite inlays using a systematic review of the available literature.

The specific objectives of the study are to compare the indirect composite inlays to direct composite restorations as well as to ceramic and gold inlays regarding the clinical parameters of longevity, aesthetic quality and postoperative sensitivity. Furthermore a comparison of their clinical effectiveness regarding tooth type and cavity size is planned. Up to now three systematic reviews (11-13) have produced some valuable data on the use of ceramic inlays but there is no paper to provide similar information on the use of indirect composite inlay.

DATA SOURCES

The Cochrane collaboration guidelines for the conduction of systematic reviews were followed. Criteria for the inclusion of studies were:

Types of studies:

Randomized Control Trials (RCT) and Controlled Clinical Trials (CCT) that evaluate composite resin inlays and onlays for the restoration of posterior teeth were included. All the studies were then subject to quality assessment.

Study design:

Split-mouth design and parallel design studies were included.

Samples:

Adults with permanent vital teeth that have been treated in universities, dental hospitals or private practices have been included.

Types of interventions:

Studies comparing composite inlays and onlays with ceramic and gold inlays as well as with direct composite restorations. No restriction was made for the way the indirect restorations were made.

Types of outcome measures:

Longevity, colour match and postoperative sensitivity.

Follow-up period:

minimum 12 months

The following exclusion criteria were in force:

Non- English

In-vitro studies

If the study did not have a separate part devoted to composite inlays or if composite inlays were not compared to gold and ceramic.

Direct inlays without any part of the procedure being done extra-orally.

Inlays being used as retainers for bridges or removable dentures.

Search method for identification of studies:

The following databases were searched:

Ovid Medline (1946 to November 2013)

Cochrane Central Register of Controlled trials

Embase (1980 to November 2013)

Reference lists of the identified articles and available similar systematic reviews were also screened to find relevant articles. Important prosthodontic journals were hand-searched focusing on the last 6 months to ensure that no related article has been published and not included yet in the above databases:

Journal of dentistry

International Journal of Prosthodontics

Journal of Operative dentistry

Journal of Prosthetic dentistry

Quintessence international journal

Journal of Adhesive dentistry

Journal of Dental sciences and

European Journal of Prosthodontics and Restorative dentistry

Data extraction

The data were extracted by the first and the second author. Out of the 305 articles of the initial sample, 291 were excluded and 14 were included. An overview of the studies screened, assessed and included can be seen in Figure 1.

Table 1. *Study's quality assessment form-Questions to be answered*

1	Are the hypotheses/aims/objectives clearly described?
2	Is the setting of the study or the source of the subjects studied described?
3	Is the distribution of the study population by age or sex described?
4	Are the inclusion criteria stated?
5	Are the exclusion criteria stated?
6	Are the treatments (sequence and steps) well described?
7	Are the main outcomes to be measured clearly described in the "Introduction or "Methods" section?
8	Is the sample size stated?
9	Was the sample size justified?
10	Was the concurrent control group used?
11	Was random allocation to treatment used?
12	Was the method of random allocation given?
13	Was blind assessment of the outcome carried out?
14	Was there more than one examiner for outcome assessment?
15	Was examiner calibration carried out?
16	Are the statistical methods described?
17	Is the participation /follow-up rate stated?
18	Was the participation /follow-up rate greater than 80%?
19	Are the non participants /subjects lost to follow-up described?
20	Are the main findings of the study clearly described?
21	Are results stated in absolute numbers instead of percentages when feasible?
22	Are confidence intervals given?
23	Are any important adverse events reported?
24	Are any conclusions stated?

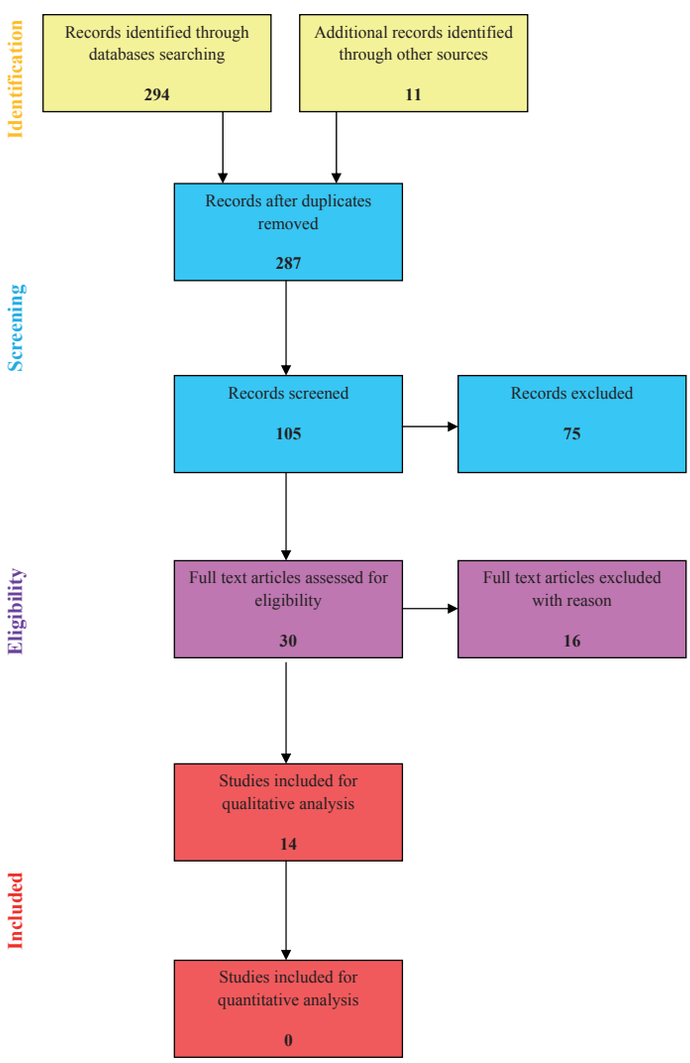

Figure 1. *Flow diagram of study identification*

To decide over the quality of the 14 included clinical studies, a systematic quality assessment list was used that has been used in previous systematic reviews of ceramic inlays (11, 12) (Table 1). This list consists of 24 questions to evaluate the scientific power of these studies and provides the author with a tool that can distinguish the well conducted studies from those that are poorly organized.

The full texts were used for the purpose of quality assessment (Table 2). In order to calibrate the ability of the assessor, four random studies were selected; two from each of the previous systematic reviews(11, 12), and the results were compared with those included in the original quality assessment forms.

The following information as extracted from the selected papers: study design, potential biases, number of participants and restorations, age and gender of participants, inclusion and exclusion criteria, setting, interventions, outcomes, follow up period, recall rate and methods of statistical analysis. Finally, data related to failure rates, postoperative sensitivity and aesthetic quality were extracted. The protocol previously used by Hayashi was followed(12) and failure was defined as when replacement of the restoration was indicated, endodontic problems occurred or the restorations were clinically unacceptable according to USPHS criteria(14) (Charlie and Delta scores). Postoperative sensitivity was regarded as sensitivity to temperature or to occlusal load up to one month after the placement. Finally, aesthetic quality was regarded as the absence of colour match or marginal discolouration according to the clinical criteria of USPHS(14) (Charlie and Delta scores). Data on the comparison of the clinical effectiveness (related to the previously mentioned characteristics) between premolars-molars and small-large cavities were also extracted. Table 3 summarizes the extracted information.

Table 2. *Study quality assessment form*

Study type	*Study*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
RCT	Manhart *et al.* 2001	+		+			+	+	+					+	+		+	+		+	+				+
RCT	Thordrup *et al*	+		+	+	+	+	+	+		+	+				+	+	+	+	+	+	+			+
RCT	Huth *et al.*	+	+	+	+	+	+	+	+		+	+			+	+	+	+		+	+	+			+
RCT	Pallesen and Qvist	+		+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+			+
RCT	Fasbinder *et al.*	+			+	+	+	+	+		+	+	+		+	+	+	+	+	+					
RCT	Spreafico *et al.*	+	+	+	+	+	+	+	+		+	+			+		+	+	+				+		
RCT	Wassell *et al.*	+		+	+	+	+	+	+		+	+	+	+			+	+							
RCT	Gladys *et al.*	+		+	+		+	+	+		+	+			+	+	+	+		+					
CCT	Mendonca *et al.*	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+						
CCT	Manhart et.al 2000	+		+	+		+	+	+		+			+	+	+	+	+							
CCT	Kaytan *et al.*	+		+	+		+	+	+		+				+	+	+	+	+						
CCT	Donly *et al.*	+		+	+		+	+	+		+					+	+	+	+			+			
CCT	Dijken	+		+	+		+	+	+		+					+	+	+	+			+			
CCT	Cetin and Unlu	+		+	+		+	+	+		+					+	+	+	+						

STUDY SELECTION

Summary of the evidence

A systematic review ideally evaluates data extracted from well conducted RCTs and consequently synthesizes the collected information. A comprehensive approach should include a meta-analysis and a thorough assessment of the bias. In the present review only 9 RCTs (15-19, 20 #418, 21-23) were identified whereas one of them(19) could not answer any of the questions. The low quality of the available evidence and the small number of randomized trials as well as the variety of the methodology and the heterogeneity of the trials prevent us from conducting a meta-analysis which could confidently give answers regarding the longevity of the composite inlays. For the above reasons the present study is limited to a qualitative analysis. Finally, authors of the RCT papers modified the acceptable USPHS clinical criteria according to their needs, making the extraction of the data challenging.

Composite inlays versus ceramic and gold

Regarding the longevity of composite inlays versus other materials, six articles have given some evidence. Five of them were comparing composite against ceramic(15, 16, 20, 23, 24) and only one was comparing composite against gold(25). The survival rate of composite inlays ranged from 100% after 3 years to 51% after 10 years. Fasbinder (26) in his study used CAD-CAM technology to construct 40 porcelain

Table 3. *Characteristics of included studies*

Study	*Participants*	*Restorations*	*Method*	*Interventions*
Huth, 2011 (17)	89	155	RCT , parallel design,4 years duration	1)75 Artglass composite inlays 2)80 Charisma composite inlays
Fasbinder, 2013 (20)	43	80	RCT , parallel design,10 years duration	1)40 resin-based composite inlays(Paradigm) 2)40 Porcelain inlays (Vita markII)
Wassell, 2000 (21)	73	100 pairs	RCT, split mouth design, 5 years duration	100 pairs of inlays and conventional restorations made from Brilliant Dentin
Thordrup, 2006 (16)	37	58	RCT, split mouth and parallel design, 10 years duration	1)15 direct ceramic inlays(Cerec)2)14 indirect ceramic inlays(Vita durN) 3)15 direct composite inlays(Brilliant)4)14 indirect composite inlays(Estilux)
Spreafico, 2005 (22)	11	44	RCT, split mouth design, 3.5years duration	1)22 direct restorations 2)22 semi-direct restorations (both made with fine-hybrid composite A.PH)
Pallessen, 2003 (18)	28	140	RCT, split mouth design, 11 years duration	1)Composite filling in Brilliant Dentin 2)Composite filling in Estilux 3)Indirect inlay in Brilliant Dentin4) Indirect inlay in Estilux 5)Indirect inlay in SR-Isosit
Gladys, 1995 (23)	20	32	RCT, parallel design,3years duration	1)8 ceramic inlays Cerec-Dicor MGC 2) 8 ceramic inlays Cerec-Vita Mark I cemented with Pontic C 3) 8 ceramic inlays Cerec-Vita Mark II cemented with Duo cement 4)8 composite inlays P-50
Manhart, 2001 (15)	45	71	RCT, parallel design,3years duration	1)47 Composite inlays a.Tetric b.blend-a-lux c.Pertac-hybrid unifil 2)24 Ceramic inlays-IPS empress
Van Dijken, 2000 (31)	40	134	CCT, parallel design, 11 years duration	1)100 direct composite inlays(Brilliant) 2)34 direct composite restorations(Fulfil)
Donly, 1999 (25)	18	54	CCT, split mouth design,7 years duration	1)18 composite inlays made from Concept, cemented with Heliobond 2) 18 composite inlays made from Concept, cemented with Special Bond 3)18 Gold inlays
Manhart, 2000 (30)	45	88	CCT, parallel design,3 years duration	1)43 direct composite restorations 2)45 indirect composite inlays (Tetric, blend-a-lux,Pertac-hybrid Unifil)
Memdonca, 2010 (28)	30	76	CCT, parallel design,1 year duration	1)44 direct composite fillings(Tetric Ceram-TC) 2)32 indirect composite inlays (Targis TG)
Cetin, 2009 (29)	54	100	CCT, split mouth design,1 year duration	1)20 fillings with Filtec Supreme composite 2)20 fillings with TetricEvo composite 3)20 fillings with Aelite composite 4)20 inlays with Estenia composite 5)20 inlays with Tescera composite
Kaytan, 2005 (24)	47	94	CCT, split mouth design,2 years duration	1)Ceramic onlays (Empress) 2)Indirect composite onlays (Soll-dex)

and 40 composite inlays and observed their features for a three years period. He states that 1 ceramic and 2 composite inlays needed replacement; however he kept some of the fractured inlays in situ as they were asymptomatic and replaced two fractured composite inlays with ceramic. Thus his estimation on survival rates of inlays is unclear. Likewise Thordrup (16) used Cerec fabricated and indirect ceramic inlays in comparison with direct and indirect composite inlays for a ten year period. He provides the reader with two versions of survival rates, with and without repairs. Although the survival rates without repairs are 80% and 61.9% for Cerec and Vita dur inlays respectively while is 50.8% and 66.7% for Estilux and Brilliant DI composite inlays, author supports that there is no statistically significant difference between the inlays for both versions. Apart from that, some of the repairs and the evaluations have been made by patients' own dentist, making his conclusions biased. Gladys (23) similarly constructed with Cerec three different types of ceramic inlays and a composite inlay as control for three years observation time. Although he used a different index

system (27), he found all the evaluated inlays clinically acceptable at the 3-year recall, however the composite that they used as a control was experimental at that time and not in use any more. Manhart on the other hand(15) studied the performance of three different composite inlays in comparison with one ceramic for three years and found insignificant difference between them. However he used ceramic for large cavities and composite for small cavities which is considered as a selection bias. Finally, insignificant difference was observed by Kaytan in his non-randomized control trial between composite and ceramic onlays in a split mouth study after a short two years period of observance (24). A later recall could give us more usable results. In the only available trial comparing composite and gold (25) for the construction of inlays the survival rates were 75% and 83% after seven years respectively, which indicates an insignificant difference between the two materials although the recall rate is only 45 %.

Although they all agreed that composite inlays can perform as well as ceramic inlays, unfortunately none of them can be used in the present review to form a clear answer to whether any difference exist between the longevity of composite resins compared to ceramic inlays. The comparison of composite and gold is an interesting idea as gold is classically regarded as the ideal material for the restoration of teeth. The authors of the paper did not find any significant differences between the two materials regarding longevity(25) however no randomization has occurred and with a recall rate of only 45%, no conclusion could be drawn.

The aesthetic quality was assessed subjectively. Criteria were chosen to assess two characteristics, colour match and marginal discolouration, aiming to get an inclusive and more unbiased "picture" of the aesthetics. Three studies were regarded as appropriate to be used for this particular aspect with conflicting results for the colour match : one showing better results for composite inlays(20), one had better results for ceramic inlays(24) and one identified no difference between the two(15). It was not surprising to see conflicting results between different authors. The reasons for this divergence were the subjectivity of the issue as well as the variability of the techniques that were used for the fabrication of the inlays. When looking at the marginal discolouration only, there is an agreement between all the authors: there is insignificant difference between the two materials.

Only two studies could be used for the assessment of the post operative sensitivity(15, 20)and they both reported no postoperative sensitivity for the composite resins and ceramics at the one month recall. Consequently the conclusion of insignificant difference between them can be accepted. There has been diversity in the time of the recall chosen by various authors which made extraction of the data for the present study very challenging.

Composite inlays versus direct composite fillings

Regarding longevity, out of seven trials that were available for comparison between composite inlays and direct composite fillings, two of them(28, 29) followed the patients up for only a period of 12 months which is not long enough to have any meaningful results. In the rest of the available studies(18, 21, 22, 30, 31) the follow-up time varied from 3.5 to 11 years and the survival rates varied from 100% after 3.5 years to 87.3% in 11 years. In the first RCT Wassell placed 100 pairs of composite fillings and inlays and found after five years 7.5% and 17.4% failure rate respectively which is reported as an insignificant difference between the two interventions(21). No failure was detected in the second RCT after 3.5 years for 22 direct fillings and 22 indirect inlays(22). Similar findings are reported by the 11 year studies of Pallessen (18) and VanDijken (31) . The former showed 17% and 16% while the latter showed 17.7% and 27.3% failure rates for inlays and fillings respectively and they both statistically evaluated these differences as insignificant. In the other CCT, Manhart used three different types of composite to restore cavities with direct fillings and indirect inlays whereas 93% of the inlays and 87% of the filings have been rated as alpha or bravo, which is an insignificant difference (30). However the allocation has been conducted according to cavity size (fillings for small and inlays for large) and not randomly which is clearly a selection bias. Mendonca (28) placed 44 fillings and 32 indirect inlays for one year and no failure was appeared. Cetin in a similar way used three different composites to make three groups of 20 fillings each and 2 different composites to make two groups of 20 inlays each and no failure was observed after one year (29). The short recall period of the last two papers does not allow us to reach to any useful conclusion.

The heterogeneous set of studies, with different design (RCTs and CCTs), different clinical procedures (direct or semi direct or indirect fabrication) and different observation periods, give us insufficient evidence to identify whether there is a difference in longevity among the restoration types.

The above studies looked at the two clinical criteria of colour match and marginal discolouration to report on the aesthetic quality. Apart from one study that reported superior results on one of the two criteria (marginal discolouration) for inlays(18), all the others agreed that composite resins provide similar aesthetic results when used either directly or indirectly .

Regarding postoperative sensitivity, four of the studies compared direct composite resins versus indirect (18, 22, 28, 30). Despite differences in the study designs, they all were well conducted and agreed that the difference in postoperative sensitivity is insignificant between the two methods.

Composite inlays on premolars versus molars

The third question that has to be answered is whether the clinical performance of composite inlays on premolar teeth is superior to that on molar teeth. Five studies reported on this matter(15, 17, 18, 30, 31). They all agreed that composite inlays perform significantly better on premolars than on molars. In the RCT by Pallessen 20% of the inlays on molars have failed while only 8% of the inlays on premolars have failed after 11 years which suggests a significant difference ($P<0.05$) (18) .Huth in his RCT used two different composites to make 155 inlays and found insignificant difference ($p=0.576$) between failure rates for the parameter of tooth type after four years (17). However in the same study the findings between the different composites were controversial. There were significant differences between premolars-molars for the characteristics of tooth integrity and postoperative symptoms in the Artglass groups while no difference was found in the Charisma groups. In one of the CCTs it is stated that marginal integrity, anatomic form of the surface and postoperative symptoms showed better results for premolars than molars while a significantly higher failure rate observed in molars but unfortunately there is no

differentiation between indirect inlays and direct fillings (30). The same author in a different three year study (15) revealed a higher failure rate for molars compared to premolars but no discrimination has been made between composite and ceramic thus we cannot evaluate his results in the present study. Finally Donly reports failure rates of 2 out of 18 for premolars and 7 out of 18 for molars but does not explain if this is significant or not (25).Van Dijken in a similar way revealed a higher failure rate for premolars versus molars 11.9% and 50% respectively(31).

However, the types of the composite resins being used seemed to have some effect on the clinical criteria of assessment used in some cases, as observed by Huth and co-workers (17). This could be due to higher filler content in the Charisma composite resin (Heraeus-Kulzer, Wehrheim, Germany) (78 wt %) compared to that of the Artglass composite resin (Heraeus-Kulzer, Wehrheim, Germany) (69 wt %). This matter could be a subject of further studies on indirect composite restorations. On the whole, despite the fact that several factors can influence the final results, the majority of the available composite resins seem to perform better on premolar teeth rather than on molar teeth.

Composite inlays on small cavities versus large

Finally only two studies were appropriate to evaluate the last hypothesis showing opposing results(17, 21). Huth found no difference between the one-two surface restorations and multi surface ones regarding failure rate while Wassell reported that all the failures were observed on large inlays. In an excluded article by Dukic, two types of composite resins for the fabrication of indirect inlays were compared (7). He used only large cavities on molar teeth and found that all of them were clinically acceptable after 2 years. This can be a positive sign for the use of composite resins to fabricate large inlays however the design of the study was not robust. He did not use a control group of small cavities and also the recall period was only 2 years(7).

REVIEW

Quality of the evidence

A well designed RCT aims to take all the co-factors that can influence the results into account and only allows the effects of the interventions to be evaluated. In the present review it was pointed out that only one trial is considered to have low bias (17) while only one study provides confidence interval(22).

Double blinding is impossible when placing dental restorations. Blinding makes sense for the outcome evaluation whereas clinicians must not participate at the evaluation procedure and the examiner has to be blind. Patient blinding is not always feasible for example when gold is used. In the present review blinding is of high importance when assessing the aesthetic quality. However an experienced dentist can spot the differences between the materials used especially when monochromatic blocks are used for CAD-CAM restorations. Five studies reported blinding of the outcome(7, 15, 17, 21, 30) while one reported that the examiner inspected the samples and at the same time an independent trained recorder was responsible to fill the forms(25).

An essential part of a well designed clinical trial should be the justification of the sample size. In the present review although all of the studies stated the sample size only two CCTs justified that (28, 29) . None of the RCTs justified the sample size. When power calculation is not performed, it is considered as a major drawback for the studies because a rather small sample size can produce results which are not meaningful.

Allocation concealment is another essential part of an RCT and is defined as "The procedure for protecting the randomization process so that the treatment to be allocated is not known before the patient is entered into the study"(32). A preferred way is that of sealed envelopes. Only two RCTs performed allocation concealment(17, 20).

Four of the studies reported that they received some kind of support from the manufacturers and therefore their results should be looked at with caution (17, 21, 25, 26).

The fact that participants drop out in a clinical trial is inevitable especially when the sample size is large and the observation period is long. The reason for these drop outs has to be stated. In the present review 82.6% of the studies reported the recall rate of which 65.2% reported a recall rate higher than 80%.

Finally 73.9% of the evaluated studies used more than one examiner for the assessment of the outcome and 65.2% report calibration of them.

Biases of the review process

A great effort has been made to retrieve all the articles for the purposes of this systematic review. Potential bias could be the exclusion of non-English articles. English abstracts for two of them have been identified but the extraction of useful information was impossible (33, 34). Authors and manufactures have not been contacted to confirm whether new trials are due to be published. The identification of the more recent versions of the long term studies was extremely difficult not only because it was not always published in the same journal but also because the co-authors swap their roles and sometimes a totally new lead author was mentioned in a study that had been started by others.

Implications for research

There is a need for well designed RCTs which can answer the various questions regarding the effectiveness of indirect composite inlays versus alternative methods of restorations either indirect(ceramic and gold) or direct .The importance of other factors such as tooth type and cavity size when restoring with indirect inlays has to be cleared by using high quality research. CONSORT guidelines must be followed by authors (35). From the studies reviewed only one followed the majority of these guidelines (17).

In addition, definitions for failed and unacceptable restorations must be standardized .This will produce homogenous results that can later be extracted and used to form a meta-analysis. Finally the control must be well tested for long time to provide adequate power of evidence to the intervention. For example, gold inlays is an excellent control to test longevity of composite inlays.

Implications for practice

Despite the heterogeneity of the evidence composite inlays seem to be a promising material for the restoration of posterior teeth for all the reasons that have been analyzed.

Equally important is the fact that the majority of the studies reported a high acceptance of them from the patients' point of view, however, more trials are needed so there would be a possibility to recommend a certain type of composite resin and a preferred method of construction.

CONCLUSIONS

In conclusion there is insufficient evidence to answer whether any difference exist between composite from one side and ceramic and gold inlays on the other side regarding longevity and aesthetic quality while both sides seem to perform equally regarding postoperative sensitivity.

There was insufficient evidence to make recommendations for the use of indirect composite inlays over direct composite fillings regarding longevity while the majority of the studies agree that differences between them regarding aesthetic quality and postoperative sensitivity are insignificant.

Restoration with composite inlays seem to be a better solution for premolars than for molars while the available studies could not answer whether cavity size can influence their clinical performance .

Despite several limitations, that have been described in details above composite inlays can compete against ceramic inlays, gold inlays and direct composite fillings and it is inevitable that their use will increase in the era of the conservative dentistry.

ADDRESS FOR CORRESPONDENCE

Mr Efsevios Grivas, Kanelopoulou 3 ,11525, Athens, Greece.
Email: efsevios@gmail.com

REFERENCES

1. Marra LM. An historical review of full coverage of the natural dentition. *The New York State Dental Journal* 1970;**36**(3):147-51.
2. Bowen RL. Properties of a silica-reinforced polymer for dental restorations. *The Journal of the American Dental Association*. 1963;**66**:57-64.
3. Ferracane JL. Resin composite—State of the art. *Dental Materials*. 2011;**27**(1):29-38.
4. da Rosa Rodolpho PA, Cenci MS, Donassollo TA, Loguercio AD, Demarco FF. A clinical evaluation of posterior composite restorations: 17-year findings. *Journal of dentistry*. 2006;**34**(7):427-35.
5. Kildal KK, Ruyter IE. How different curing methods affect the degree of conversion of resin-based inlay/onlay materials. *Acta odontologica Scandinavica*. 1994;**52**(5):315-22.
6. Peutzfeldt A, Asmussen E. The effect of postcuring on quantity of remaining double bonds, mechanical properties, and in vitro wear of two resin composites. *Journal of dentistry*. 2000;**28**(6):447-52.
7. Dukic W, Dukic OL, Milardovic S, Delija B. Clinical evaluation of indirect composite restorations at baseline and 36 months after placement. *Operative Dentistry*. 2010;**35**(2):156-64.
8. Signore A, Benedicenti S, Covani U, Ravera G. A 4- to 6-year retrospective clinical study of cracked teeth restored with bonded indirect resin composite onlays. *The International Journal of Prosthodontics*. 2007;**20**(6):609-16.
9. Van Landuyt KL, Nawrot T, Geebelen B, De Munck J, Snauwaert J, Yoshihara K, *et al*. How much do resin-based dental materials release? *A meta-analytical approach*. *Dental Materials* 2011;**27**(8):723-47.
10. Kukrer D, Gemalmaz D, Kuybulu EO, Bozkurt FO. A prospective clinical study of ceromer inlays: results up to 53 months. *The International Journal of Prosthodontics*. 2004;**17**(1):17-23.
11. Pol CW, Kalk W. A systematic review of ceramic inlays in posterior teeth: an update. *The International Journal of Prosthodontics*. 2011;**24**(6):566-75.
12. Hayashi M, Wilson NH, Yeung CA, Worthington HV. Systematic review of ceramic inlays. *Clinical Oral Investigations* 2003;**7**(1):8-19.
13. Banks RG. Conservative posterior ceramic restorations: a literature review. *Journal of Prosthetic Dentistry* 1990;**63**(6):619-26.
14. Cvar JF, Ryge G. Criteria for the clinical evaluation of dental restorative materials. publication. *United States Public Health Service in San Francisco* 1971.
15. Manhart J, Chen HY, Neuerer P, Scheibenbogen-Fuchsbrunner A, Hickel R. Three-year clinical evaluation of composite and ceramic inlays. *The American Journal of Dentistry* 2001;**14**(2):95-9.
16. Thordrup M, Isidor F, Horsted-Bindslev P. A prospective clinical study of indirect and direct composite and ceramic inlays: ten-year results. *Quintessence International*. 2006;**37**(2):139-44.
17. Huth KC, Chen HY, Mehl A, Hickel R, Manhart J. Clinical study of indirect composite resin inlays in posterior stress-bearing cavities placed by dental students: results after 4 years. *Journal of dentistry*. 2011;**39**(7):478-88.
18. Pallesen U, Qvist V. Composite resin fillings and inlays. An 11-year evaluation. *Clinical Oral Investigations* 2003;**7**(2):71-9.
19. Alhadainy HA, Abdel-Aziz AH, Abdel-Kereim UM. Clinical evaluation of repairing old amalgam restorations with composite inlays. *The American Journal of Dentistry* 1998;**11**(3):134-6.
20. Fasbinder DJ, Neiva GF, Dennison JB, Heys DR. *Journal of Cosmetic Dentistry*—Winter 2013.
21. Wassell RW, Walls AW, McCabe JF. Direct composite inlays versus conventional composite restorations: 5-year follow-up. *Journal of dentistry*. 2000;**28**(6):375-82.
22. Spreafico RC, Krejci I, Dietschi D. Clinical performance and marginal adaptation of class II direct and semidirect composite restorations over 3.5 years in vivo. *Journal of dentistry*. 2005;**33**(6):499-507.
23. Gladys S, Van Meerbeek B, Inokoshi S, Willems G, Braem M, Lambrechts P, *et al*. Clinical and semiquantitative marginal analysis of four tooth-coloured inlay systems at 3 years. *Journal of dentistry*. 1995;**23**(6):329-38.
24. Kaytan B, Onal B, Pamir T, Tezel H. Clinical evaluation of indirect resin composite and ceramic onlays over a 24-month period. *General Dentistry* 2005;**53**(5):329-34.
25. Donly KJ, Jensen ME, Triolo P, Chan D. A clinical comparison of resin composite inlay and onlay posterior restorations and cast-gold restorations at 7 years. *Quintessence International*. 1999;**30**(3):163-8.
26. Fasbinder DJ, Dennison JB, Heys DR, Lampe K. The clinical performance of CAD/CAM-generated composite inlays. *Journal of the American Dental Association*. 2005;**136**(12):1714-23.
27. Vanherle G, Verschueren M, Lambrechts P, Braem M. Clinical investigation of dental adhesive systems. Part I: An in vivo study. *Journal of Prosthetic Dentistry* 1986;**55**(2):157-63.
28. Mendonca JS, Neto RG, Santiago SL, Lauris JR, Navarro MF, de Carvalho RM. Direct resin composite restorations versus indirect composite inlays: one-year results. *Journal of Contemporary Dental Practice*. 2010;**11**(3):025-32.
29. Cetin AR, Unlu N. One-year clinical evaluation of direct nanofilled and indirect composite restorations in posterior teeth. *Dental Materials Journal* 2009;**28**(5):620-6.
30. Manhart J, Neuerer P, Scheibenbogen-Fuchsbrunner A, Hickel R. Three-year clinical evaluation of direct and indirect composite restorations in posterior teeth. *Journal of Prosthetic Dentistry* 2000;**84**(3):289-96.
31. van Dijken JW. Direct resin composite inlays/onlays: an 11 year follow-up. Journal of dentistry. 2000;28(5):299-306.
32. Forder PM, Gebski VJ, Keech AC. Allocation concealment and blinding: when ignorance is bliss. *Medical Journal of Australia*. 2005;**182**(2):87-9.
33. Haas M, Arnetzl G, Wegscheider WA, Konig K, Bratschko RO. [Clinical results and material behavior of composite, ceramic and gold inlays]. *Deutsche Zahnarztliche Zeitschrift*. 1992;**47**(1):18-22.
34. Khairallah C, Hokayem A. [Long-term clinical evaluation of 2 dental materials used for the preparation of esthetic inlays]. *Odonto-Stomatologie Tropicale*. 2009;**32**(127):5-13.
35. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Annals of Internal Medicine* 2010;**152**(11):726-32.