MASTEROPPGAVE

Resin composite or ceramic inlays/onlays in posterior permanent teeth? A review of the literature.

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Abstract

Objective: To compare the clinical survival and long-term costs of extensive composite restorations to ceramic inlays and onlays. The hypothesis was that ceramic inlays and onlays can be more tooth substance saving and long-term economic for the patient than composite restorations.

Methods: The dental literature, predominantly since 1990, was reviewed for prospective clinical studies of longevity of ceramic inlays/onlays and direct composite restorations in permanent posterior teeth. Only studies lasting at least 1,5 years and with 30 restorations at baseline were accepted, and retrospective studies, case studies and studies performed at universities were excluded.

Results: A total of 20 studies met the established inclusion criteria. Failure rates varied from 4-30% in observation times of 1,5 years to 18 years for composite restorations, and from 0-19% during 2-10 years of follow-up for ceramic restorations. The most common reasons for failure were secondary caries (57%) for composite fillings and material fracture (64%) for ceramic inlays and onlays. The initial cost ratio of a typical 3-surface composite filling to that of a similar sized ceramic restoration was found to be 1:4,4.

Conclusions: Bulk fracture and secondary caries are the main causes for failures of ceramic inlays/onlays and composite resin restorations, respectively. Oral hygiene, calibration methods and control of the patients drop out are important factors to be accounted for in long-term clinical trials. More RCTs and CCTs with solid study designs are still needed to evaluate the survival and costs of both composite restorations and ceramic inlays/onlays in posterior teeth.

Introduction

Patients and practitioners have a variety of options when choosing materials and procedures for restoring carious lesions and fractures of teeth or previous restorations. Amalgam has been widely used to restore posterior teeth because of its reported successful longevity, easy-handling and low-costs[1]. In the past decades the patients demands for aesthetic and tooth-colored restorations have increased, leading to more frequent use of polymer resin composite materials and ceramic indirect restoratives in posterior teeth[2].

Factors that should be considered when deciding between different materials are both patient-, material- and procedure-related. Thus, the choice of material and procedures to restore form, appearance and function to the dentition is an important health care decision that is ultimately made by the patient after careful consultation with his or her dentist[3]. Therefore it is important for the general practitioner to have knowledge about excepted durability and costs of the different materials available.

Composite resin-based materials have been improved very fast since their development in the early 1960s[4], becoming the primary choice for restoration of permanent teeth. However, high failure rates are still being reported[9,12] , suggesting that the need for alternative, more durable treatments should be considered from case to case.

Ceramic inlays and onlays are alternatives to composite where a tooth is largely damaged and a more resistant material is indicated. However, with their higher cost due to the time consuming procedure producing the reconstruction and an indirect technique[35], usually requiring at least two dental appointments, their use is still strongly limited by patient wishes and economy.

The failure rate of ceramic inlays has recently been reported to be very promising after 8 to 10 years in clinical service[5,15,33]. However, the long-term clinical performance of ceramic inlays in relation to other posterior restorations remains to be fully evaluated. With the increasing demand for evidence-based dentistry, it is important to evaluate restorative materials over longer periods, to better estimate a predicted survival rate, thereby giving dentists a proper evidence-based knowledge to inform their patients about the prognosis of the different alternatives in each case.

The hypothesis for this study was that ceramic inlays and onlays can be more tooth substance saving and long-term economic for the patient than composite restorations. It therefore aims to compare the clinical survival and long-term costs of extensive composite restorations to ceramic inlays and onlays by analyzing the literature currently available, predominantly published since 1990.

Materials and methods

Inclusion and exclusion criteria for the selection of papers were determined prior to the literature search:

Inclusion criteria

Prospective clinical studies of the longevity of ceramic inlays/onlays and direct composite restorations in permanent posterior teeth, with most attention given to randomized clinical trials (RCTs) and controlled clinical trials (CCTs).

Only studies with an observation time of at least 1,5 years with at least 30 restorations at baseline were included. No restrictions regarding the types of ceramic and composite materials were made and all cavity sizes were considered due to the difficulty of finding studies containing only extensive restorations.

Previous reviews have considered a recall rate of >80% as acceptable[11]. But for long-term studies lasting up to a decade, very few studies manage to present recall rates that high. Therefore long-term studies with recall rates of less than 80% were also included in this review.

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Exclusion criteria

Retrospective studies, case reports and studies performed at universities were excluded. The differences in time and costs between university clinical settings and general dental practice can challenge applying the results to individual patients who are treated in a general practice[6], and these studies were therefore left out.

Search strategy

In the present review, an electronic journal search was performed using the PubMed search engine to access the MEDLINE database from 1990 to present. The key words used in the search were “composite” and “ceramic inlays/onlays” combined with “longevity AND posterior teeth”.

Each publication was initially assessed for relevance by the authors using data presented in the abstract. The full paper was obtained when the article was deemed

relevant or when the abstract was not available or failed to provide sufficient information. The reference lists of relevant reviews[1,7,8,9,10,11,12,13] were screened for additional relevant publications.

Data analysis

The longevity of composite and ceramic restorations were evaluated. In addition, several important factors affecting the quality of the individual studies were evaluated by the authors;

- drop out of patients
- oral hygiene
- calibration methods
- reasons for failure
- tooth type
- restoration size

The effect of these factors on survival of the restorations were discussed and statistical calculations were performed when feasible using a Spearman`s correlation coefficient. A simple regression model for failure rate was also made using the observation period as an independent variable.

Results

Electronic and hand searching of articles retrieved a total of 20 papers that met the inclusion criteria; ten on the clinical performance of ceramic inlays and onlays and nine on the clinical performance of composite restorations. The last article was a comparison of the two materials. The results of the selected studies are summarized in Tables 1 and 2.

This review demonstrates that a majority of composite restoration failures are due to secondary caries (figure 1). However, while most studies of observation times of 8 years and less report secondary caries as the main cause of failure, all studies with observation times of 10 years or more report fracture as the main cause. In comparison, all but one of the studies on ceramic inlays and onlays in the present review point to fracture as the main cause of failure. In fact, as much as 64% of the reported failures in the reviewed ceramic studies are due to fracture of the material (figure 2).

Figure 3 presents a simple regression model for failures over time showing that ceramic inlays and onlays have a higher survival rate and lower increase in failure per year of observation ($y=1,1213x + 0,9434$) compared to resin composite restorations ($y=1,4195x + 5,9064$). It also reflects the fact that composite fillings have been followed up for longer periods of time than ceramic restorations.

Discussion

Comparison of tables 1 and 2 and the graphs of figure 3 shows a tendency for lower failure rates for ceramic studies compared to composite studies. However, some important factors regarding the quality of the studies must be discussed and carefully analyzed before trying to draw any conclusions.

Drop out of patients

The occurrence of dropped participants is unavoidable in clinical trials involving representative samples of patients, as is the associated uncertainty as to the fate of their restorations[11]. For long-term studies lasting for up to a decade, recalling all the patients is a common problem because of changes in people's life (moving away, health issues etc.), making it impossible for some patients to attend the recall sessions.

For the ceramic studies included in this review 8 of the 10 studies retrieved recall rates of over 80% over periods from 2 to 10 years. For the composite studies 5 of the studies retrieved recall rates of over 80% over periods from 1,5 - 18 years. As for the study comparing composite to ceramic inlays/onlays it presented a high recall rate, with 95% after ~5 years. Careful consideration of dropped restorations is required when considering outcome, given that actual failure rates can only be determined if a 100% recall is achieved. That being said, there was not found any relationship between recall and failure rates for neither ceramics ($r= -0.059$, $p>0.2$) nor composites ($r= -0.085$, $p>0.2$) in this review.

Comparing the composite and ceramic studies of comparable observation periods shows that the composite studies have lower recall rates than the ceramic studies. A possible reason for this could be that ceramic inlays and onlays are more expensive treatments that require more time and visits, making it easier to motivate the patient about the need to follow-up of the restoration. In comparison, composite fillings have lower costs and short treatment sessions, which may make it harder to convince the patient about the need for follow-up. One could also suspect that patients who accept the more expensive treatment of inlays and onlays are those with higher socioeconomic status. These patients have better dental health than the population as a general[34], and one could therefore assume that they might be more aware of the need for regular follow-ups.

Oral hygiene

Three of the ceramic studies[14,16,21] included only patients with good oral hygiene and low caries risk, while none of the composite studies report to have excluded any patients due to such assessments. This might be a source for bias in these three studies, as better results could be expected for low-risk patients.

One ceramic study[18] and one composite study[26] had high portions of high-risk caries patients; 46% and 45% respectively. These studies report some of the highest failure rates in this review (see tables 1 and 2), supporting the findings of Köhler et. al.[30] that there is a need for appropriate patient selection, monitoring and managing of the caries risk factors to prevent early replacement of restorations.

Calibration methods

The evaluation of the restorations, and how it is done, should always be described. To avoid bias, the same operator that placed the restoration should not be the evaluator. The term "blinding" refers to keeping study participants, clinicians, and sometimes those collecting and analyzing the clinical data unaware of the assigned intervention[11]. The optimal evaluation should be carried out by at least two blind operators who have received a good calibration, leading to a high degree of agreement between them.

In 3 out of 10 ceramic studies the operator who placed the restorations participated in the evaluation. In all three of the studies[14,20,21] the evaluation was performed by the operator who placed the restorations and by a blind evaluator with a high degree of agreement, thereby reducing the risk for bias. As for the composite studies, the same operator who placed the restoration was involved in the evaluating process in 5 of the 9 studies without a blind evaluator. This represents a great risk of bias and is a potential weakness for these studies.

Failures

Almost all of the studies included in this review present the different failures they experienced well, but why the failure occurred and how it could be repaired is often poorly described. The reason for this can be that this is difficult and time consuming work, requiring a throughout investigation of each different case, including both examination of the restoration and the patient history. But the importance of this, in relation to tooth substance saving question, cannot be put to doubt.

Many of the studies present fracture of the material as the main cause of the failure (figures 1 and 2). But why did the material fracture? Possible reasons can be bruxism, strong biting forces, weak bonding, poor cementation, marginal gap, weak material strength or secondary caries. Some of these failures are easy to fix, while others can lead to need for expensive and invasive treatment. As a dentist, knowing the reason is also essential when choosing which material to use for restoring the teeth again.

Two studies[14,20] found that as many as 80% of failed ceramic inlays and onlays could be fixed either by composite repair or placement of new inlays or onlays without removal of healthy tooth substance. The remaining 20% had to be restored by full-coverage crowns due to secondary caries or insufficient retention for inlays and onlays. This is in strong contrast to failures of composite restorations, where more tooth substance often needs to be removed due to the high rate of secondary caries (see figure 1).

One could also assume that restorations included in a follow-up study get a more thorough examination compared to those examined in everyday clinical practice, leading to earlier diagnosis of failures. Therefore, secondary caries and its consequences can be an even bigger problem in reality, as a later diagnosis increases the need for more invasive treatments. This suggests that inlays and onlays should be preferred when there is a large loss of tooth substance, as the need for replacement of a composite restoration often requires removal of further tooth substance, thereby increasing the risk of harming the pulp of the already largely damaged tooth. This theory needs further investigation in long-term studies, however, as the ceramic studies in this review report higher rates of endodontic complications than the composite studies (see figures 1 and 2).

Tooth type and restoration size

Only eight out of the total 20 studies discussed the survival of restorations in premolars compared to molars, while just four studies considered the influence of cavity size. Two studies[14,19] presented higher fracture rates for molars compared to premolars for ceramic inlays, whereas three studies[17,21,22] presented no significant difference.

Among the composite studies, one study[25] found that molars had three times higher failure rate compared to premolars. This was supported by van Dijken[26] who found the risk of mechanical failure to be 2,3 times higher in molars than in premolars. Another study, however, presented no significant difference between premolars and molars[30]. All the three studies present a relatively low material ranging from 33-54 restorations. An important difference is that the studies that found a significant difference lasted for 11 years with fracture as the main reason for failure in both of the studies, whereas the study that found no significant difference lasted 5 years and the main reason for failure was secondary caries. The latter study presented a failure percent of 27,6%, higher than both of the 11-year studies. This high amount of secondary caries at a relatively short study weakens it further as the number of restorations in function at the end of the study is very low.

Bernardo and coworkers[29] found that the size of the filling and the number of surfaces involved had an important impact on survival, with single-surface and small restorations having highest survival rate (93,6%), and restorations with four or more surfaces lowest survival rate (50,0%) after 7 years. Brackett and coworkers[32] also reported a tendency that cavity size contributes to the failure rate, but they did not find it

to be significant. Although this might indicate that composite should be avoided when there is a large loss of tooth substance, more long-term studies that take the restoration size into account are needed to support this theory. The same has to be said for ceramic inlays and onlays, as only two[14,17] out of the 11 studies included in this review evaluates the influence of restoration size. Otto et. al.[14] found that inlays covering three surfaces had significantly lower survival times compared to all other inlays, whereas Krämer and coworkers[17] found that no significant influence was attributed to the size of the inlay.

Long-term costs

The weakest link in predicting long term cost of restorative treatment is data on longevity of restorations. As demonstrated in this review, data on longevity are difficult to interpret, not only because of the different results in different studies, but also because so many factors play a role in the survival time of the restorations.

With all the factors discussed influencing the observed success of the restorations in a given study, it becomes very difficult to estimate how long the restorations are actually expected to last. Long lasting, high quality studies with highly standardized clinical procedures are needed to overcome the obstacles highlighted in this study, so that sound statistical analysis can be performed and expected survival time calculated.

Table 3 shows the initial costs of the two materials based on the dental fee schedule of Troms county and the material and fabricating costs of the ceramics obtained from a local dental technician. It suggests that the cost ratio of a typical three-surface composite filling to a similar ceramic inlay/onlay is about 1:4,4. This means that a ceramic restoration needs to last more than 4,4 times as long as its composite counterpart

for it to offer the patient an economic advantage. Although this doesn't seem very likely based on the figure 3, it can't be rejected with certainty because this study wasn't able to calculate expected survival times. It becomes further complicated, as discussed earlier, by the fact that not all failures can be fixed by simple and inexpensive means, and that failures of some restorations may lead to more frequent need for more invasive and expensive treatments.

Another uncertainty when trying to predict the survival of the restorations is the lack of available documentation of what happens with ceramic inlays and onlays after about 10 years of function, when the most long-lasting studies published end.

Thorough comparative studies of the two materials with detailed and careful analysis of the factors discussed in the current review might be able to fully answer the question of what material is most tooth substance saving and long-term economic to the patient in a given situation. Until such material is available, dentists must still rely on their knowledge and experience when making material choice recommendations to their patients.

Conclusion

Within the limits of this study the following conclusions can be drawn:

- Bulk fracture and secondary caries are the main causes for failures of ceramic inlays/onlays and composite resin, respectively.

- Oral hygiene, calibration methods and control of the patients drop out are important factors to be accounted for in RCTs and CCTs.
- More long-term randomised, controlled, clinical trials with solid study designs are still needed to evaluate the survival and costs of both composite restorations and ceramic inlays/onlays in posterior teeth.

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Figures

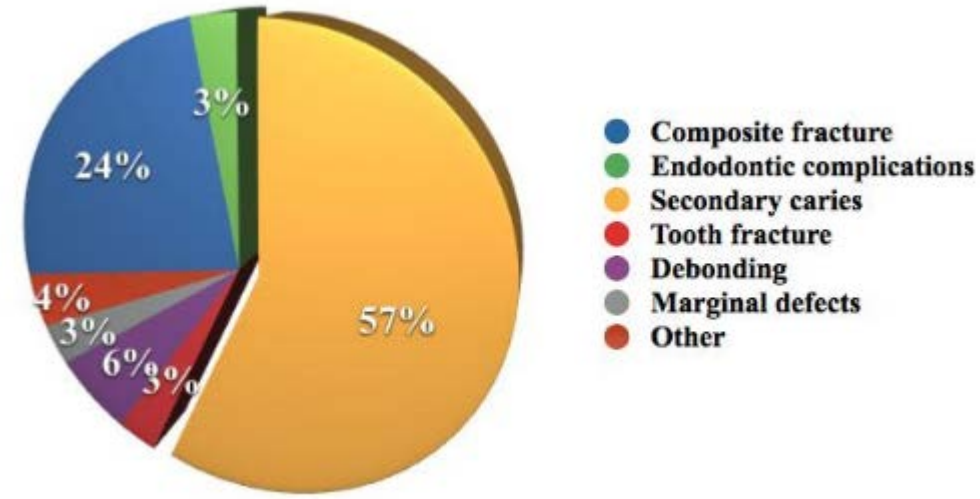

Figure 1 Reasons for failure of composite resin restorations.

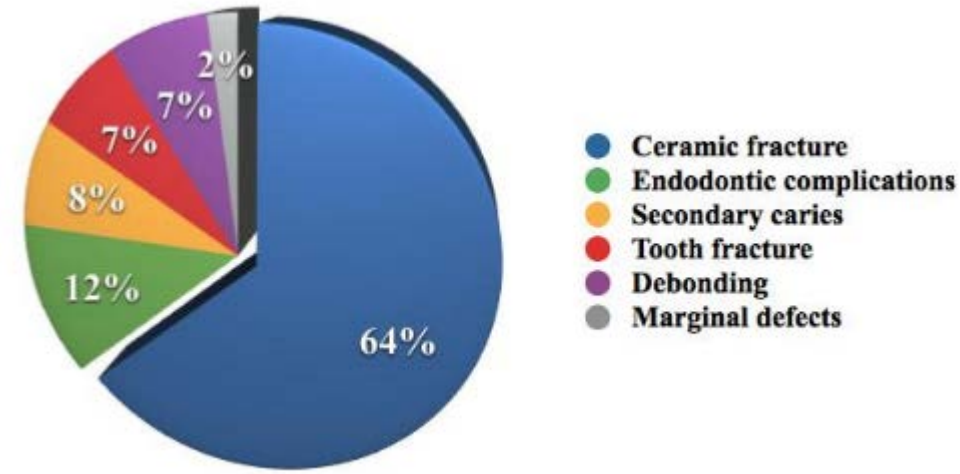

Figure 2 Reasons for failure of ceramic inlays and onlays.

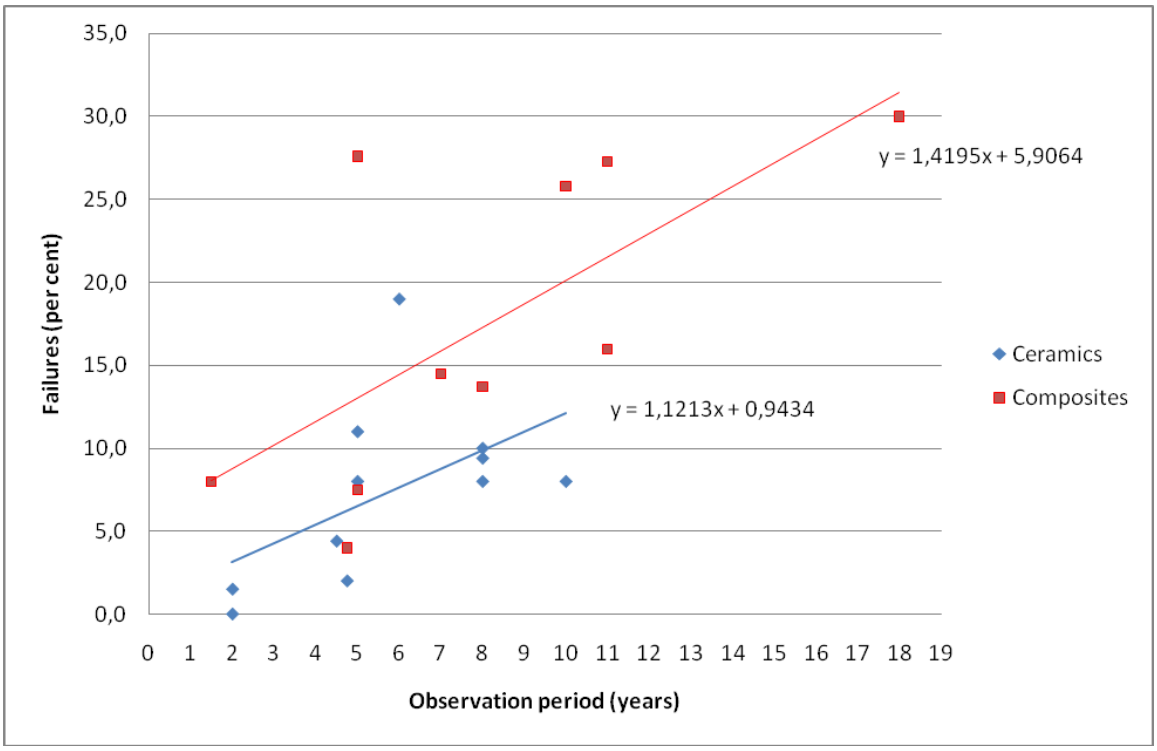

Figure 3 Correlation between observation period and failure rate of ceramic and composite restorations.

Tables

Reference	*Material*	*Observation period*	*Restoration/ Patient*	*Restoration Drop out*	*Failure*	*Main cause of failure*
14	Cerec	10 years	1.9	6.5%	8%	Ceramic fracture
15	Cerec	8 years	2.0	0%	9,4%	Ceramic fracture
16	IPS Empress	8 years	3.0	28%	10%	Hyper-sensitivity
17	IPS Empress	8 years	2.8	40%	8%	Ceramic fracture
18	Mirage	6 years	2.4	2.5%	19%	Ceramic fracture
19	Cerec	5 years	2.4	0%	11%	Inlay/tooth fracture
20	Cerec, IPS Empress, Mirage	5 years	3.0	0%	8%	Ceramic fracture
2	Evopress	4,75 years	2.4	5%	2%	-
21	IPS Empress	4,5 years	4.3	0%	4,4%	Ceramic fracture
22	IPS Empress	2 years	2.7	5%	0%	-
23	IPS Empress	2 years	3.4	3%	1,5%	Ceramic fracture

Reference	*Material*	*Observation period*	*Restoration/ Patient*	*Restoration Drop out*	*Failure*	*Main cause of failure*
24	P-50 / Herculite XR	18 years	-	24%	30%	Fracture
25	Brilliant dentin / Estilux posterior	11 years	2.0	4%	16%	Fracture
26	Fulfil	11 years	-	3%	27,3%	Fracture
27	Visio-molar posterior	10 years	2.7	56%	25,8%	Fracture
28	3 brands	8 years	4.6	35%	13,7%	Fracture/sec. caries
29	Filtek z100	7 years	3.8	0%	14,5%	Sec. caries
30	P-50 / Superlux molar	5 years	1.4	8%	27,6%	Sec. caries
31	Coltene Brilliant Dentin	5 years	1.0	35%	7,5%	Periapical abscess
2	Filtek z250	4,75 years	2.1	7%	4%	Marginal gap/sec. caries
32	Alert / Surefil	1,5 years	1.0	0%	8%	Fracture

Table 1 Longevity of ceramic inlays and onlays in posterior teeth.

Restoration	*Dentist fee*	*Technician fee*	*Total cost*
Composite			
One-surface	490	-	490
Two-surfaces	840	-	840
≥ Three-surfaces	1020	-	1020
Ceramic			
One-surface	1200	2000	3200
Two-surfaces	1990	2200	4190
≥ Three-surfaces	2250	2200	4450

Table 2 Longevity of composite resin restorations in posterior teeth.

Table 3 Initial costs of different sized composite and ceramic restorations. [36,37]