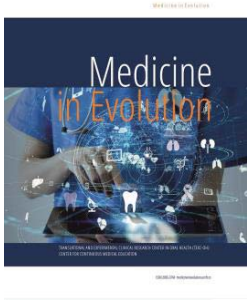
Clinical assessement of ceramic inlays compared to resin composite inlays- literature review



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Abstract

The development and enhanced performance of restorative dental materials—both direct and indirect restorative materials, along with adhesives—are paving the way for minimally invasive dental treatments. High-performance composite resins and ceramic materials, when appropriately matched to the clinical case, ensure excellent restorative outcomes. These outcomes include superior aesthetics, precise marginal fit, conservative or minimal tooth preparation, strong adhesion, and long-term success.

Materials and Methods

This systematic review analysed various published studies with similar objectives and a minimum follow-up period of 3 years. The outcomes assessed included quantifiable factors such as tooth and restoration fractures, chipping of both teeth and inlay restorations, the frequency of endodontic issues, secondary caries, and debonding.

Results and Discussions

The selection of a material for inlays and onlays need to absorb significant occlusal forces. Consideration regarding the durability and effectiveness of the selected materials used through direct or indirect technique and clinical case are essential for a long-term success. The survival rate of adhesive restorations is heavily influenced by factors like dental cement and adhesive system, marginal fit, bruxism and interdental contact areas.

Conclusions: Ceramic inlays and onlays have shown higher survival rates over a 5-10 year period of time compared to alternative materials such as composite resin. Fractures is the most frequent type of failure for composite resin restorations. This evidence indicates that ceramic inlays are a highly successful treatment option with a very favourable prognosis.

Keywords: inlay, onlay, ceramic, composite resin, survival rate, direct restorative, indirect restorative

INTRODUCTION

Recently, the composite restorations, combined with advancements in adhesive techniques, has significantly increased the use for restoring posterior teeth [1]. Composite restorations allow a conservative restorative treatment, preserving tooth structure more than most indirect dental materials. It is performed exceptionally well when the proximal ridges remain intact. Although composites are less rigid than ceramics and have a modulus of elasticity similar to dentin, they cannot fully restore the high load-bearing capacity of proximal enamel ridges lost in large Class II cavity restorations. Adhesively bonded restorations offer metal-free, aesthetic alternatives that replicate the tooth's morphology, providing cusp protection, aesthetics, and flexible restoration [2]. However, when full cusp coverage is needed, composite adhesive restorations are insufficient, and ceramic inlays and onlays are recommended [2].

Composite restorations can be used either through direct or indirect techniques. In most cases, direct adhesive composite are preferred for small to medium-sized cavity preparations but the challenges include marginal adaptation inaccuracies, material sensitivity—in the presence of oral fluids—difficulties in placement and carving, finish and polishing. The proper contacts and contours with direct composite increments can be challenging and Material defects like voids in the restoration are difficult to remove and can weaken the restoration and induce postoperative sensitivity in deep cavity preparations [1].

Indirect adhesive composite restorations offer excellent colour matching, save time for patients and dentists and finishing is made outside the oral cavity. The drawbacks are a higher risk of marginal inaccuracies, additional laboratory time and costs, poorer adhesion to the tooth compared to direct composite restorations [1].

New ceramic materials indicated in the posterior region has seen a significant increase in recent, allowing ceramic restorations to replace many traditional options [3,4].

The advancements about physical, strength and adhesive properties have expanded the applications and indications for dental ceramic restorations [5]. Before ceramic bonding, posterior cavities were restored with conventional amalgam or cast gold [6]. Clinicians are now regularly faced with the challenge of making informed decisions about the best materials to use for optimal function and aesthetics [5]. Patients increasingly prefer treatment options that offer both effective mastication and pleasing aesthetics, leading to the growing popularity of all-ceramic restorations [7].

Posterior ceramic inlays offer superior physical properties and greater flexural strength. However, compared to direct composite restorations, ceramic inlays require more visits, are more expensive due to the materials and laboratory work involved, and demand a higher level of skill [8].

Aim and objectives

Therefore, the aim of this systematic review research study is to offer an up-to-dated conclusion from randomized controlled clinical trials which evaluate the clinical performance of different inlay/onlays restorations.

MATERIAL AND METHODS

This systematic study compared different published research with a similar aim and a follow-up of at least 3 years. The outcomes were dependent on the quantifiable factors such as fracture of teeth and restorations, chipping of the teeth, chipping of inlays restorations, frequency of endodontic problems, secondary caries, and debonding. This systematic review

research study was founded on PRISMA statement recommendations for writing systematic reviews studies.

The following parameters were included: 1. study design-randomized clinical trials and clinical follow up studies were qualified as inclusion criteria while case reports and non-randomized clinical trials were non-qualified for this study; 2. patients above 18 years old with cavities that needed to be treated with composite resins inlays or restorations; 3. indirect inlays or ceramic onlays for posterior teeth; 4. the survival rate for posterior inlays/onlays; 5. follow-up of minimum 3 years; 6. The exclusion criteria considered in-vitro studies, case reports, failure of more than 30%, unfinished facts for the analysis and studies with no survival analysis.

The strategy for identifying the studies included: the comprehensive search methods were developed and thoroughly reviewed for each database, taking into account variations in terminology and language rules. The electronic databases MEDLINE and COCHRANE were searched for relevant randomized clinical trials published in English over the past ten years, up until December 2018. Additionally, all eligible studies were manually reviewed to identify any that may have been missed during the electronic search, in accordance with the Moher (2009) guidelines (Figure 4). Study selection was made according to the method poised reading of abstract and full-text interpretation for the sake of categorizing the studies that possibly encountered the eligibility criteria.

Data extraction was made to record the needed information: year of study, evaluation criteria, age of the patients, restoration type (either inlay or onlay), material used, follow-up period, rate of failure, and any outcome measured.

Treatment effect measurements, for constant results, was measured the mean and standard deviation from each qualified study was summarized and confidence interval of 95% was calculated. The heterogeneity assessment was made by examining the characteristics of the studies, the similarity between the patients, the interventions and the results as listed in inclusion criteria.

The evaluations of the survival rate were made in the study groups. For studies that presented no standard deviation was used the investigation of the total amount of failures during follow-up period. The collected data from the study research was calculated using life tables. Survival rates were collected for the following outcomes: chipping of the restoration, fracture of the restoration, endodontic pulp involvement, recurrent caries, debonding and marginal discoloration. Marginal discoloration assessment was usually based on the modified UPSHS criteria of evaluation as in many research studies or CDA/Ryge. The following parameters were taken into consideration the amount of cusp coverage (inlay/ onlay/ overlay) and the location of the restoration on the maxilla versus mandible.

RESULTS

1,382 studies were identified as relevant from the electronic search based on the inclusion criteria. The duplicates were removes and the remaining studies were assessed for their reliability in the review. 240 studies were excluded after abstract screening, and 6 were rejected after full-text review. Ultimately, 15 clinical research studies were deemed eligible for inclusion in our systematic review (Figure 1). Figure 2 presents the flowchart of the study selection process. Table 1 provides detailed information on the selected studies, including the author's name, year of publication, patient age, and evaluation criteria. Table 2 displays the survival rates from each included study, along with dropout percentages, the number of inlay restorations, and the number of onlay restorations. Figure 1 shows the meta-analysis of the included studies in a forest plot with a 95% confidence level. Statistical tests revealed significant heterogeneity between the studies; therefore, a random effects model was applied.

With this model, the Q statistic was 16.682, and the I^2 value was 16.076. The odds ratio was 0.870, suggesting that overall, ceramic inlays have an 87% likelihood of success.

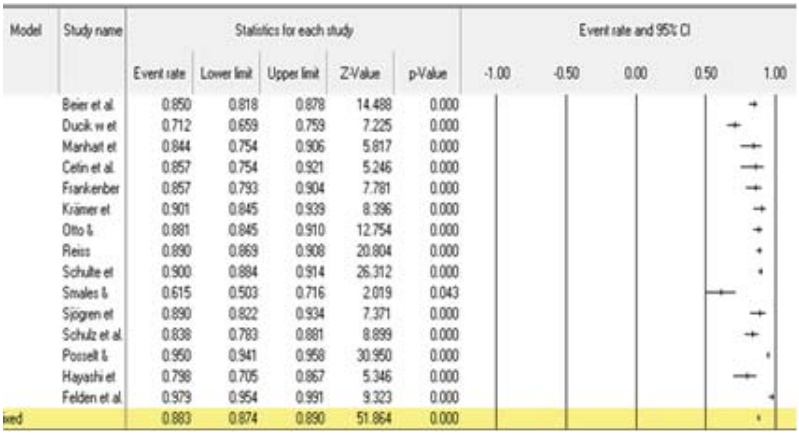

Figure 1. The survival rate of ceramic inlays

Resin inlay studies included in the systematic review 3 resin study including composite inlays with a follow-up period was three years for all the three studies.

Ceramic inlay studies included in the systematic review: Five of the included studies used feldspathic porcelain and another five used glass ceramics In two studies, they both used both materials. The survival rate of the entire collective studies including composite resins, feldspathic porcelain and glass-ceramic for a minimum of a 3-year follow-up (N=7456 restorations) was 85%.

A single study presented detached information for the inlay versus the onlay ceramic restorations. Feldspathic porcelains showed a survival rate of 90% compared to the 95% survival rate of glass ceramics for more than a 5y period follow-up which is a very good survival rate and presents a great clinical success. As for the survival rate of composite restorations which also presented a good clinical success for a minimum of 3 years' follow-up was 80%.

Regarding the different outcomes evaluated in this systematic reviews, fracture of the inlay restorations was only 2% for in the 15 included studies (110 fractures out of 7456). Endodontic pulp involvement was 3% (116 failures out of 3784) for 11 included studies. The frequency of recurrent caries was 2% (74 out of 4644) for 11 included studies.

The rate of debonding was 2% for 6 included studies (25 out of 4700). The incidence of marginal discoloration was 1% for 6 included studies (12 out of 488). 4 research studies linked the types of preparation with the survival rate, however, not in a consistent pattern. Assessment of colour stability, occlusal wear, the integrity of the marginal, tooth sensitivity, and patient contentment were not possibly involved due to the absence and the lack of criteria standardization

Not any of the retrospective clinical studies were capable to accomplish all the requirements for unbiased study, with a 60% value. The risk of bias of the systematic review included articles, was in a range from 46% to 75% according to risk bias analysis.

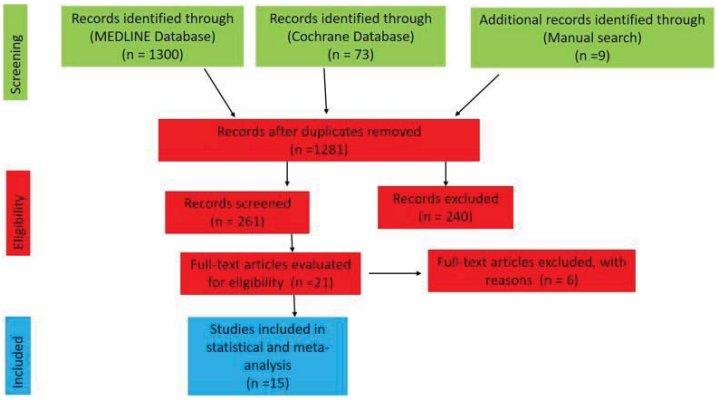

Figure 2. Search of studies and screening for eligibility and final number of included publications

Table 1. General selected criteria of the selected studies

Author	Year of publication	Material	Evaluation criteria	Follow-up period (y)	Age	No of patients
Beier et al. (57)	2012	Glass-ceramic	CDA/Ryge	12y-20y	18-70	120
Ducik w et al. (58)	2010	Ormocer Composite	modified USPHS	3y	18-60	NM
Manhart et al. (59)	2010	Charisma Composite	modified USPHS	3y	20-60	NM
Cetin et al. (60)	2009	Nanofilled direct composites	Ryge criteria	3 y	NM	NM
Frankenberger et al. (22)	2008	Glass-ceramic	modified USPHS	12y	20-55	60
Krämer et al. (61)	2008	Glass-ceramic	modified USPHS	8y	25-55	54
Otto & Schneider (62)	2008	Feldspathic porcelain	modified USPHS	17y	18-75	197
Reiss (63)	2006	Feldspathic porcelain / Glass-ceramic	CDA/Ryge	18 y	18-70	299
Schulte et al. (64)	2005	Glass-ceramic	NM	9y	18-65	824
Smales & Etemadi (55)	2004	Feldspathic porcelain	NM	6y	18-50	50
Sjögren et al. (49)	2004	Feldspathic porcelain	modified USPHS	10Y	25-70	52
Schulz et al. (54)	2003	Feldspathic porcelain	CDA/Ryge	9Y	25-75	103

Table 2. The outcomes tested

Author	Drop out percentage %	Number of inlays	Number of onlays	Survival rate %
Beier et al. (57)	0 %	213	334	85%
Ducik w et al. (58)	10%	312	-	71%
Manhart et al. (59)	15%	90	-	84%
Cetin et al. (60)	0%	70	-	85%
Frankenberger et al. (22)	23%	96	58	86%
Krämer et al. (61)	25%	94	68	90%
Otto & Schneider (62)	17%	200	187	88%
Reiss (63)	0%	1011	-	89%
Schulte et al. (64)	10%	810	783	90%
Smales & Etemadi (55)	0%	78	-	62%
Sjögren et al. (49)	7%	66	61	89%

DISCUSSIONS

When selecting a material for restorations that must absorb significant occlusal forces, careful consideration is essential to ensure durability and effectiveness. The survival rate of adhesive restorations is heavily influenced by the choice of dental cement and adhesive system. Various studies have examined the properties of adhesive resin luting materials—such as high bond strength, degree of conversion, and resistance to occlusal wear—to predict their clinical performance [9-14].

An adequate degree of polymerization of the resin luting agent is a critical factor impacting the clinical longevity of indirect restorations. Additionally, successful tooth adhesion depends on the proper treatment of both the internal surfaces of the restoration and the dentinal surface. This systematic review explores the materials and procedures employed

in adhesive cementation for indirect composite and ceramic inlay restorations [15-19]. Clinical trials indicate that studies with inadequately concealed allocation sequences tend to overestimate treatment effects compared to those with properly concealed allocation [20-22]. Therefore, careful attention to randomization is essential in both the execution and reporting of clinical trials. Despite the importance of random distribution sequences, none of the randomized clinical trials on ceramic inlays have specified the methods used for randomization.

In clinical trials involving representative patient samples, it is inevitable that some patients will withdraw before the study is completed, leading to uncertainty about the outcomes of their restorations. In the current review, 50% of the included research articles reported recall rates of over 70%, with 25% achieving recall rates of 90% over 1 to 5 years. Careful consideration of these dropped restorations is crucial when evaluating results, as accurate failure rates can only be determined if a 100% recall rate is achieved [23].

A comprehensive approach for evaluating the clinical effectiveness of ceramic inlays need to include survival rates, postoperative pain, secondary caries, aesthetic outcomes, and inlay fractures. Properly designed clinical trials of ceramic inlays, adhering to the CONSORT checklist, would have been more valuable and could have better supported future systematic reviews of these types of restorations. The survival rate remained consistently high, regardless of whether the follow-up period was 5 or 10 years. However, restoration fractures were the most common and frequent type of failure among all outcomes [24]. When comparing ceramic inlays to composite resin inlays, ceramic restorations required greater technical expertise, more time, and higher costs. Nonetheless, ceramic inlays demonstrated significantly higher survival rates. The type of tooth did not impact the survival rate for either composite resin or ceramic inlay restorations.

CONCLUSIONS

When a posterior tooth is compromised due to a wide isthmus preparation, ceramic inlays offer significant advantages over direct composite resin restorations. They provide an aesthetically pleasing and longer-lasting alternative with proven clinical success.

In recent years, there has been significant improvement in the physical properties of ceramics. Marginal and internal adaptation of milled restorations have also benefited from advancements in CAD/CAM technologies. However, the brittle nature of ceramic materials necessitates adequate tooth reduction to ensure sufficient bulk, enabling the ceramic to withstand functional loads. Ideally, the marginal preparation should be within the enamel, as this creates a strong and resilient bond when resin luting is applied. In contrast, bonding to dentin at the margins presents a higher risk of micro-leakage.

Ceramic inlays and onlays have demonstrated higher survival rates over a 5-10 year period compared to other alternatives like composite resin, with fractures being the most common type of failure. This evidence suggests that ceramic inlays are a successful treatment option with a very good prognosis. Overall, ceramic inlays can now be considered a superior restorative material for inlay restorations, offering clinically acceptable outcomes.

Future clinical trials should focus on improving the study design and publication strategy. The study design should aim to minimize the number of confounding variables, and potential influencing factors—such as patient characteristics, materials used, or clinician techniques—should be carefully recorded. Before beginning research, all objectives and strategies for addressing potential confounding factors should be clearly established. Additional attention should be given to statistical considerations, including the appropriate population size and confidence level for the results.

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