A Systematic Review of Ceramic Inlays in Posterior Teeth: An Update

Christiaan W.P. Pol, DDS[a]/Warner Kalk, DDS, PhD, FDS RCSEd[b]

Purpose: Ceramic materials, first introduced in restorative dentistry in the late 18th century, offer a wide range of possibilities and exhibit esthetic properties. The last systematic reviews on the subject of ceramic inlays were published in 2003. All articles published up to 2001 were surveyed regarding the longevity, esthetic qualities, and postoperative discomfort associated with the use of ceramic inlays compared to other restorative materials. The present review aimed to establish the current state of the art. ***Materials and Methods:*** Using methods identical to those of previous reviews, the literature from 2001 up to and including 2009 was assessed. The scientific and methodologic qualities of all articles describing the use of ceramic inlays were established. Articles comparing the results of ceramic inlays to other types of inlays were then used to answer the hypotheses that there were no differences in longevity, postoperative sensitivity, or color match. ***Results:*** Three articles comparing the results of ceramic to other materials were analyzed further. No new reliable evidence was found to update the answer to the hypothesis that there was no difference in longevity, at least in the first year postoperative. The evidence found regarding postoperative discomfort backs the previous conclusion that there was no difference. New evidence found on color matching suggests that there is no significant difference in color match over assessment periods of up to 57 months. ***Conclusion:*** Current ceramic materials in inlay restorations seem to perform as well as other restorative options for selected properties during the first years after placement. *Int J Prosthodont 2011;24:566–575.*

Although ceramic materials have been used in dentistry since the late 18th century, the possibilities for their use in the posterior region have never been as great as presently. Modern developments enable ceramic restorations to be used as an alternative to many restorative materials. All-ceramic systems did not gain popularity until the introduction of reinforced ceramics in the 1980s provided more reliable, flexible, and esthetic results.[1–3] In the 1990s, the introduction of computers in dentistry and, with that, of computer-aided design/computer-assisted manufacturing, enabled additional applications for ceramic restorations.[4] These systems use prefabricated blocks of feldspathic porcelains or glass-ceramics to produce ceramic restorations either chairside or in a dental laboratory.

Over the years, problems with high failure rates in early ceramic materials were reportedly solved with improved materials and the introduction of adhesive techniques.[1] Since then, further enhancements have been made in both the physical properties and adhesive cementation techniques of ceramics.[5–7]

Presently, many major dental companies have developed their own systems for designing and manufacturing ceramic restorations out of several different types of ceramics that can in turn be luted with an increasing number of adhesive systems. Today, the main ceramic materials are the classic porcelain ceramics, based on feldspar and glass or a metal oxide. Glass gives ceramics an esthetic translucent property, while oxide ceramics provide high-strength solutions for even the most complicated structures.

Feldspathic ceramics are produced in a powder-based form and can be applied to many different substructure materials. The material can also be formed into a block to be used in a milling unit or can be pressed in a mold to form a restoration. With the addition of various colorants, it can be made to mimic natural enamel shades and is therefore commonly used as a veneer on other less esthetic materials.

Glass-ceramics consist of part glass and part crystalline tetrasilicic mica, which makes the material stronger than feldspathic ceramic. Prefabricated blocks of glass-ceramics can be used to mill substructures. Blocks are pre-fired in the factory because of

[a]*Private Practice, Groningen, The Netherlands.*
[b]*Professor, Center for Dentistry and Oral Hygiene, University Medical Center Groningen, Groningen, The Netherlands.*

Correspondence to: *Dr Warner Kalk, Center for Dentistry and Oral Hygiene, University Medical Center Groningen–The Netherlands, Antonius Deusinglaan 1, 9713 AV Groningen, The Netherlands. Email: ctm@meg.umcg.nl*

the high temperatures required in this process, and the restoration gets its final strength after a second firing at a lower temperature, manageable under normal lab conditions.

Modern oxide ceramics are composed of a metal oxide, mainly either aluminum or zirconia. Glass-infiltrated oxide ceramics are mostly processed in the form of prefabricated, partially fired milling blanks. The final firing or sintering process gives the material its final strength, while milling it in a partially sintered state makes it much easier to process. The strength of this material can be enhanced by increasing the proportion of zirconia, but this also greatly diminishes the esthetic properties.[8–10]

The latest additions to the market are the yttria tetragonal zirconia polycrystal–based (Y-TZP) ceramics, introduced in the 1990s. These have even higher strength and fracture resistance than previous ceramic materials as well as some esthetic properties. Because of this high strength, Y-TZP ceramics are predominantly used to produce crowns and fixed partial dentures (FPDs).[1,2,4,11]

Each ceramic or luting system demands different procedures and has different advantages and disadvantages. It is of the utmost importance to know the specific properties of the materials used to achieve the best possible results in clinical practice.

The first computerized restoration system, Cerec (Siemens, now Sirona), was introduced 25 years ago. Since then, several companies have developed and enhanced the concept. This resulted in numerous systems for use in both the dental office and the dental lab. Some manufacturers use ceramic blocks unique to the system, while others allow for third-party materials to be used. The computer-based techniques of today are capable of delivering a wide range of restorations, from inlays and veneers to multiunit FPDs and structures for use on implants. With either compact milling units for use in a dental practice or the industrial units in dedicated milling centers, each type of ceramic material can now be formed into a restoration for almost every application in the field of dentistry.[2,12]

When conducting evidence-based clinical practice, the best available evidence should support a particular intervention.[13] The first step in evaluating the clinical effectiveness of any treatment is establishing the criteria to be considered. In the field of restorative dentistry, esthetic satisfaction, longevity, and postoperative pain are important criteria for success. On the subject of all-ceramic inlays, the most recent comprehensive literature review was conducted in 2002, including literature up to 2001.[3]

Hayashi and Yeung[14] published the first and only Cochrane review on the subject of ceramic inlays, aimed at evaluating the clinical effectiveness of ceramic posterior inlays in human adults. The authors found no significant differences in longevity or postoperative sensitivity between ceramic and other forms of posterior restorations over assessment periods of up to 1 year. Few well-designed clinical trials were available to support their conclusion.

The aim of this review was to evaluate the clinical effectiveness of ceramic inlays using a systematic approach including all articles published since 2002. This evaluation was carried out according to the same hypotheses as used by Hayashi and Yeung[3,14] to update their findings. These hypotheses were: *(1)* there is no difference in longevity in ceramic inlays compared to other posterior restorations, *(2)* there is no difference in postoperative discomfort between ceramic inlays and other posterior restorations, and *(3)* there is no difference in esthetic qualities of ceramic inlays and other tooth-colored posterior restorations.

Materials and Methods

Before conducting the study-selection procedure, the procedures as well as the inclusion and exclusion criteria were set. After searching for possible relevant publications, all articles were assessed to establish their scientific status, and data relevant to this review were extracted according to the following protocol.

Search Strategy

The literature search was performed in November of 2009. The search strategy was used to search PubMed, Cochrane, and Picarta databases. The layout of the search strategy was adapted to fit each online database and used combinations of the terms "dental" and "inlay" with "ceramics" or "porcelain."

Hand Searching

The reference lists of all retrieved articles were screened to find other relevant articles. These articles were then reviewed in the same manner as previously located articles.

Inclusion and Exclusion Criteria

All articles published between January 2001 and November 2009 were considered. Since Hayashi et al[3] included a portion of the articles published in 2001, a comparative analysis of articles published that year was done to include only the articles not yet included in the previous review.

Table 1 Quality Assessment Form

Item	Theme assessed
1	Is the hypothesis/aim/objective of the study 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 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 nonparticipants/subjects lost to follow-up described?
20	Are the main findings of the study clearly described?
21	Are results stated in absolute numbers when feasible (eg, 10/20, not 50%)?
22	Are confidence intervals given?
23	Are any important adverse events reported?
24	Are any conclusions stated?

No restrictions on the language of the publications were set, while the need for translation would be determined after assessment of the abstract.

All published clinical studies on Class I and Class II ceramic inlay restorations in permanent premolar and molar teeth were included. Included studies could be randomized clinical trials (RCTs), controlled clinical trials (CCTs), or case series (CSs). Studies concerning any type of ceramic inlay restoration—fired, milled, cast, or pressed—were included.

Studies not containing inlays as a distinguishably separate part of the design or studies not involving adult humans were excluded. In vitro studies and single case reports were also not included.

All articles retrieved were first reviewed based on their titles and then based on their abstracts to determine if they met the inclusion or exclusion criteria. Then, when available, the full-text article was retrieved for further assessment. Only data reported in the actual abstract or article were used to assess the content. When an article could only be excluded after assessing the abstract or full text, the reason for exclusion was noted.

Quality Assessment

To establish the quality of the included articles, the systematic assessment list as used by Hayashi et al,[3] consisting of 24 criteria, was used to score each of the included articles. The form used is presented in Table 1.

Calibration was achieved by using the list of criteria to evaluate five articles, randomly selected from those previously included in the review by Hayashi et al.[3] The findings were compared to those published, resolving any differences by re-examining both the articles and the list of criteria.

Criteria were scored on the list using the page number on which the item to be judged was first stated, such that the presence of this number could be read as a "yes" score and the absence of a number as

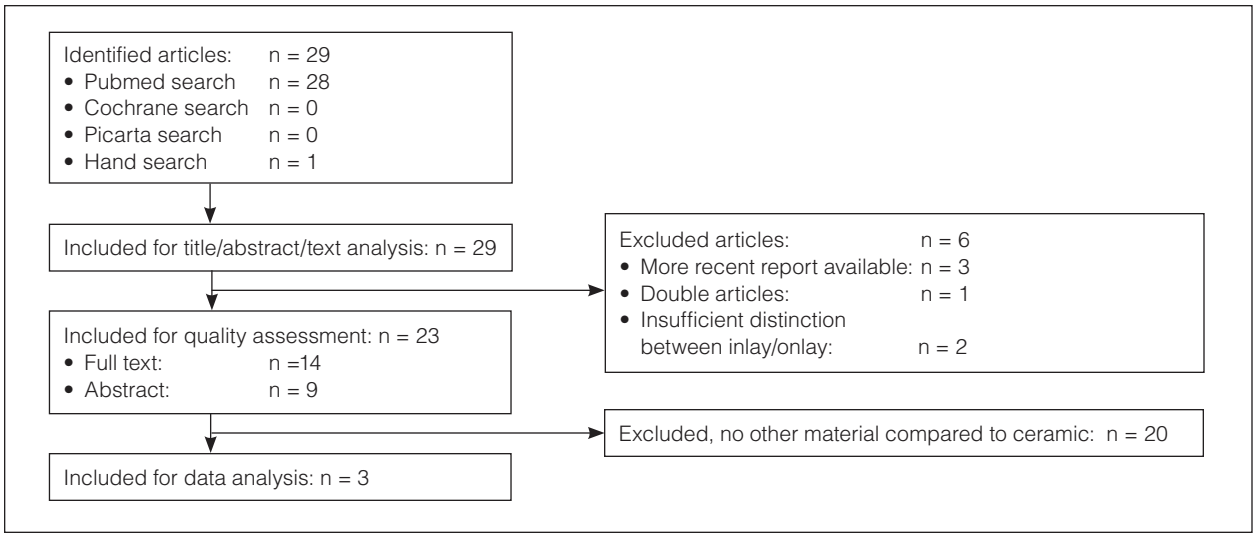

Fig 1 Algorithm of the study-selection procedure.

a "no" score. In cases when insufficient information was given to determine whether a particular criterion was applicable, no score was given.

One month after the first assessment, all articles were assessed again to determine inter-rater reliability. A blank copy of the same questionnaire as used the first time was used in the same manner, after which an analysis of the reliability was made. A kappa agreement score was calculated to quantify the differences between the first and second assessments. Results of both the first and second assessments, combined to form one score with any differences resolved through analysis, were used as the final score for the quality assessment.

Data Extraction

To evaluate the clinical effectiveness of ceramic inlays, only articles comparing ceramics with a different type of posterior restoration material were selected, using the results of the quality assessment. After this selection, the following were extracted: data about the article (authors, date of publication, journal), data on the study design (population size, duration of the study, participants, setting of the study, criteria used, statistics used), and data on interventions as well as on the outcomes and conclusions. When possible, information presented in the text, tables, graphs, or figures was extracted.

To be able to answer the hypotheses set for this review, data on failure rates, postoperative pain or discomfort, and esthetic qualities were extracted. In accordance with the protocol used by Hayashi and Yeung,[3,14] an inlay was considered to have failed when replacement was indicated or endodontic problems occurred. Restorations evaluated as clinically unacceptable according to clinical criteria, such as the United States Public Health Service (USPHS) or California Dental Association (CDA), were also considered as failures. Postoperative pain or discomfort was evaluated as the presence or absence of sensitivity to temperature or occlusal loading within 1 month after restoration. Esthetic quality was defined as the color match of an inlay as judged by the clinical criteria used. This information was recorded per intervention per study.

Results

Literature Search

After conducting both the electronic and the hand-searching procedures, 29 articles remained. The electronic search revealed 28 articles.[8,10,15–40] One additional article was found using the hand-searching procedures.[9]

After assessing the abstracts, six articles were excluded. Of these, three articles[21,22,24] were excluded because a more recent report on that same trial was available, two articles[32,39] were excluded because an insufficient distinction was made between clinical inlay and onlay results, and one article in the German language[31] was excluded because the same article was also published in English.

After the exclusion of these 6 articles, the remaining 23 articles (14 full-text and 9 abstracts) were subjected to quality assessment. Figure 1 outlines the algorithm of the study-selection procedure.

Table 2 Results of Quality Assessment

Study design	Study	Style	Items assessed*									
			1	2	3	4	5	6	7	8	9	10
RCT	Thordrup et al[38]	Full text	+		+	+	+	+	+	+		+
RCT	Fasbinder et al[17]	Full text	+			+	+	+	+	+		+
RCT	Sjögren et al[8]	Full text	+	+	+			+	+	+		+
CCT	Frankenberger et al[9]	Full text	+	+	+	+	+	+	+	+		+
CCT	Lange and Pfeiffer[40]	Full text	+	+	+	+	+	+	+	+		+
CCT	Krämer et al[23]	Full text	+	+	+	+	+	+	+	+		+
CCT	Arnelund et al[33]	Full text	+	+	+	+	+	+	+	+		+
CCT	Coelho Santos et al[15]	Full text	+	+	+	+	+	+	+	+		+
CCT	Kükrer et al[10]	Full text	+		+	+	+	+	+	+		+
CCT	van Dijken[29]	Full text	+	+	+	+		+	+	+		+
CCT	Frankenberger et al[18]	Abstract	+					+	+	+		+
CCT	Santos et al[35]	Abstract	+					+	+	+		+
CCT	Gemalmaz et al[20]	Abstract	+					+	+	+		+
CS	Galiatsatos and Bergou[19]	Full text	+	+	+	+	+	+	+	+		
CS	Stoll et al[37]	Full text	+	+	+	+	+	+	+	+		
CS	Wrbas et al[30]	Full text	+	+	+	+	+	+	+	+		
CS	Schulte et al[36]	Full text	+	+	+	+	+	+	+	+		
CS	Bernhart et al[34]	Abstract	+	+				+	+	+		
CS	Otto and Schneider[25]	Abstract	+	+				+	+	+		
CS	Fabianelli et al[16]	Abstract	+					+	+	+		
CS	Reiss[27]	Abstract	+	+				+	+	+		
CS	Posselt and Kerschbaum[26]	Abstract	+	+				+	+	+		
CS	Schulz et al[28]	Abstract	+	+	+			+	+	+		
Total (%)			23 (100.0)	16 (69.6)	14 (60.9)	13 (56.5)	12 (52.2)	23 (100.0)	23 (100.0)	23 (100.0)	0 (0.0)	13 (56.5)
Kappa†			NC	1.0	0.9	0.9	0.9	0.0	0.0	NC	0.0	0.8

RCT = randomized clinical trial; CCT = controlled clinical trial; CS = case series; + = item discussed in article; NC = not calculable.
*See Table 1 for item explanation.
†Intra-assesor agreement (kappa).

Quality Assessment

The results of the quality assessment are presented in Table 2. The scores from the first and second assessments were used to calculate the kappa coefficient of intrarater agreement.

When assessing the methodologic quality of the 23 included articles, it was found that only 3 articles[8,17,38] could be regarded as RCTs and 10 articles[9,10,15,18,20,23,29,33,35,40] as CCTs, while the remaining 10 articles[16,19,25–28,30,34,36,37] were CSs without control groups or randomization.

None of the included articles addressed all of the items on the quality assessment form. All articles mentioned an objective or aim of the study and presented information regarding the treatments, their main findings, and conclusions. No important adverse effects were reported by any article.

Of the 13 CCTs, 7 appeared or claimed to use a split-mouth design,[8,9,15,18,23,29,38] while 6 used a parallel design.[10,17,20,33,35,40]

In the present review, 5 articles were found to be reports on a long-term study on which an earlier report was also included in Hayashi's review. These articles included 2 RCTs,[8,38] 2 CCTs,[18,29] and 1 CS.[27] Of the 14 full-text articles included in the present review, only 3 articles[36,37,40] presented the 2003 systematic review of Hayashi et al[3] in their reference lists; only 1 article[37]

11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total (%)
+					+	+	+	+	+	+			+	16 (66.7)
+	+		+	+	+	+	+	+	+				+	17 (70.8)
+			+	+	+	+	+	+	+	+	+		+	18 (75.0)
			+		+	+	+	+	+	+	+		+	18 (75.0)
					+	+	+	+	+	+	+		+	17 (70.8)
			+		+	+		+	+	+			+	16 (66.7)
		+	+	+	+	+	+	+	+	+			+	19 (79.2)
			+	+	+	+	+		+				+	16 (66.7)
			+	+	+	+	+	+	+				+	16 (66.7)
			+	+	+	+	+	+	+	+			+	17 (70.8)
			+	+	+				+	+			+	11 (45.8)
			+		+	+	+		+				+	11 (45.8)
					+	+	+		+	+			+	11 (45.8)
						+	+		+	+			+	13 (54.2)
					+	+	+		+	+	+		+	15 (62.5)
			+	+	+	+	+	+	+	+			+	17 (70.8)
					+	+	+		+	+	+		+	15 (62.5)
						+	+		+	+			+	10 (41.7)
					+	+	+		+	+			+	11 (45.8)
						+	+		+	+			+	9 (37.5)
					+				+	+			+	9 (37.5)
					+				+	+			+	9 (37.5)
						+	+		+	+			+	11 (45.8)
3 (13.0)	1 (4.3)	1 (4.3)	11 (47.8)	8 (34.8)	19 (82.6)	20 (87.0)	19 (82.6)	10 (43.5)	23 (100.0)	19 (82.6)	5 (21.7)	0 (0.0)	23 (100.0)	322
1.0	1.0	0.6	0.9	1.0	0.7	0.8	0.8	0.9	NC	0.7	0.5	NC	NC	

also included the 2003 Cochrane Library publication by Hayashi and Yeung.[14] None of the included articles discussed the implications or the implementation of the many recommendations, on the design and reporting of studies, as published by Hayashi et al.[3,14]

Evaluation of Clinical Effectiveness

To evaluate the clinical effectiveness of ceramic inlay systems, studies comparing results of ceramic materials to other systems were identified using the results of the quality assessment. This yielded only three articles, two RCTs[17,38] and one CCT,[40] all comparing a ceramic material to a composite resin material. The overall characteristics of these three studies are presented in Table 3.

The first RCT was a 3-year update on research to examine the clinical results of 40 composite resin–based inlays compared with 40 porcelain inlays, both milled with the same system.[17] The second RCT was a 10-year report of a long-term trial to evaluate the durability and performance of 4 different types of ceramic and composite resin inlays.[38] The retrospective CCT compared 264 ceramic inlays to 145 direct composite restorations. Clinical re-examination using the USPHS criteria was performed after a mean time in function of roughly 3 years.[40]

Table 3 Characteristics of the Articles Used for Final Data Analysis

Study design	Study	Method	Participants	Interventions	Outcomes (as provided by article)
CCT	Lange and Pfeiffer[40]	11 up to 58 mo (mean: 33 mo) Retrospective, parallel design Private practice	264 ceramic inlays in 109 patients 145 composite resin inlays in 68 patients	Evopress (ceramic) Filtek Z250 (composite resin)	Modified USPHS criteria 94%/93% survival at up to 57 mo No significant difference in survival curves No significant difference in color match Alpha ratings
RCT	Thordrup et al[38]	10-y prospective Split-mouth + parallel design Various locations	29 ceramic inlays (15/14 split) 29 composite resin inlays (15/14 split) 37 patients (split provided) 1 operator	Cerec/Vitadur (ceramics) Brilliant/Estilux (composite resin) Direct vs indirect (both groups)	CDA criteria 80% survival with repair 51% survival without repair With repair: survival not significantly different Color match: significantly equal results
RCT	Fasbinder et al[17]	3-y prospective Parallel design Location unclear (university?)	80 inlays (40/40 split) 43 patients (no information) 2 operators (62/18 split)	Vita Mk II (ceramic) Paradigm (composite resin) Both CAD/CAM with Cerec 2 unit	Modified USPHS criteria Postoperative sensitivity not significant Composite resin: better color match No clear conclusions on survival

CCT = clinical controlled trial; RCT = randomized clinical trial; USPHS = United States Public Health Service; CDA = California Dental Association; CAD/CAM = computer-aided design/computer-assisted manufacture.

Analysis of Longevity

In the first RCT,[17] one of the porcelain and two of the composite resin restorations required replacement after 3 years. The porcelain inlay was replaced because of fracture of the restoration; the composite resin–based restorations were replaced because of incomplete fracture of the tooth. Because only the percentage of Alpha ratings was reported and broken inlays remained in the trial, it was not possible to calculate the Kaplan-Meier survival rate with use of the criteria set for "failure."

The second RCT[38] reported that repair of some of the inlays occurred, some by a general practitioner outside the trial, but it was not reported how or in which patient group these repaired restorations belonged. Although the use of the CDA criteria list was reported, neither data on the distribution of scores nor data comparing different treatment options in the same patient were given. For this review, the survival rate per group could not be calculated because of a lack of information on the moment restorations were repaired.

The CCT[40] reported that all restorations were placed on teeth showing a vital reaction to pulp tests. At some point during the observation period, 3 of the ceramic and 4 of 135 examined teeth in the composite resin group had to undergo root canal treatment. These restorations were repaired after treatment and not regarded as failures. To account for the deviations from the research protocols of the present review, insufficient information was given on each individual restoration, and the survival rate according to the Kaplan-Meier method could therefore not be recalculated.

Since all three articles reported insufficient data to calculate the corrected survival rate, no conclusions could be drawn in the present review regarding the longevity of ceramic inlays.

Analysis of Postoperative Sensitivity

In one RCT, one of the ceramic inlays exhibited slight sensitivity in the first week after placement; no sensitivity was reported during the remaining 3-year duration of the study.[17] The other RCT used the CDA criteria to assess discomfort. No discomfort was discovered at any stage of the trial. It was not reported if patients sustained any discomfort between placement and the first assessment at the 6-month follow-up.[38] The CCT did not report on sensitivity or discomfort during clinical function.[40]

Neither of the RCTs reported significant differences in postoperative sensitivity between ceramic and other materials; the CCT did not report on this subject.

Analysis of Esthetic Quality

In the first RCT,[17] only the number of "perfect" scores ("Alpha" on the list of criteria) at each interval was presented. The ceramic material scored 85% perfect at baseline, reportedly a result of the monochromatic nature of the blocks used to mill the inlay, while the

composite resin started at a score of 100%. After 3 years of clinical function, perfect scores on color match were down to 58.8% for the ceramic and 86.5% for the composite resin material. This article reported a significant clinical advantage in color match to the tooth for the resin-based system. Patients were reported to be satisfied with the esthetic results of all inlays.[17] However, referring to the criteria for assessment used in the present review, this conclusion could not be drawn because of a lack of information on the esthetic quality of the nonperfect but clinically acceptable inlays.

The second RCT[38] reported that the esthetic appearance decreased over time with the four systems used. After some initial differences, no significant difference in esthetic scores was found after 10 years of clinical function. All systems were reported to have clinically acceptable esthetics, and all patients were satisfied with the esthetic results. Of the 41 inlays available for assessment at the final interval, external practitioners assessed 11 inlays. This article did not report on either calibration of or methods used by these external practitioners.

Of the 246 ceramic inlays available at the assessment presented by the CCT,[40] 234 scored "perfect" and 12 scored "acceptable" regarding esthetic quality. In the composite resin group, ratings were 105 and 25, respectively. The differences between the groups were reported not to be significant.

Both RCT articles did not comply with the protocols used in the present review. Therefore, only the results of the CCT were sufficiently reliable to be used for the conclusion on the esthetic quality: There is no significant difference between ceramic and other (esthetic) materials.

Discussion

Although information on the study design, such as the way control groups were formed and distributed or the way randomization was achieved, greatly influences the perception of the methodologic value of an article, it was found that few articles provided this information in a clear manner.

When conducting a clinical trial in the field of medicine, an RCT is generally considered to provide the best possible evidence achievable. The use of randomization and control, when performed correctly, eliminates possible variations between either patients or practitioners and ensures that any difference measured is the result of differences in the treatments applied. Since dental restorations are easy to recognize, randomization is only useful when applied to the selection of the materials after preparation of the tooth. In long-term studies, the restoration not only influences the patient, it is also, to a high degree, influenced by the patient. A true controlled study would therefore also include untreated teeth and would need to record several variations, such as the presence of caries and the condition of the opposing tooth. Some of this is covered initially by the inclusion and exclusion criteria but should also be measured, reported, and compared at each follow-up interval.

Only a few articles met the strict protocol of the present review. Overall, only a small number of new high-level evidence articles in the form of controlled trials were published over the past 8 years, but compared to previous reviews, a lot of new low-level evidence was found in the present review. When considering the three-fold hypothesis of the present review, an answer to each of the questions asked would require articles to cover longevity, esthetic quality, and postoperative sensitivity.

Data extraction was made difficult by the many different definitions used for outcome variables, such as "failure" or "clinically acceptable." Although such words are used regularly in all articles, almost none predefined when an inlay would be regarded as having failed.

Regarding the subject of longevity, all three articles selected for this analysis exhibited several shortcomings in the design of either their research or the published articles. All three reported insufficient data to calculate the corrected failure rate. The survival rates reported in the articles varied between 51% without repairs after 10 years up to 94% after a mean time in function of 33 months. The method of randomization was never published clearly enough to validate this randomization, and, when a split-mouth setup was used, this was done incompletely without reporting enough data on the different test groups. Therefore, none of the three articles selected for analysis could be used to answer the hypothesis on longevity in the present review.

Regarding postoperative sensitivity recorded in the first month, the article by Fasbinder et al[17] is the only one that qualifies to answer the hypothesis. Thurdrup et al[38] found no discomfort at the 6-month interval, but it is unclear if any patient sustained any discomfort in the first month after placement. Therefore, only the conclusion drawn by Fasbinder et al[17] can be added to the data gathered by Hayashi et al[3] to support the previous conclusion that no significant difference exists in sensitivity at 1 month postoperative.

Many of the shortcomings described in the analysis of longevity also affect the analysis of esthetic quality. Esthetic quality is a subjective variable, but by applying both multiple examiners and careful calibration on the matter of color match, this subjectivity can be

limited. The studies of Thordrup et al[38] and Lange and Pfeiffer[40] concluded that there was no significant difference in color match between the materials used, while Fasbinder et al[17] reported that the composite resin material performed statistically significantly better than the ceramic material. All authors reported that the patients were satisfied with the esthetic results at the final evaluation interval. Fasbinder et al[17] only reported on the perfect esthetics; thus, data on nonperfect but clinically acceptable inlays were unavailable for assessment. The assessment partially done by external practitioners in the study by Thordrup et al[38] makes the overall data unreliable. Because of these statistical and design shortcomings, only the results published by Lange and Pfeiffer[40] can be used in the analysis on esthetic quality. All inlays included in this study were judged to be clinically acceptable at the assessment, with no significant difference between the two groups. Since Hayashi et al could not answer this hypothesis because of a lack of appropriate publications, the information found in the present review provides a new answer but does not offer strong evidence because only one small-sampled article was involved.

Conclusions

Eight years after Hayashi et al published the previous systematic review on this subject,[3] their conclusion on longevity still stands: No significant difference exists regarding longevity between ceramic and other posterior restorations over assessment periods of up to 1 year. On the subject of postoperative discomfort, new evidence supports the previous conclusion by Hayashi et al that there is no difference between ceramics and other restorative materials.[3] The present review provides evidence that the color match of ceramic materials is equal to that of other esthetic materials, at least for a period of up to 57 months.

Overall, ceramic materials can now be considered to perform as well as alternative restorative materials when used in inlay restorations. Because of a lack of sufficient, long-term research, this conclusion can only be supported for periods of up to 1 year for longevity and up to 57 months for color match.

The strict criteria set for inclusion of articles in the present review resulted in a small sample size. A study with criteria set to include more of the available articles could provide a valid answer to the research question. With strict control on the scientific value and the methodologic quality, the larger sample size could be used to rule out potential confounding variables when including the many trials without a control group.

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Literature Abstract

The relationship between the OSTEODENT Index and hip fracture risk assessment using FRAX

OSTEODENT has been proposed to measure the diagnostic accuracy of a combination of mandibular cortical bone thickness measured from dental panoramic radiographs with clinical information and the Osteoporosis Index of Risk to produce the OSTEODENT Index for probability of osteoporosis. This study assessed the correlation between the OSTEODENT Index, which predicts probability of osteoporosis, and hip fracture risk, as determined by FRAX, developed by the World Health Organization, a computer-based algorithm that provides models for the assessment of fracture risk by incorporating clinical risk factors to identify the need for osteoporosis treatments. The performance of the OSTEODENT Index and FRAX tool (without femoral BMD data) in determining proper intervention, as recommended by the UK National Osteoporosis Guideline Group, was compared. This study analyzed 339 female subjects (mean age: 55.3 years) from two centers (Manchester, United Kingdom and Leuven, Belgium) retrospectively. Clinical and femoral neck BMD data were available for FRAX. Clinical and dental panoramic radiographic data were available to calculate the OSTEODENT Index. Subjects were categorized into "treat" or "lifestyle advice and reassurance" categories using the National Osteoporosis Guideline Group threshold. The results showed that *(1)* the OSTEODENT Index was statistically significant to the 10-year probability of hip fracture derived from the reference standard FRAX (Rs = 0.67, $P < .001$), *(2)* 84 patients (24.8%) were assigned to the "treat" category on the basis of FRAX and UK national guidance, and *(3)* using this treatment or without treatment classification as the reference standard, receiver operating characteristic analysis demonstrated no significant difference between areas under the curves for the OSTEODENT Index (0.815) and the 10-year hip fracture probability derived from the FRAX Index with BMD (0.825) when used as tests for determination of therapeutic intervention. The authors concluded that the OSTEODENT Index had predictive value in hip fracture risk. Prospective trials are required to confirm the findings and to examine its feasible usage in primary dental care.

Horner K, Allen P, Graham J, et al. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:243–249. **References:** 31. **Reprints:** Hugh Devlin, School of Dentistry, University Dental Hospital of Manchester High Cambridge Street Manchester, M15 6FH, United Kingdom. Email: Hugh.DevLin@manchester.ac.uk—*Arthur S. Sham, Hong Kong*