

# The success of indirect restorations in posterior teeth: a systematic review of the literature

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**Aim.** Aim of the study was to evaluate the long-term reliability and effectiveness of inlays and onlays in ceramic and composite material, examining scientific studies published from 2004 to 2013. The results of this review were analyzed and compared with the important literature review proposed by Manhart in 2004.

**Methods.** With this review it was possible to analyze a total sample of 5858 Class I and II restorations, made in the posterior region: 5295 ceramic and 563 composite restorations in 2377 patients. Works were evaluated using USPHS, modified USPHS and CDA criteria after a mean observation period of 5.4 years (5.9 years for ceramic restorations, 2.6 for composite restorations).

**Results.** The arithmetic average of success was 94%, higher in ceramic restorations (94.9%) than composite materials (91.1%). The weighted average success rate was 95.3%, 92.8% for composite restorations and 96.3% for ceramic ones. The highest rates of success were found in ceramic restorations notwithstanding the longer observation period.

**Conclusion.** Indirect restorations have a low failure rate and they prove to be an excellent choice in the treatment of both class I and II lesions. During the last 6 years, the parameters related to these restorations have improved, with a 4% increase of success.

**KEY WORDS:** Inlays - Dental restoration repair - Follow-up studies.

Due to the increasing demand for esthetic restorations, their use even in poste-

rior areas is increasing, giving priority to the choice of ceramic or composite materials, used with both direct and indirect methods.

Direct restorations are indicated in situations of poor destruction of the tooth and need of a conservative approach.

Indirect restorations are indicated in all cases which require the reconstruction of class II cavities with large interproximal areas; reconstruction of one or more cusps; intercusp isthmus extended for more than one third of the occlusal surface width.

The review includes controlled, randomized and retrospective studies from 1990 onwards on different materials: amalgam, glass ionomer, gold, compomer, composite and ceramic materials. Anyway, for the purposes of this study, only data concerning indirect composite and ceramic restorations were analyzed. The review included studies with a minimum two-years follow-up and at least ten restorations at the last control.

Manhart's study of 2004 (Table I) reviewed the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition, examined the restoration longevity in permanent posterior teeth

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TABLE I.—*Manhart 2004.*

	Number of restorations	Mean follow-up (years)	Arithmetic average success rate	Weighted average success rate
Composite restorations	1559	4.9	86%	82.7%
Ceramic restorations	10,863	5.2	91.3%	94%
Total restorations	12,422	5.1	90%	92.6%

(class I and II according to Black) and assessed the factors that may contribute to the success or failure of such restorations. The study considered a total of 12422 restorations with a mean follow-up of 5.1 years, showing a higher success rate in ceramic materials (91.3%) than composite resins (86%).

The aim of this study was to evaluate long-term inlays and onlays reliability and effectiveness in ceramic and composite material, examining the scientific studies published from 2004 to 2013.

**Materials and methods**

Articles published from 2004 to 2013 were analysed. Each article should have met the inclusion and exclusion criteria (Table II) chosen, referring to Manhart’s review of 2004. Researches have been carried out on Medline scientific database using keywords as “inlays and onlays”, “indirect res-

torations”, “follow-up”, and “longevity”, and setting the chosen inclusion criteria as filter. Only studies published from 2004 onwards, studies in English and Italian languages and studies defined as clinical trials and controlled clinical trials were taken into account.

*In-vitro* studies, experiments on laboratory animals and previous reviews of literature were excluded, while works on patients of all ages have been considered.

According to these inclusion criteria 76 items were available, their abstracts were examined and 39 items were found to respond to the study requirements. Full texts were analyzed, and 7 items were excluded because of incomplete information. The resulting 32 items (Table III) were analyzed to connect data and clinical results. Different evaluation methods were adopted in these studies: USPHS (United States Public Health Service), modified USPHS and CDA (California Dental Association) criteria. The United State Public Health Service (USPHS) criteria were developed by Cvar and Ryge in an

TABLE II.—*Inclusion and exclusion criteria.*

Inclusion criteria	Exclusion criteria
Studies published after 2004	Studies with less than 1 year follow-up
Publications in English and Italian languages	<i>In-vitro</i> studies
Randomized clinical trials and controlled studies	<i>In-vivo</i> studies (animals)
Studies with clinical follow-up of at least 1 year	Systematic reviews of literature
<i>In-vivo</i> studies (humans)	

TABLE III.—*Repair or intervention, margin sealing, aesthetic criteria and comparative scale correspondence among them.*

Modified criteria	Description	Analogous USPHS criteria
“Excellent”	Perfect	“alpha”
“Good”	Slight deviations from ideal performance, correction possible without damage of tooth or restoration	“alpha”
“Sufficient”	Few defects, correction impossible without damage of tooth or restoration.	“bravo”
“Insufficient”	No negative effects expected	
“Poor”	Severe defects, prophylactic removal for prevention of severe failures. Immediate replacement necessary.	“charlie” “delta”

attempt to evaluate the restoration quality in a standardized and repeatable way. Such criteria have been modified over the years; in 2007, a group of scientists tried to redefine the Ryge criteria so that they could be adapted to modern clinical situations.

In particular, the successful inlays have been proved to be those included in Alpha and Bravo categories. Those restorations did not require any action during the check.

The results were summarized in a table according to the following criteria: publication year of the study, follow-up time, restoration type, material, number of restorations and patients, evaluation method, success rate, causes of failure. Studies were then split in two categories:

- 1) indirect ceramic restorations;
- 2) indirect composite restorations for cross assessments on different materials.

The so organized data were used to comparative statistical analysis among the various techniques and to extrapolate short and long-term effectiveness of indirect restorations.

The most relevant data of the 32 publications selected in this study are shown in Table IV.

The articles refer to 2004-2012 years. Six articles are on composite resins, 25 on ceramic materials and 1 on composite material and ceramic.

A total of 5858 restorations have been placed on 2377 patients.

## Results

A total of 5858 restorations (5295 in ceramic, 563 in composite material), on a total of 2377 patients were included in this review. The mean follow up was 5.4 years. The studies on composite restorations showed a 2.6 years lower mean follow up than ceramic studies, 5.9 years. The arithmetic mean of success was 94%: 94.9% in ceramic restorations and 91.1% in composite materials restorations. Weighted average was considered in this study in order to give a different weight to the percentages, basing on the number of samples examined

by each study: overall success was 95.3%, 92.8% for composite restorations, 96.3% for those in ceramic. Results are summarized in Table V.

Table VI provides an immediate comparison between the results obtained in 2004 by Manhart and the present review.

## Discussion

This study includes 32 works published between 2004 and 2013 about indirect composite and ceramic restorations, with a mean follow-up of 5.4 years.<sup>1-41</sup> The obtained data can be used in the analysis of variations determining the success of an indirect restoration. The highest success rates were found in Spreafico 2004,<sup>2</sup> Coelho 2004,<sup>3</sup> Fabianelli 2006,<sup>4</sup> Guess 2009,<sup>5</sup> Tagtekin 2009,<sup>6</sup> Mendonça 2010<sup>7</sup> (100%) studies. The study carried out by Coelho *et al.* in 2004 examined 33 onlays and 53 inlays highlighting an excellent success rate (100%) after 2 years of follow-up both in sintered Duceram and castable IPS Empress ceramic restorations.<sup>3</sup>

In 2004, Kramer *et al.* conducted a study on 34 patients, performing 96 IPS Empress ceramic inlays and onlays. After 8 years, 92% of the restorations met the USPHS success criteria.<sup>8-13</sup> The study conducted by Fabianelli *et al.* in 2006 shows the highest success rate among studies on IPS Empress ceramic restoration taken into examination: after 3 years of service none out of 40 inlays required replacement.<sup>4</sup>

Kramer performed several clinical evaluations on IPS Empress ceramic restorations (2004, 2005, 2006, 2008), obtaining success rates of 96% in studies with shorter observation times and 90-92% in longer follow-ups (8 years).<sup>13-16</sup> In 2009, the same author analyzed 57 Cergogold ceramic inlays after 4 years since placement: the success rates for dual-curing composite cemented restorations were 95.2% and forOrmocer resin-cemented restorations were 93.3%. These values are similar to those obtained in previous studies and demonstrate the equal validity of the two pressed ceramic systems.<sup>17-23</sup>

TABLE IV.—Data of the 32 publications selected in this study.

Year	Author	SD	Follow-up	Type of restoration	Restorative materials
2004	Spreafico	Clinical trial	3.5	Inlays and onlays	Semidirect restorations, APH composite
2004	Kramer	Split-mouth study	8		Ips empress
2004	Coelho	Prospective controlled clinical trial	2	Onlays 33 Inlays 53	Ips empress Duceram
2004	Sjogren	Clinical trial	10	Class II	Cad cam cerec ceramic
2004	Arnelund	Retrospective study	5	Inlays and onlays	Ips empress Vitadur alpha
2004	Reich	Pilot study	3		Cerec II
2004	Coelho	Clinical study	1		Ips empress Duceram
2005	Fasbinder	Clinical trial	3	Inlays	Cerec ceramic
2005	Shulte	Clinical trial	9	Inlays and onlays	Ips empress
2005	Kaytan	Clinical trial	2	Onlays	Empres ceramic Solidex composite
2005	Kramer	Prospective clinical splith-mouth study	8		Ips empress
2006	Fabianelli	Prospective Clinical trial	3	Inlays	Ips empress II
2006	Kramer	controlled prospective split-mouth study	4		Ips empress
2006	Reiss	Clinical trial	18	Inlays, Onlays	Cerec ceramic
2006	Bartlett	Controlled clinical trial	3		Direct composite Indirect composite
2007	Stoll	Data of a prosp study examined in retrospect	10	Inlays and partial crowns	Ips empress
2008	Frankemberger	controlled clinical trial	12	Inlays and onlays	Ips empress
2008	Kramer	Controlled prospective clinical splith-mouth study	8		Ips empress
2008	Galiatsatos	Clinical study	6	Inlays and onlays	Ips empress
2008	Naeselius	Retrospective clinical study	4	Onlays	Ips empress
2008	Otto	Follow-up study	17	Inlays and onlays	Cerec
2008	Barone	Prospective clinical study	3	Inlays	Signum composite
2009	Guess	Prospective clinical splith-mouth study	5	Partial coverage restorations	IPS e.max press heat pressed ceramic ProCAD ceramic (cerecIIIand cerec inl.ab CAD/CAMsystem)
2009	Kramer	Controlled prospective clinical study	4	Inlays	Cergogold ceramic luted with variolink luted with definite ormocer resin
2009	Taschner	Prospective clinical study	1	Inlays and onlays	Ips empress
2009	Lange	Clinical trial	3	Inlays	Evopress
2009	Tagtekin	Clinical trial	2		Ips empress II
2009	Bernhart	Clinical trial	3	Inlays	Cerec ceramic
2010	Barnes	Prospective clinical evaluation	3	Veneers Inlays and onlays	Finesse All-Ceramic
2010	Dukic	Clinical trial	3		Ormocer (Admira) nano-hybrid resin composite (Grandio),
2010	Mendonça	Clinical trial	1	Class I and II restorations	direct resin composite restorations (Tetric Ceram-TC) and indirect composite inlays (Targis-TG)
2010	Manhart	controlled clinical trial	3	Class I and II	Artglass polyglass composite Charisma microhybrid composite



N. of restoration	N. of patients	Methods	Success rate%	Causes of failure
22	11	Modified USPHS criteria and SEM	100	
96	34	Modified USPHS criteria	92	Fractures hypersensitivity Ceramic fracture
44	35	Modified USPHS criteria	100	
42				
66	27	Modified USPHS criteria	89	Inlay fracture, Cusp fracture, endodontic problems, postoperative symptoms
215		CDA criteria	92	Fractures, caries
102			98	
58	26	Modified USPHS criteria	97	Bulk fractures
37	34	Modified USPHS criteria	100	
37				
80	43	Modified USPHS criteria	95	Fractures, secondary caries
810	390	USPHS criteria	96.7	
47	47	Modified USPHS criteria	99	Pulpitis
47				
96	34	Modified USPHS criteria	92	Bulk fractures, endodontic problems
40	40	Modified USPHS criteria	100	
94	31	Modified USPHS criteria	96	Hypersensitivity
1011	299	Modified USPHS Criteria	91.5	Ceramic fractures, Tooth fractures
16	32	USPHS Criteria	50	Fractures, lost of retention
16				
1276	643	Modified USPHS Criteria	96.8	Fractures, endodontic problems, loss of adhesion, marginal defects
96	34	Modified USPHS criteria	84	Bulk fractures
94	31	Modified USPHS criteria	90	Fractures, hypersensitivity
64	29	Modified USPHS	93.7	Fractures
130	91	CDA criteria	93	Caries, fractures
200		Modified USPHS criteria	88.7	Ceramic fracture, tooth fracture, caries, endodontic problems
113	30	Modified USPHS criteria	97.4	
40	25	Modified USPHS criteria	100	Fractures
40			97	
57	24	Modified USPHS criteria	95.2 93.3	
83	30	Modified USPHS criteria	98.8	Fractures
250	109	Modified USPHS criteria	94	Fractures, secondary caries
35	35	Usphs criteria	100	
62		Modified USPHS criteria	95	loss of sensitivity, restoration fracture, marginal gap formation
20	43	Usphs criteria	98.5	
20				
35	51	Modified USPHS criteria	100	
36			100	
44	30	Modified USPHS criteria	100	
32				
75	89	Modified USPHS criteria	89.8	inlay fracture, loss of marginal integrity,
80			84.1	secondary caries, and loss of tooth vitality

TABLE V.—Results of the present work.

	Number of restorations	Mean follow-up (years)	Arithmetic average success rate	Weighted average success rate
Composite restorations	563	2.6	91.1%	92.8%
Ceramic restorations	5295	5.9	94.9%	96.5%
Total restorations	5858	5.4	94%	95.3%

TABLE VI.—Comparison between 2004 and 2013 studies.

	2004 arithmetic average success rate	2013 arithmetic average success rate	2004 weighted average success rate	2013 weighted average success rate
Composite restorations	86%	91.1%	82.7%	92.8%
Ceramic restorations	91.3%	94.9%	94%	96.3%
Total restorations	90%	94%	92.6%	95.3%

The study by Manhart *et al.* (2010) is very interesting since they evaluated the success at 3 years of 75 Artglass composite resin inlays and 80 micro-hybrid composite resin inlays.

The lowest percentage of success among the studies was found by Bartlett *et al.* in 2006: after 3 years since placement on badly worn posterior teeth, 50% of the composite resin restorations were fractured or lost.

Sjogren *et al.* in 2004 carried out a study on 27 patients receiving 66 Class II Cerec ceramic restorations, showing a success rate of 89% after 10 years of follow-up.<sup>8</sup> Higher percentages were found in the following studies on the same material: Reich 2004 (97%),<sup>9</sup> Fasbinder 2005 (95%),<sup>10</sup> 2009 Guess (97%),<sup>5</sup> Bernhart 2009 (95%).<sup>11</sup>

The largest study on Cerec ceramic was performed in 2006 by Reiss *et al.*, who evaluated 1011 inlays and onlays after 18 years experiencing a success rate of 91.5%.<sup>12</sup> In 2008, in a study on Cerec ceramic restoration, Otto *et al.* found lower survival times in restorations of molars compared with premolars.<sup>24</sup> Manhart's results about the influence of the restoration surface number on incidence of fractures were confirmed. In this study, after 17 years since inlay placement, 88.7% of restorations did not require any action. This percentage is slightly lower than that one detected by Reiss (91.5%) in 2006 in a study with a follow-up of 18 years on the same material.<sup>12</sup>

Dukic *et al.* (2010) evaluated 35 Ormocer and 36 nano hybrid composite restorations;

this study showed a 100% success rate, measured on the basis of modified USPHS criteria, for both materials considering them as an excellent choice for the treatment of severely damaged posterior teeth.<sup>20</sup>

Arnelund observed the same success rate (92%) in his 2004 study on 215 Cerec restorations evaluated according to the CDA criteria after 5 years of observation.<sup>14</sup> High rates of failure (16%) were reported by Frankenberger in 2008 in a study with long-term follow-up (12 years) about IPS Empress inlays and onlays; such failures were mostly due to fracture of ceramic and of the remaining tooth substance.<sup>15</sup> Fractures were found to be the leading cause of failure also in the studies of Kramer 2004,<sup>13</sup> Sjogren 2004,<sup>8</sup> Arnelund 2004,<sup>14</sup> Fasbinder 2005,<sup>10</sup> Reiss 2006,<sup>12</sup> Kramer 2008,<sup>16</sup> Galitsatos 2008,<sup>17</sup> Guess 2009<sup>5</sup> and Lange 2009.<sup>18</sup> Such low percentage of success is due to high bruxism-related masticatory loads and impact of the increased vertical dimension.<sup>19</sup>

The study of Kaytan *et al.* in 2005 had the aim of making a direct comparison between indirect Solidex composite restorations and Empress ceramic restorations. This work examined 94 onlays equally divided between the two materials on 47 patients. Both types were cemented with a dual-curing resin cement and they were evaluated after 2 years since placement, on the basis of the modified USPHS criteria. Both materials showed a 99% percentage of success and no significant differences were found.<sup>22</sup>

Statistical analysis about the influence of

cavity size shows a different behaviour of one or two surface restorations compared with larger restorations relating to some USPHS parameters: better marginal integrity, greater integrity restoration and lower marginal discoloration. In 2010, Manhart found no significant differences in any parameter comparing composite restorations of molars and premolars.<sup>21</sup>

### Conclusions

The success of an indirect restoration depends on many factors related to materials, operator and patient.

Indirect restorations have a low failure rate and proved to be an excellent choice in treating class I and II lesions.

During the last 6 years the parameters related to these restorations have improved, in particular concerning composite resin. This is probably linked to the use of more reliable materials and greater attention in operating protocols.

The difference in success rates between ceramic and composite restorations does not appear significant.

In conclusion, the use of a material rather than another entirely depends on specific applications.

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## Il successo dei restauri indiretti nei settori posteriori: review sistematica della letteratura

A causa della crescente domanda di restauri estetici, il loro utilizzo anche in aree posteriori è in aumento, dando la priorità alla scelta dei materiali ceramici e compositi, utilizzati con i metodi diretti e indiretti.

I criteri per la scelta per la ricostruzione diretta sono: scarsa distruzione del dente e necessità di un approccio conservativo. Per quando riguarda, invece, i restauri indiretti, si prendono in considerazione la ricostruzione di una o più cuspidi, tutti i casi che richiedono la ricostruzione di classe II cavità con ampie zone interprossimali, un istmo-intercuspidale prolungato per più di un terzo della larghezza della superficie occlusale.

Lo studio di Manhart del 2004 (Tabella I), una review della sopravvivenza clinica di restauri diretti e indiretti in denti posteriori della dentizione permanente, ha esaminato la longevità restauro dei denti posteriori permanenti (Classe I e II di Black) e ha valutato i fattori che possono contribuire al successo o al fallimento di tali restauri.

La revisione comprende studi controllati, randomizzati e retrospettivi dal 1990 in poi su materiali diversi: amalgama, vetroionomeri, oro, compomeri, compositi e materiali ceramici.

Comunque, ai fini di questo studio, vengono analizzati solo i dati relativi al composito indiretto e restauri ceramici. La revisione comprende studi con un minimo di due anni di follow-up e almeno dieci restauri all'ultimo controllo. Lo studio ha esaminato un totale di 12.422 restauri con un follow-up medio di 5,1 anni che mostra un tasso di successo più elevato in materiali ceramici (91,3%) rispetto alle resine composite (86%).

### Materiali e metodi

Abbiamo analizzato gli articoli pubblicati 2004-2013. Ogni articolo doveva rispondere ai criteri di inclusione e di esclusione (Tabella II) proposti dalla revisione di Manhart del 2004.



Le ricerche sono state effettuate su Medline banca dati scientifica utilizzando parole chiave come “inlay e onlay”, “restauri indiretti”, “follow-up”, e “longevità”, e impostando i criteri di inclusione scelti come filtro. Solo studi pubblicati dal 2004 in poi, gli studi in lingue italiana ed inglese e studi definiti come studi clinici e studi clinici controllati sono stati presi in considerazione.

Sono stati esclusi dallo studio i lavori *in vitro*, le ricerche effettuate su cavie non umane le precedenti review della letteratura mentre sono stati inclusi studi con pazienti di ogni età.

Secondo questi criteri di inclusione erano disponibili, 76 articoli i loro estratti sono stati esaminati e solo 39 articoli rispondevano alle esigenze di studio.

I testi integrali sono stati analizzati e sono stati esclusi altri 7 elementi a causa di informazioni incomplete.

I risultanti 32 articoli (Tabella III) sono stati analizzati per la connessione dati e risultati clinici. Abbiamo notato che gli studi hanno adottato diversi metodi di valutazione, USPHS (United States Public Health Service), USPHS modificato e CDA (California Dental Association) criteri.

Sono stati considerati restauri clinicamente accettabili quelli inclusi nelle categorie Alpha e Bravo, quelli cioè che non hanno richiesto alcuna azione durante il controllo.

Sulla base di questi risultati, abbiamo riassunto in una tabella basandoci su una serie di criteri: anno di pubblicazione dello studio, follow-up, tipo di restauro, materiale utilizzato, numero di restauri e pazienti, metodo di valutazione, tasso di successo, cause del fallimento.

Gli studi sono stati poi suddivisi in due categorie:

- a) restauri in ceramica indiretti;
- b) restauri in composito indiretto

per le valutazioni incrociate su materiali diversi. I dati così organizzati sono stati usati per un'analisi comparativa statistica tra le varie tecniche ed poter estrapolare l'efficacia a breve e lungo termine dei restauri indiretti.

I dati più rilevanti delle 32 pubblicazioni selezionate in questo studio sono mostrati nella Tabella IV.

Gli articoli si riferiscono agli anni 2004-2012, 6 articoli riguardano resine composite, 25 materiali ceramici e 1 materiale composito e ceramica.

Sono stati valutati un totale di 5858 restauri in 2377 pazienti.

## Risultati

Abbiamo analizzato un totale di 5858 restauri, 5295 restauri in ceramica e 563 in materiale composito, su un totale di 2377 pazienti.

Il follow-up medio è stato di 5,4 anni. Abbiamo notato che gli studi sui restauri in composito ha mostrato una media di follow-up del 2,6 minore rispetto agli studi di ceramica, 5,9 anni. La media aritmetica del successo è stata del 94%: 94,9% nei restauri in

ceramica e 91,1% in materiali restauri in composito.

La media ponderata è stato considerato in questo studio in modo da dare un peso diverso alle percentuali, in base al numero di campioni esaminati da ciascuno studio.

Il tasso di successo medio ponderato è stato 95,3%, 92,8% per i restauri in composito, 96,3% per quelli in ceramica. I risultati sono riassunti nella Tabella V.

La Tabella VI mostra un confronto immediato tra i risultati ottenuti nel 2004 da Manhart e questa review della letteratura.

## Discussione

I più alti tassi di successo sono stati trovati in restauri in ceramica nonostante il periodo di osservazione più lungo. Le cause più frequenti di fallimento in entrambi i tipi di restauri erano fratture sia di denti e restauro, carie secondarie; e pulpiti.

Questo studio include 32 lavori pubblicati tra il 2004 e il 2013 riguardo restauri indiretti in composito e ceramica con un follow-up medio di 5,4 anni<sup>1-41</sup>.

I dati ottenuti possono essere utilizzati per l'analisi di variazioni determinanti il successo di un restauro indiretto. I più alti tassi di successo sono stati trovati in Spreafico 2004<sup>2</sup>, Coelho 2004<sup>3</sup>, Fabianelli 2006<sup>4</sup>, Indovina 2009<sup>5</sup>, Tagtekin 2009<sup>6</sup>, Mendonça 2010<sup>7</sup> (100%) studi.

Lo studio effettuato da Coelho *et al.* nel 2004 ha esaminato 33 onlay e 53 inlay evidenziando tassi di successo elevati (100%) dopo 2 anni di follow-up, sia in sinterizzato Duceram e restauri in ceramica per pressatura IPS Empress<sup>3</sup>.

Nel 2004, Kramer *et al.* hanno condotto uno studio su 34 pazienti, l'esecuzione di 96 intarsi in ceramica IPS Empress i. Dopo 8 anni, il 92% dei restauri ha soddisfatto i criteri di successo USPHS<sup>8-13</sup>.

Lo studio condotto da Fabianelli *et al.* nel 2006 mostra il tasso di successo più alto tra gli studi sugli intarsi in IPS Empress presi in esame, dopo 3 anni dal collocamento di tutti i 40 inserti non richiedono alcuna sostituzione<sup>4</sup>.

Kramer ha eseguito numerose valutazioni cliniche su restauri in ceramica IPS Empress (2004, 2005, 2006, 2008) in cui ha trovato tassi di successo del 96% in studi con tempi di osservazione più brevi e 90-92% nel follow-up più lungo (8 anni)<sup>13-16</sup>. Nel 2009, Kramer ha analizzato 57 intarsi in ceramica Cergogold dopo 4 anni dal collocamento, i tassi di successo per restauri cementati in cemento composito ad indurimento duale erano 95,2% e per restauri in resina cementata Ormocer erano 93,3%. Questi valori sono simili a quelli ottenuti negli studi precedenti e dimostrano la stessa validità dei due sistemi ceramici pressati<sup>17-23</sup>.

Lo studio di Manhart *et al.* nel 2010 è molto interessante in quanto ha valutato il successo di 3 anni in 75 intarsi in composito Artglass e 80 intarsi in composito micro-ibrido.

La più bassa percentuale di successo tra gli studi è stato trovato da Bartlett *et al.* nel 2006: dopo 3 anni

dal posizionamento sui denti posteriori in malocclusione, il 50% dei restauri in resina composita era fratturato o sono stati persi.

Sjogren *et al.* nel 2004 hanno effettuato uno studio su 27 pazienti con 66 intarsi di classe II in ceramica Cerec, che mostra un tasso di successo del 89% dopo 10 anni di follow-up<sup>8</sup>. Percentuali più elevate sono stati trovati nelle seguenti studi sulla stessa materia: Reich 2004 (97%)<sup>9</sup>, Fasbinder 2005 (95%)<sup>10</sup>, Indovina 2009 (97%)<sup>5</sup>, Bernhart 2009 (95%)<sup>11</sup>.

Il più grande studio sulla ceramica Cerec è stata condotta nel 2006 da Reiss *et al.*, che ha valutato 1011 inlay e onlay dopo 18 anni sperimentando un tasso di successo del 91,5%<sup>12</sup>. Nel 2008, in uno studio sul restauro in ceramica Cerec, Otto ed altri hanno trovato i tempi di sopravvivenza più bassi nei restauri dei molari rispetto ai premolari<sup>24</sup>. Risultati di Manhart circa l'influenza del numero superficie restauro incidenza di fratture sono state confermate. In questo studio, da un follow-up di 17 anni, l'88,7% dei restauri non ha bisogno di alcuna azione. Tale percentuale è leggermente inferiore rispetto a quella rilevata da Reiss (91,5%) nel 2006 in un lavoro con un follow-up di 18 anni con lo stesso materiale<sup>12</sup>.

I risultati di questo studio mostrano tassi di successo più elevati rispetto il lavoro di Manhart nel 2004, preso come guida. Le review della letteratura di cui sopra ha percentuali di tasso di successo nei restauri in ceramica più elevata sia considerando la media aritmetica che quella ponderata.

Dukic *et al.* con il loro studio del 2010 hanno valutato 35 Ormocer e 36 nano restauri in composito ibrido; questo studio ha mostrato un tasso di successo del 100%, misurata sulla base dei criteri USPHS modificati, per entrambi i materiali considerandoli come una scelta eccellente per il trattamento dei denti posteriori gravemente danneggiati<sup>20</sup>.

Arnelund osservò la stessa percentuale di successo (92%), nel suo studio del 2004 su 215 restauri CEREC valutata secondo i criteri CDA dopo 5 anni di osservazione<sup>14</sup>. Alti tassi di fallimento (16%) sono stati osservati nello studio di Frankemberger nel 2008 a lungo follow-up (12 anni); questi fallimenti erano principalmente a causa della frattura della ceramica e della sostanza dentale residua<sup>15</sup>. Le fratture sono risultate essere la principale causa di fallimento, anche negli studi di Kramer 2004<sup>13</sup>, Sjogren 2004<sup>8</sup>, Arnelund 2004<sup>14</sup>, Fasbinder 2005<sup>10</sup>, Reiss 2006<sup>12</sup>, Kramer 2008<sup>16</sup>, Galitsatos 2008<sup>17</sup>, Indovina 2009<sup>5</sup>, Lange 2009<sup>18</sup>.

Questa bassa percentuale di successo è dovuto ai carichi masticatori bruxismo relativi alti e l'impatto della maggiore dimensione verticale<sup>19</sup>.

Lo studio di Kaytan *et al.* nel 2005 ha avuto l'obiettivo di fare un confronto diretto tra i restauri in composito Solidex indirette e dei restauri in ceramica Empress. Questo lavoro ha esaminato 94 onlay equamente divisi tra i due materiali su 47 pazienti.

Entrambi i tipi sono stati cementati con un cemento resina a polimerizzazione duale e sono stati valutati dopo 2 anni dal inserimento, sulla base dei criteri

USPHS modificati. Non c'erano differenze significative tra i due materiali che presentano sia una percentuale di successo del 99%<sup>22</sup>.

L'analisi statistica circa l'influenza della dimensione della cavità mostra un comportamento diverso di uno o due restauri di superficie rispetto ai restauri più grandi relativi ad alcuni parametri USPHS: una migliore integrità marginale, maggiore restauro integrità e minore scolorimento marginale. Nel 2010, Manhart non ha trovato differenze significative in nessuno dei parametri a confronto restauri in composito di molari e premolari<sup>21</sup>.

## Conclusioni

Il successo di un restauro indiretto dipende da molti fattori legati ai materiali, operatore e paziente. I restauri indiretti hanno un basso tasso di fallimento e dimostrano di essere una scelta eccellente sia nel trattamento delle lesioni di prima e seconda classe. Durante gli ultimi 6 anni, c'è stato un miglioramento dei parametri relativi a questi restauri, in particolare per quanto riguarda quelli in resina composita, probabilmente legati alla ricerca di materiali più affidabili e una maggiore attenzione in protocolli operativi. La differenza nei tassi di successo tra restauri in ceramica e composito non appare significativa. In conclusione, l'utilizzo di un materiale piuttosto che di un altro dipende interamente da applicazioni specifiche.

## Riassunto

**Obiettivo.** Valutare l'affidabilità e l'efficacia di intarsi a lungo termine in ceramica e materiale composito, esaminando gli studi scientifici pubblicati 2004-2013. I risultati di questa revisione sono stati analizzati e confrontati con la letteratura importante proposta da Manhart nel 2004.

**Metodi.** Con questa review è stato possibile analizzare un campione totale di 5858, restauri di classe I e II realizzati nei settori altero posteriori: 5295 in ceramica e 563 restauri in composito in 2377 pazienti. I lavori sono stati valutati usando la metodica USPHS, USPHS modificata e con i criteri CDA dopo un periodo medio di osservazione di 5,4 anni (5,9 anni per restauri in ceramica, 2,6 per restauri in composito).

**Risultati.** La media aritmetica del successo era del 94%, superiore per i restauri in ceramica (94,9%) rispetto ai materiali compositi (91,1%). Il tasso di successo medio ponderato è stato 95,3%, 92,8% per i restauri in composito e il 96,3% per quelli in ceramica. I più alti tassi di successo sono stati trovati in restauri in ceramica nonostante il periodo di osservazione più lungo.

**Conclusioni.** I restauri indiretti hanno un basso indice di fallimento e dimostrano di essere una scelta eccellente nel trattamento di lesioni di I e II classe. Durante gli ultimi 6 anni, c'è stato un miglioramento dei parametri relativi a questi restauri, con un aumento del 4% di successo.

PAROLE CHIAVE: Inlay - Denti, restauri - Follow-up.