

CLINICAL FOLLOW UP OF AESTHETIC INLAYS AND ONLAYS: SYSTEMATIC LITERATURE REVIEW**Boukhris Hanen^{1*}, Ben Miled Mariem¹, Hajjemi Hayet³, M'ghirbi Nouha² and Karoui Lassaad¹**¹DDM, Department of Fixed Prosthodontics, Faculty of Dental Medicine, University of Monastir, Tunisia.²Associate Professor, Department of Fixed Prosthodontics, Faculty of Dental Medicine, University of Monastir, Tunisia.³Professor, Department of Fixed Prosthodontics, Faculty of Dental Medicine, University of Monastir, Tunisia.***Corresponding Author: Boukhris Hanen**

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ABSTRACT

Aim: to analyze factors affecting success and failure of indirect bonded partial restorations (IBPR) include inlays, onlays and other partial crowns through a systematic review based on in vivo studies. **Materials and Methods:** A systematic literature review was performed on MEDLINE, via Pubmed interface using Mesh terms and Boolean equations to identify the clinical trial articles dealing with inlays and onlays published from 2003 to 2017. After selection of articles, data was extracted and analyzed by independent authors according to a predefined reading grid. **Results:** Twenty two articles were selected according to the inclusion and exclusion criteria, These articles were based on in vivo studies concerning the survival rate and the main failure factors of inlays onlays. **Conclusion:** In view of this study, data analysis of the retained articles has allowed to show the reliability of IBPR presenting an important survival rate (higher than 90%). Failures exist but their causes are well-identified. A good knowledge of the indications, the materials properties and the preparation and bonding rules are a prerequisite for the success of these restorations.

KEYWORDS: Inlays onlays; ceramics; composite; in vivo clinical studies; systematic literature review.**INTRODUCTION**

Since last decade, the progress witnessed in the field of adhesive dentistry as well as the actual concept of bio-economy of dental substance has allowed the use of more and more conservative treatments.^[1]

Preservation of maximum residual healthy dental tissues has nowadays become the priority in the treatment of tooth structure loss both for anterior and posterior teeth.^[2]

The indications of IBPR, inlays and onlays type, in the posterior sector are actually based only on in vitro studies. In the other hand, few in vivo studies were about their clinical performances and longevity.^[3]

Through this article, an analysis of the international scientific literature based on in vivo studies in relation to the use of inlays onlays was conducted. Later, these restorations were confronted to their real conditions for more or less long periods. Finally, the failure causes, the risks and the benefits of these restorations were identified.

MATERIALS AND METHODS

A systematic review was performed on Medline, via Pubmed interface using the following Mesh words (medical subject Healing) "inlays", "onlays", "ceramics", "composite resins", "clinical studies". Some Boolean equations were formulated by using the Boolean operator "AND". The articles responding to the following inclusion criteria were retained: Articles published in the English Language, clinical trials articles, whose full text is accessible and published during the period of 15 years extending from 2003 to 2017.

In the majority of the studies retained, **USPHS** (United States Public Health Services) and **CDA** (California Dental Association) were the criteria used in the evaluation of the clinical performances of these restorations. These criteria allow the evaluation of the degree of excellence or conformity to the standards.^[4]

The CDA method includes two principle assessments, either "satisfactory" (A or B) or "non acceptable" (C or D), knowing that "A": conforms to standards/"B": to be reassessed/"C": to be preventively replaced/"D": to be immediately replaced.^[4]

In each category, the surface condition, the shade, the anatomic shape and the marginal integrity (to which other sub criteria such as occlusal contour or discoloration are added) are taken into account to evaluate the longevity of the restorations.

The USPHS method uses four scores^[4]

"Alpha": if the restoration does not require any modification and it is clinically unchangeable.

"Bravo" in case of presence of a minor defect without periodontal problems, secondary carious lesion, irreversible pulpitis, minor discoloration changes not requiring intervention or minor repair.

"Charlie": a defect altering the dental structure, the periodontal tissue or the inlay onlay structure :requiring a repair of the restoration.

"Delta": a defect altering the tooth structure ,the periodontal tissue or the inlay onlay structure: requiring replacement of the restoration.

RESULTS

Twenty two international articles published between 2002 and 2017 were therefore selected, based either on in vivo studies or on literature review concerning the survival rate and the main failure factors of inlays onlays in ceramics and /or composite resin.

The relevant data in these articles are presented in table I, II and III considering the materials used ,the bonding materials, the study duration and the number of restorations performed.

* Table I:(7articles):concerning only inlays onlays in composite resin.

* Table II(14articles):dealing with the use of restorations in ceramics.

* Table III(one article):concerns a study comparing inlay onlays in composite resin and in ceramics.

Table I: The different clinical studies related to composite resin inlays onlays.

Authors / year (study's type)	Used materials	Bonding materials	Duration of follow-up	Number of restorations /patients	Survival rate	Number of failures	Results
kukrer et col;2004(A Prospective Clinical Study) ^[14]	Micro-hybrid composite Ceromer	dual-curing resin cements	53 months	99	97.9%	2	Failures 'causes = fracture, Secondary caries 29% of the restorations were placed in patients with parafunctional habits such as bruxism or clenching.
Signore et col ; 2007(A Prospective Clinical Study) ^[8]	Micro hybrid composite:	dual-curing resin cements	6 years	43	93.02%	3	*3 failures: needed endodontic treatment (3weeks, 2months, 5months) *5 IO with a significant increase in marginal discoloration * Bonded indirect resin composite onlays can be successful in treating painful, cracked teeth. From the findings of this study, it appears that cuspal protection should be incorporated into the design of coronal restorations.
Barone et col;2008(prospective clinical study) ^[17]	Micro hybrid composite: Signum composite	a light cured resin composit	3 years	113/30 patients	97.4%	3	3: fracture or loss of marginal integrity *Neither the size of the restorations nor the tooth type significantly affected the clinical outcome of the restorations.. *all IO present a loss of marginal integrity
Manhart et col;2008(a longitudinal randomized controlled clinical trial) ^[11]	Micro hybrid composite: *Composite Artglass *Charisma	dual-curing resin + Solid Bond Twin look 2bond2	3 years	155/89 patients	89.8% Artglass 84.1% Charisma	5 10	15failures: postoperative symptoms,bulk fracture and loss of marginal integrity *No significant differences were recorded comparing premolars and molars *,Small inlays showed significantly better outcome for some of the tested clinical parameters
Huth et col;2011(a longitudinal randomized controlled clinical trial) ^[16]	Micro hybrid composite *Composite Art glass *Charisma	*dual-curing resin cements	4 years	155/89	87.2% Artglass 76.6% Charisma	5 11	16:5 Artglass and 11 Charisma inlays failed because of postoperative symptoms, bulk fracture, and loss of marginal integrity. * No significant differences between both composite resin materials could be detected *The comparison of restoration performance with time yielded a significant increase in marginal discoloration and postoperative symptoms, deterioration of surface texture quality, marginal and restoration integrity for both inlays

							*Small inlays compared to large inlays and premolar restorations compared to molar restorations showed significant better outcome for some of the tested clinical parameters for the Artglass inlays (p<0.05). For Charisma inlays, no such influences were revealed.
Barabanti et col; 2015 (follow up clinical trial ^[19])	composite resin	* dual-curing + light cured resin cement	10 years	48/23	91% Calibra 94% Filtek	2 2	*a comparable clinical performance of indirect composite resin inlays/onlays placed with a light cure or dual cure luting procedures.

Table II: The different clinical studies related to ceramic inlays onlays.

Authors / year (study scheme)	Used materials	Bonding materials	Duration of follow- up	Number of restorations /patients	Survival rate	Number of failures	Results
Sjögren et col;2004 (follow-up study) ^[6]	Felds c: CEREC-CAD CAM	* dual-curing + * chemically cured resin composite	10 years	66/27	89% dual-curing resin 100% a chemically cured resin composite	7	4: fracture of the ceramics 1: fracture of the cusp 1: hypersensitivity (postoperative pain) 1: endodontic treatment * CAD/CAM-manufactured (Cerec) ceramic IO have shown satisfactory results. * The properties of the luting agents seem to affect the longevity of the type of ceramic inlays evaluated. (chemically cured resin composite have fewer failures)
Schulte et col;2005(follow-up study)^[7]	heat-pressed glass ceramic: IPS empress	*a light-curing composite resin.	116 months	810/390	96,7%	27	*5: fracture of the ceramics 1: fracture of the cusp 10:loss of adhesion 10: needed endodontic treatment Factors such as endodontic condition of the tooth, type of the tooth, position of the tooth, extent of the restoration, experience of the operator or gender of the patient had no significant influence on the survival probability of the ceramic restorations. * Heat-pressed glass ceramic inlays and onlays can be used successfully in routine clinical therapy. In addition,

							this type of inlays and onlays can be placed successfully with solely light-curing composite resin.
Krämer et col ; 2005(A prospective controlled clinical study^[15])	CRL IPS empress:	four different resin composite systems	8 years	96/34	92%	8	6: fracture of the ceramics 2: required endodontic treatment * 98% of the surviving restorations exhibited marginal deficiencies, independently of the luting composite Neither the absence of enamel margins, nor cuspal replacement significantly affected the quality of the restorations.
Krämer et col;2006(A prospective controlled clinical study^[9])	IPS empress:	two luting systems : *3MESPE (EBS Multi+Compolute) *IVOCLAR (Syntac+Variolink)	4 years	94/31	96%	4	4: hypersensitivities (3compolute et 1 /Variolink) 55%: of cases had overhangs 38% showed marginal ditching * Between the adhesives ,No differences were found for the surface roughness, color matching, tooth integrity, proximal contact, hypersensitivity, and satisfaction
Krämer et col;2008(A prospective controlled clinical study^[10])	IPS empress	two luting systems : *3MESPE (EBS Multi+Compolute) *IVOCLAR(Syntac+VariolinkIIIow)	8 years	94/31	90%	7	5: hypersensitivities (3compolute and 1 Variolink) 2: fracture * no difference between the two luting systems *Significant deteriorations were found for marginal integrity *Compolute was more prone to wear
Galiatsatos et col;2008(follow up clinical trial)^[13]	IPS empress: Ivoclar Vivadent	* dual-curing resin cements	6years	64/29	93.7%	3	*2:fracture;1: Secondary caries IPS Empress ceramic inlays and onlays are clinically acceptable. However, a disadvantage is the dissolution of the resin matrix of composite resins in oral fluids
Neaselius et col; 2008 (controlled clinical trial)^[9]	--	*dual-cured +chemically cured resin composite cement	4years	130/91	93%	6 s	1: Secondary caries 5: molar fracture Ceramic onlay therapy is an acceptable treatment alternative over a 4-year period * No significant difference between the

							two types of two luting systems (dual and chemically cured resin cement)
Frankenberger et col; 2009 (controlled clinical trial) ^[21]	IPS empress	4 luting systems : Tetric Variolink ultra Variolink low Dual cement	12 years	96/34	84%	15	*12: bulk fractures *Secondary caries was not observed. *significantly more bulk fractures were found when light-curing composite was used for luting *Restorations luted with dual-cured resin composites revealed significantly fewer bulk fractures.
Krämer et col;2009(A prospective controlled clinical study) ^[22]	Cergogold (Degudent)	2luting systems : *IVOCLAR SV(Syntac+Variolink Ultra) *Definite multibond MD+Definite)	4years	57/24	95.2% IVOCLAR 93.3% Ormocer	4	*3:ceramic fracture *1:dental fracture *a statistically significant deterioration was detected for both groups regarding the criteria of marginal adaptation, filling integrity (cracks/chippings/fractures), and tooth integrity *hypersensitivity is more likely to happen with a light-curing composite resin.
ATali et col;2011(clinical evaluation) ^[18]	Leucite reinforced glass ceramic IPS empress	2luting systems : Self adhesive resin cement *etch and rinse multistep resin cement	3years	20/20,	100%	0	*no failure a statistically significant deterioration was found for the critiria marginal integrity,anatomical form and surface roughness *no difference between the two luting systems was detected
Murgueito et col;2012(clinical evaluation) ^[23]	Leucite reinforced glass ceramic IPS empress	*IVOCLAR(etch and rinse multistep resin cement	3years	210/99	96.,67%	7	*7 failures : ceramic fracture (material thickness<2mm) *vital teeth are less likely to fail than non vital teeth *second molars were five times more susceptible to failure than first molars.
Tashner et col;2011(A Prospective Clinical Study) ^[24]	IPS empress:	2luting systems: *3MESPE *IVOCLAR	2years	83/30	-	-	*better marginal and tooth integrity was found in the group of inlay onlay luted with etch and rinse resin cement compared to the use of self adhesive cement. *the dental location does not influence the treatment success

							*there is no significant difference between the two luting systems
Peumans et col;2013(randomized clinical trial) ^[25]	Discilicate of lithium reinforced glass ceramic: IPS empressII	Self-adhesive dual curing resin cement with or without prior etching	4years	62/31	95%	3	2:loss of adhesion 1:fracture *prior enamel etching does not have an impact on the luting quality *an obvious deterioration in the marginal integrity was observed after 4 years in 95% of the cases
Nejatidanesh et col; 2015 (retrospective study) ^[20]	Felds c: 2 blocs *CEREC bloc *Empress CAD bloc	Duolink bisco composite à prise duale	5years	159/109	96% CEREC bloc 94,6% Empress CAD	7	3: ceramic fracture 1:loss of adhesion 3:necessity of root treatment * the location (M or PM) and the size do not have an impact in the treatment success * More failures on depiluted teeth * No significant difference between the two types of blocks

Table III: Comparative clinical study between resin and ceramic inlays onlays.

Thordrup Met col ; 2006 (A Prospective Clinical Study) ^[12]	*direct Ceramic (Cerec Cos 2.0), *direct composite (Brilliant DL, *indirect Ceramc (Vita Dur N), *indirect Composite (Estilux, Kulzer)	--	10years	58/37	80%	12	9 : secondary caries / fractures 3 : persisting hypersensitivity or pulpal damage 80% of restorations were in function after 10 years including the 6 repaired ones(they were repaired for minor fractures) *during the observation period, the surface of vita dur N inlays became significantly rougher *the survival rates were within the range of survival for direct composite restorations.
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DISCUSSION

* In this work, the systematic review has used more than three Boolean formulas in order to guarantee a maximum of in vivo clinical studies dealing with the longevity and the failure factors of IBPR, inlays onlays type. The search was performed on Medline database via Pubmed interface.

* In this review, all the studies agree that IBPR show a survival rate higher than 90% within 10 years and a mean annual failure rate between 2.1 and 20% for the restorations in composite resin and between 0 and 16% for the restorations in ceramics.

* According to the High Authority of Health (HAH), clinical failure is defined by, at least, one of the following situations:^[5]

-Either in case of a fractured or debonded inlay and onlay: in this case the score C or D would be attributed to the restoration (according to CDA) or the score Charlie or Delta (according to USHPS).

-Or in case of an abutment tooth requiring an endodontic treatment (hypersensitivity) or a new prosthetic restoration (following tooth fracture).

* Through the entire studies analyzed, the authors succeeded to highlight the main failure causes of IBPR as well as their onset frequency.

* **The first cause: "Fracture"**^[6-9]

It represents the major enemy to IBPR in cosmetic material and more particularly in ceramics.

This fracture can occur within the material itself indicating an occlusal overload or a defect in the preparation that does not allow enough prosthetic space. This phenomenon can also be explained by a too narrow isthmus or an unrounded angle within the preparation.

It is worth noting that treatment of such fractures differs according to the material of restoration used. Unlike ceramic restorations which necessarily requires its removal on fracture, resin repair remains possible even if it negatively affects its mechanical properties.

The fracture can also occur within the dental tissue. This can be explained by a defect in the preparation, a bad evaluation of the residual tissue resistance, or a defect of the occlusion adjustment. To treat this problem, cusp coverage may be used in case of deep restoration.

* **Second cause: "Hypersensitivity"**^[6,10-12]

It can appear during the first weeks following bonding.

Operator controlled preparation criteria and the extent of carious lesion dictate pulp proximity. Moreover, because of the materials used during the bonding protocol, the pulp is more aggressed and an inflammatory reaction process can be initiated, sometimes reaching the

condition of irreversible pulpitis. To prevent this problem, the use of an immediate dentin sealing during the temporization phase allows not only to limit the risk of postoperative hypersensitivity but also to reduce the risk of bacterial contamination and to increase the quality of adherence after bonding. Thus, the use of a self-etching adhesive seems to be preferable given its low aggressiveness towards the pulp.

Third cause: "Secondary caries"^[9,12,13,14]

* It is a rare factor. In fact in most studies no secondary caries was detected. They generally occur following a loss of marginal integrity.^[10,15]

* In all the studies analyzed, the marginal adaptation defect appeared in the majority of the restorations whatever is the nature of the bonding materials or the restoration. However it seems that this problem is less frequent in case of ceramic restorations and when we use a resin cement with etch and rinse adhesives.

The loss of marginal integrity is clinically reported by marginal discoloration.^[8,11,16] Several hypotheses allow to explain this phenomenon.^[17,18]

- -A lack of bonding to the enamel
- -A dissolution of the resin matrix of the bonding agent in oral fluids due to the bonding material fatigue.
- -A bad polymerization of the bonding material

Through these studies, the authors studied a set of factors and parameters that could affect the survival rate and the longevity of IBPR. Among them, we can cite :

***The choice of the restorative material**

All the authors agree that the materials used in IBPR should present sufficient mechanical resistance to be able to support the **masticatory forces** while being compatible with the bonding procedures.

****Composite resin:** Its weak elasticity resembling that of the dental tissue allows it to play the role of a shock absorber. However, under the effect of the high occlusal forces, resin undergoes a deformation and consequently transmits more constraints to the dental structure. This phenomenon may be at the origin of dental fracture.^[14,17,19]

We therefore note the benefits of nano ceramic resins (e.g. LAVA TM Ultimate proposed by M ESPE) requiring the use of the CAD-CAM technique and offering better mechanical properties.

****Glass ceramics:** It represents the material of choice given its mechanical resistance, its **biomimetics** and its biocompatibility. The restoration is therefore performed either by the CAD-CAM technique or the pressed ceramics technique.^[6,9,18,20]

Thanks to its rigidity, glass ceramics undergo little deformation under the effect of occlusal forces and

reinforce accordingly the tooth-restoration entity. However, it is exposed to a higher risk of fracture. Therefore, It is beneficial to reinforce it using Lithium Disilicate or Zirconium dioxide (eg: SUPRINITY-VITA).

Moreover, ceramics badly support occlusal correction In fact, they are often at the origin of fracture due to the fatigue phenomenon. A meticulous polishing is therefore essential following such retouches.

The luting systems^[9,10]

It is admitted nowadays, that esthetic inlays should be bonded. Bonding is a necessary condition for the longevity of indirect partial restorations. The bonding joint plays the role of stress absorbing and by its thickness, it can influence the internal and the marginal adaptation of the restoration.

Based on the studies dealing with the choice of the bonding materials for IBPR, we can conclude that: -Resin cements with etch and rinse adhesives remain the most used and lead to more reliable results.

-**Self -adhesive resins** have satisfactory results (Rely X Unicem as an example) that can be improved by a **prior enamel etching**. **Dual curing resins** seem to have better luting quality (Variolink is very documented in the studies we analyzed).

The size and location^[11,16]

It is admitted that the importance of the restoration extent represents a risk factor. In fact, the more the width and depth of the preparation increases, the more the residual dental structure resistance decreases.

Concerning the location, there seems to be no difference between the mandible and the maxilla. However, the clinical prognosis seems to be more favorable for the premolars than the molars. In fact, they are more accessible and they undergo less occlusal constraints than the molars It is worth noting, however, that some studies do not show significant differences.

Pulp vitality^[11,20]

It is a real controversial issue. According to some studies esthetic inlays onlays present a better prognosis on the pulped tooth. However this result is not proved in the majority of in vivo studies In fact, we have noticed that several studies showed that pulp vitality has no impact on the longevity of the restoration.

Occlusal overload/bruxism^[14,20]

The presence of an occlusal para-function seems to greatly reduce the longevity of ceramic inlays onlays .We have to be prudent in case of patients with bruxism who need to wear bite splints at night.

CONCLUSION

Data analysis of the retained articles in this systematic review has allowed to show the long-term reliability and

effectiveness of inlays and onlays In fact they have a high survival rate (more than 90%) they prove to be an excellent restorative choice Few complications can be occurred and happily, their causes are well-identified.

A good knowledge of the indications, the materials properties and the preparation and bonding rules should been a prerequisite for the success of these restorations.

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