THE TOOTH-COLOURED INLAY/ONLAY RESTORATIONS – A REVIEW

AA Abdul Razak. The Tooth-Coloured Inlay/Onlay Restorations, Annals Dent Univ Malaya 1998; 5: 17-23

ABSTRACT

Much interest has been generated in tooth-coloured inlays/onlays especially with patient's concern for esthetic appearance and the dentist's appreciation for additional strength of the restored tooth, together with bonding. Many types of tooth-coloured inlay/onlay restorations are available but none have undergone extensive and long term research. The different types of inlay/onlay restorations together with steps in their preparation are presented in this paper.

Keywords: Tooth-coloured inlay/onlay restorations

Abdul Aziz Abdul Razak

Associate Professor
Department of Conservative Dentistry
Faculty of Dentistry
University of Malaya
50603 Kuala Lumpur
Malaysia

INTRODUCTION

Currently, a dentist is provided with many options for restoring a posterior tooth, depending on the clinical situation, esthetic requirements, patient's ability to pay and other factors.

These options include (Table I):

- Amalgam
- Gold
- Apatite
- Ceramics
- Composites

A recent study (1) has shown that mercury, which is released by amalgam fillings in monkeys has induced an increase in mercury- and antibiotic-resistant bacteria in the oral and intestinal floras. This has drawn widespread publicity in the United States. The Swedish National Board of Health and Welfare in August 1992 recommended its government to reduce the use of amalgam by July 1995, especially in teenagers and children. The Austrian Ministry for Health has submitted a recommendation that amalgam fillings not be used in pregnant women and by 1995 not be used in children under 14 years of age (2). An increasing awareness of the risk of mercury to health and the environment has led some patients to reject amalgam as a restorative material. While gold inlays and onlays have excellent durability and biocompatibility, they can be considered unsuitable by many patients for esthetic reasons.

At present, the use of direct posterior composites remains restricted. Even though wear resistance can be achieved with the fine particle hybrid composites suitable for occlusal stress-bearing restorations, restoring posterior teeth with sufficient marginal integrity can still be difficult. Despite the application of the acid etch technique, microleakage does still occur in Class II cavities because of shrinkage stresses during polymerization. The marginal integrity can be improved by use of light-curing with the incremental technique. However, this needs considerable clinical effort. Most researchers therefore agree that direct posterior composite restorations should be restricted to occlusal and small two or three surface cavities (3-5).

The patient's concern for an esthetic appearance and the dentist's appreciation of the additional strength of the restored tooth, and from acid etching and bonding, have generated much interest in the tooth-coloured inlays and onlays. Many researchers and clinicians have the opinion that esthetic inlays and onlays are suitable as an alternative restoration for moderately broken down posterior teeth (6-9).

The cavity design principle for the tooth-coloured restorations differ from that of gold inlay/onlay preparations where all axial walls should be flared between 10° to 15°, without any bevels. The increased taper of the axial walls allows easier placement and removal of the restoration during the try-in stage, but the taper should not be exaggerated so as to unnecessarily remove additional tooth structure. All internal line angles should be rounded to reduce stress-bearing areas and there should be no undercuts. Even if there are undercuts within the dentine, this can be blocked out with a glass-ionomer cement prior to the final preparation and impression. Alternatively, it can be blocked out in the laboratory, on the die, prior to the fabrication of the restoration. During the seating procedure, this space will be filled and bonded with the composite resin cementing agent, restoring cuspal stiffness and strength to the entire tooth. This strengthening effect is caused by the dual bonding of the composite resin to the tooth enamel and to the etched inlay restoration, thus not only providing support for the compromised cusps but also effectively sealing the margins.

All margins for onlays or large inlays should be chamfered or butt-joined. The minimum isthmus width required is 2.0 mm, while the minimum depth from the opposing supporting cusp is 1.5 mm and the wall thickness should be a minimum of 1.0 mm of material for adequate strength.

TYPES OF TOOTH-COLOURED INLAYS/ONLAYS.

There are many types of tooth-coloured inlay/onlay restorations available at present but none has been the focus of significant long term research. However, most of these materials have been used in dentistry for some other purposes.

1. APATITE

In 1986, casting of apatite, which is similar in nature to the composition of enamel was developed and called Cerapearl

Table I. A Comparison of some materials used for posterior restorations

	Amalgam	Gold	Ceramics	Apatite	Posterior Composite	Direct Resin	Indirect Resin
Esthetics	Poor	Poor	Good/excellent	Good/excellent	Excellent. May lack translucency.	Excellent. May lack translucency.	Excellent. May lack translucency.
Clinical Performance	Proven. Single visit. Poor margins but seal themselves.	Proven. Good marginal fit. Does not wear opposing teeth.	Still being proved.	Still being proved.	Still being proved. Similar hardness to tooth structure.	Still being proved. Similar hardness to tooth structure. One visit. No stress on tooth.	Still being proved. No stress on tooth. Similar hardness to tooth structure. Short Chairside time.
Clinical Weaknesses	Metellic. Mercury toxicity. Large tooth structure required.	Metallic. Weakens tooth. Two visits. Tooth preparation critical. Finishing of margin time-consuming.	Requires good margins. One/two visits. Generally wear opposing teeth.	Colour is external. Two visits. Requires good margins. Wear opposing teeth.	Polymerization shrinkage can stress tooth. Long chairside time. Technique is meticulous.	Requires good margins.	Two visits Laboratory performs all construction work.
Laboratory weaknesses (if any)	No laboratory cost.	Requires good margins. Lost wax technique is time-consuming. Material is expensive.	Lost wax technique is time-consuming. Expensive outlay.	Lost wax technique is time-consuming. Expensive outlay.	No laboratory cost.	No laboratory cost.	Needs finishing.
New technology or technique	Not required.	Not required.	New technology.	New technology.	Not required.	Not required.	Not required. Can be made in one operation. Simpler and faster than apatite or ceramic.

(Kyocera International Inc.) (10). The technique is similar to that of cast ceramics. Like cast ceramic, cast apatite is not tooth coloured and therefore needs pigments to be fired onto the surface of the restoration. Being a new material, not much literature has been reported on this system.

2. CERAMICS

Current full-ceramic systems for inlay/onlay restorations can be class)fied according to the manner of production of the restorations which would be vacuum-fired, cast, pressed or CAD-CAM produced.

(i) Vacuum-fired Ceramics

Ceramic inlays has been used since the early l900s. (11, 12). However the new concept in fired ceramic inlay is the bonding of acid-etched porcelain restorations into acid-etched tooth preparations. Although this technique is relatively new, considerable clinical experience has been gained of the porcelain veneer technique. It has not been well accepted because of the problem of poor fitting margins.

The various steps in the preparation are: an impression is made of the tooth preparation; a die is made from die stone; an impression of the die is made by the technician; a refractory investment is poured into the impression; several bakes of low-fusing porcelain are fired into the refractory die in increments until the correct tooth anatomy is formed; the inlay is then removed from the refractory die and fitted onto the stone die by selective grinding and alterations; the margins are finished before the rest of the refractory investment is sandblasted away after staining and glazing; the inlay is then etched with a form of hydrofluoric acid, silanated and ultimately cemented into the acid-etched tooth with dual-curing composite resin cement.

(ii) Cast Ceramics

The first cast ceramic restorative material introduced was that of Dicor, introduced by Dentsply International and developed by Dow Corning (13). Apart from inlays/onlays, this system has also been used for making crowns, laminate veneers, all-ceramic fixed partial dentures and cores for ceramic crowns.

This technique has some similarities to that of the cast gold procedure, whereby, a wax-pattern is made on a die, invested and then removed. Molten ceramic is then cast into the mould; the inlay is allowed to mature in the oven and then a surface sealer containing pigments is fired on the inlay.

Durable and esthetic restorations have been achieved with cast ceramic inlays (14). The adhesive bonding of enamel, composite and the ceramic inlay is achieved by conditioning and silanation of the fit surfaces of the inlay, together with acid etching of the enamel. The disadvantage of this system is that since its surface colour is only surface-stained, any grinding of the restoration will leave an opaque white area; an additional appointment is necessary to fit and adjust the contact area, anatomic form and occlusion prior to staining; once it is stained, the surface cannot be remodified without affecting the esthetics.

(iii) Pressed Ceramics

A new material of the all-ceramic type is the IPS Empress (Ivoclar-Vivadent) which not cast but pressure-pressed and injection moulded. It is a unique leucite-reinforced ceramic. This system uses high- temperature pressing of a precerammed glass ceramic with hydrostatic pressure in a vacuum unit. Restorations are waxed, sprued and invested in a special flask system. The pressed-ceramic restoration is tried on the die and adjusted for contact and occlusion before being finished with microfine rotary diamonds.

Different types of ceramic ingots can be used in either the shaded or layered technique by pressing these materials in a special furnace to fill the invested mould. The pressed-ceramic material is somewhat translucent, so that the color of the underlying tooth structure can be transmitted through it. The ceramic pellets are therefore available in 7 different dentinal shades. External staining can be done either by painting with shade porcelain onto the base-coloured restoration or layering of the Empress anatomic coping for occlusal translucency and individual characterizations. The final restoration can be very esthetic and fit quite well. They can be bonded easily into the preparations and finished rapidly and provide nearly optimum esthetic results and wear characteristics.

IPS Empress has many advantages and its success can be attributed to the many different characteristics that make it an esthetic and precise material. It is reasonably easy to handle, has natural colours, optimum fit, good strength and an abrasion factor similar to that of enamel (15).

(iv) CAD/CAM Ceramics

It was Mormann, Brandestini and Lutz (1987)(16) who developed a computer aided milling system to make ceramic reconstructions. An example of a system, the Cerec 2, allows inlays/onlays, veneers and partial crowns to be produced from ceramic materials, chairside, in one appointment, without having to incur any laboratory costs or the construction of temporary restorations.

The cavity preparation is stereogrammetrically scanned immediately after the preparation has been made. The miniaturized video camera in the scanning head allows the cavity preparation to be seen at a higher magnification on the computer's screen. As soon as the dentist starts the measuring procedure, the computer calculates the parameters necessary to determine the third dimension. The registered data can be saved in the graphic system. The dentist supplies the additional information necessary to define and construct the inlay. The computer uses the data points of the inlay seen on the video screen to calculate its outline. Using this information, a microprocessor controls the production of the ceramic inlay in a miniaturized milling machine. The restoration is cut, using both a milling disc and a cylindrical diamond instrument, from a preformed ceramic block within 4 to 8 minutes with a diamond disc powered by a water turbine.

The restoration's occlusal morphology can be programmed. The resulting fit (marginal width opening) of the inlays produced with the Cerec 1 system, for example, before cementation has been measured to be between 0.0 um to 250 um (17) and did not show any dye penetration after fatigue stress and had good morphologic margin qualities (18, 19).

Cast ceramic inlays, whether laboratory-made or computer aided, are time-consuming and very expensive to make.

(v) Reinforced Conventional Porcelain

When large amount of tooth substances are lost, fabrication of a conventional porcelain restoration is somewhat difficult. Variation in porcelain thicknesses on different tooth surfaces results in differences in sintering shrinkage deformation and poor marginal adaptation.

Traditionally, an even layer of porcelain is created by building up the cavity preparation with a base. However, some of these base materials such as glass ionomer cement are too weak for extremely large core builtups.

To overcome this problem, an impression of the uneven cavity preparation is made and a cast with dies poured. A base of one of the reinforced aluminous ceramic cores is first built up in the large cavity preparation which will support the surface layers of porcelain in the subsequent firings and prevent shrinkage.

One system that is reportedly stronger and more stable than conventional porcelain is Hi-Ceram (Vident). A stronger glass-refilled ceramic system (In-Ceram, Vident) will effectively support large amounts of porcelain. These core materials are built as the base to the conventional ceramic and are stable, so that with subsequent firings, the uneven thickness of the porcelain and the repeated firing process do not result in distortion of the overlying ceramic.

4. COMPOSITE RESIN

In comparison to the direct composite restorations, composite inlays are characterized by improved physical and mechanical properties which are achieved by curing the inlays with different techniques after modelling (Table II & III).

In the inlay technique, polymerization shrinkage of the composite restorative occurs before bonding to tooth structure (20). Any shrinkage that occurs is restricted to the small film thickness of the composite material used for cementation. This has led to the considerable improvement of the marginal integrity of the restoration. Tests on inlays made of modern fine particle hybrid composite showed that such inlays are at least equal to ceramic inlays with respect to esthetics, marginal integrity, abrasion resistance and adhesion to calcified tissues (21, 22).

Composite inlays are less expensive to produce compared to ceramic and gold inlays. Since the technique is simple and uncomplicated, this allows the composite inlay to be made quickly with less effort and in cases where the direct immediate inlays are made, this obviates the need for a temporary restoration.

Table II. Examples of some composite inlay materials.

MATERIALS	TYPE OF MATERIAL	TYPE OF SYSTEM RECOMMENDED	METHOD OF CURING
belleGlass	Hybrid	Indirect	Light+Heat+Pressure
Brilliant	Hybrid	DirectIIndirect	Light + Heat
ClearFil CR	Hybrid	Indirect	Light + Heat
Concept	Microfill	Indirect	Heat + Pressure
Conquest	Hybrid	Indirect	Light+Vacuum+Heat
Dentacolor	Microfill	indirect	W Light
EOS	Microfill	Direct/Lndirect	Light + Heat
Heliomolar	Microfill	Direct	Light + Heat
Herculite XRV Lab	Hybrid	Indirect	Light + Heat
Marathon	Microfill	Direct	Light + Heat
P50	Hybrid	Direct	Light + Heat
Prisma TPH	Hybrid	Direct/Indirect	Light + Heat
Targis	Ceramic-reinforced	Indirect	Heat+Vacuum+Pressure
Tetric	Hybrid	Direct	Light + Heat
True Vitality	Hybrid	Direct/Indirect	Light + Heat
Visio-Gem	Microfill	Indirect	Light + Vacuum

Table III. List of materials and manufacturers of some composite inlay materials.

MATERIALS	MANUFACTURER
belleGlass	belle de St. Claire,Orange, California
Brilliant	Coltene/Whaledent Inc., New York
ClearFil CR	J. Morita Corporation, U.S.A.
Concept	Vivadent, Schaan, Liechtenstein
Conquest	Jeneric/Pentron Inc., U.S.A.
Dentacolor	Kulzer GmbH, West Germany
EOS	Vivadent, Ivoclar Div., U.S.A.
Heliomolar	Ivoclar, Amherst
Herculite XRV Lab	Kerr Manufacturing Co., Romulus
Marathon	Den-Mat Corp, Santa Maria
P50	3M Dental Co., St. Paul
Prisma TPH	DeTrey/Dentsply, Germany
Targis	Ivoclar, Liechtenstein
Tetric	Ivoclar, Amherst
True Vitality	Den-Mat Corp., U.S.A.
Visio-Gem	ESPE, Germany

Composite inlays/onlays can be fabricated by 3 methods:

(i) Direct Immediate Inlay/Onlay

For this method, the composite inlay/onlay is made at the chairside, in one appointment without any need for laboratory work.

The technique is as follows: a matrix and separator medium are placed on the tooth preparation and the composite resin is placed into the cavity preparation, contoured and cured with a light activator; it is then removed from the preparation and the occlusal anatomy improved; the inlay is further cured by heat and/or light and/or pressure; finally, it is cemented into the acid-etched tooth preparation with dual-curing composite resin cement and finished. By aftercuring the inlay at optimum temperatures, using heat, researchers (23, 24) have shown that some physical and mechanical properties such as modulus of elasticity, compressive strength, toughness, diametral tensile strength and dimensional stability, can be significantly improved. These are the main advantages over that of direct posterior composite restorations.

The production of a direct immediate inlay can be difficult. No undercuts must be present in the cavity preparation, since it may be impossible to remove the inlay from the cavity for aftercuring. However, excessive divergence of the walls of the cavity can lead to a greater loss of calcified tissues. Furthermore, deformation may also occur on removing the inlay, which could have a negative effect on stability of the restoration. The exact fit and the proper contouring of the proximal contact areas may also be a problem.

Any posterior composite resin can be utilized to produce a direct inlay, as long as a suitable separator medium is employed.

(ii) Indirect Immediate Inlay/Onlay

This method also allows the inlay to be made and inserted in one appointment. It is an alternative to the direct immediate inlay.

The technique is as follows: an impression is made of the prepared tooth using a fine-bodied silicone model material. Within a few minutes, a cast is readily produced which, like the pin die, allows access to the proximal surfaces and gingival margins and also allows good marginal adaptation. Aftercuring is done by either placing it in a light and heat-curing oven or heat treated in boiling water. This is done without having to remove the inlay from the model. The inlay is shaped and finished at the chair-side.

The above advantages of proximal contouring and better marginal adaptation makes it preferable to the direct immediate method. Another advantage over the direct inlay is that, there is no necessity to place a separator medium over the prepared tooth and premature tooth bonding is avoided (25).

(iii) Indirect Laboratory-Fabricated Inlay/Onlay

For this method, the composite inlay/onlay is made in two appointments. The inlay/onlay is made and processed on a model in the laboratory by the dental technician.

The technique is as follows: an impression is made from the tooth preparation; a stone die is cast from the impression; the composite resin inlay is prepared and contoured in the die and cured with a light activator; the inlay can be aftercured either in a light- and heat-curing oven or heat treated in an oven or in boiling water. At the second appointment, the inlay is cemented into the acid-etched prepared tooth with a dual-curing composite resin cement. Since the technique requires two appointments, it is considered a disadvantage over the one visit direct inlay. Moreover, a temporary restoration needs to be made and this may be time consuming.

Mitchem (1990)(26) compared wear rates of an indirect resin with that of some direct resins over a five year period. The indirect resin had the lowest wear rate, which was less than the direct filling material that exhibited the lowest wear rate of all the direct materials tested. It is interesting to note that the wear rate diminished during the study period. A wear rate of approximately 7 um per year corresponds to natural tooth substance.

Indirect inlays (immediate or laboratory-fabricated) are expected to have larger marginal discrepancies as compared to the direct inlays because of the inherent wetting contraction of both the impression materials and that of the dental stones. The advantages, however, are similar to those of the indirect immediate inlay technique. Another advantage of the indirect inlay system is that, since the majority of unbound monomer and oligomer present in the composite, which are said to be cytotoxic (27), are leached with 24 hours of being submerged in water (28), this will make it more biocompatible (29).

This technique is especially suitable for complex or extensive cavities or when a large number of cavities require restoration. Theoretically, any posterior composite resin restorative can be utilized to produce composite inlays as long as secondary curing and suitable dual-curing resin-based cements are used.

DISCUSSION

Presently, many clinicians avoid or restrict using tooth-coloured restorative materials in the posterior because of some internal problems that may have arisen in the past. These problems include interproximal recurrent caries, high bite sensitivity, marginal leakage and breakdown, poor interproximal contacts and polymerization shrinkage. These problems do occur with bulk composite placement technique (direct technique). By using suitable materials and techniques, predictable long-term results can be achieved.

Studies on posterior bonded restorations have indicated successful 12-year restorations with direct resin such as Heliomolar (30) and 8-year results with indirect, heat and pressure-cured microfills such as Concept (31).

A new technique is being tested using a hybrid resin or a liner under the microfill in order to provide a more etchable surface, as hybrid materials contain glass particles that can be etched and silanated. This will provide micromechanical bonding to the resin cement (32). Bonded restorations can provide patients with ideal functional and esthetic restorations.

As in all techniques, failure do occur. In the direct restorations, bulk placement of the composites may result in eventual failure. However in indirect restorations, bond failure is often a result of microleakage and this can usually be avoided by using the proper cementation technique.

In a study comparing the effect of restorative materials on enamel wear, the results supported the claim that porcelain occlusal surfaces, for example, may be damaging to opposing enamel surfaces. Empress crowns and inlays are said to be enamel friendly, having abrasion resistance similar to that of natural tooth enamel. An in-vitro study on amalgam and enamel showed that wear of IPS Empress on opposing enamel cusp was in the range of enamel and amalgam (33).

Fracture of restorations is found to be minimal. However if this should occur, the adhesive nature of the materials will allow for intracoronal repair. The longevity of the inlay/onlay is extended since the entire restoration need not be replaced (34).

CONCLUSIONS

It has been observed that more and more patients are requesting for esthetic posterior restorations. As dentist, we have the responsibility to offer to our patients a tooth-supportive method to provide esthetic results that our patients demand.

This article reviews laboratory and clinical techniques for the successful preparation and placement of direct/indirect functional esthetic restorations. These materials have given clinicians the ability to conservatively restore and reinforce broken-down tooth structure esthetically. Even though these tooth- coloured inlay/onlay systems are not meant to replace other restorative materials; they do complement other materials and systems and widen the scope of treatment given.

REFERENCES

1. Summers AO, Wiremwn J, Vimy M, Lorscheider F, Marshall B, Levy S, Bennett S, Billard L. Mercury released from dental 'silver' fillings provokes an increase in mercury and antibiotic-resistant bacterial in oral and intestinal floras of primates. Antimicrob Agents Chemoter 1993; 38:825-834
2. Jackson RD. Esthetic inlays and onlays. Current Opinion in Cosmetic Dentistry. 2nd Edition, Current Science. 1994; pp. 30-39.
3. Lutz F. Indikationskatalog fur zahnfarbene Fullungsmaterialien, die sich auf Komposites abstutzen. Phillip Journal 1990; 6:283.
4. Roulet JF, Salchow B, Wald M. Margin analysis of posterior composites in vivo. Dent Mater 1991; 7:44-49.
5. Christensen, GJ. Don't underestimate the Class II resin. J Am Dent Assoc 1992; 123:103-104.
6. Dickerson W. Indirect resin restorations: All the benefits without the disadvantages. Dent Today 1991; 10:32-36.
7. Christensen GJ. A look at the state-of-the-art tooth-colored inlays and onlays. J Am Dent Assoc Dent Assoc 1992; 123:66-70.
8. Wendt SL, Leinfelder KF. Clinical evaluation of a heat-treated resin composite inlay: 3-year results. Am J Dent 1992; 5:258-262.
9. Mormann WH, Krejci I. Computer-designed inlays after 5 years in situ: Clinical performance and scanning electron microscopic evaluation. Quintessence Int 1992; 23:109-115.
10. Christensen GJ. Alternatives for the restoration of posterior teeth. Int Dent J. 1989; 39:155-161.
11. Christensen GJ, Brown TA, Babb R. Accuracy of fit of direct-firing porcelain inlays. J Prosthet Dent 1969; 22(1):46-53.
12. Brinker HA. Simplified porcelain inlays. J Prosthet Dent 1978; 40(1):44-50.
13. Christensen GJ, Christensen RP. New esthetic crowns (Cerestore, Dicor and Renaissance). CRA News 1986; 10(3): 1-2.
14. Roulet JF, Herder S. Ceramic inlays: an alternative for aesthetic restorations in posterior teeth. Todays FDA 1990; 2(6): 1C, 4C-6C.
15. Ratledge DK, Smith BG, Wilson RF. The effect of restorative materials on the wear of human enamel. J Prosthet Dent 1994; 72: 194-203.
16. Mormann WH, Brandestini M, Lutz F. Das Cerec-System: Computer gestutzte Herstellung direkter Keramikinlays in einer Sitzung. Quintessenz 1987; 38: 457-469.
17. Jans H. Marginale Adaptation von maschinell hergestellten Keramikinlays in vitro. Dr med dent 1988.
18. Brandestini M, Mormann W, Lutz F, Krejci I. Computer machined ceramic inlays: In-vitro marginal adaptation. J Dent Res 1985; 64: 208 (Abstr. No. 305)
19. Mormann W, Jans H, Brandestini M, Ferry A, Lutz F.

Computer-machined adhesive porcelain inlays: marginal adaptation after fatigue stress. J Dent Res 1986; 65:763.

20. Ruyter E. Types of resin-based inlay materials and their properties. Int Dent J 1992; 42:139-144.
21. Krejci I, Reich T, Lutz F, Albertoni M. In-vitro testverfahren zur evaluation dentaler restaurationssysteme. Schweiz Monatsschr 1990; 100:953-960.
22. Krejci I. Evaluation von AP.H-komposits und modifizierter glasskeramik als adhesive MOD- molareninlays. Unveroffentlicht, Universitat Zurich 1991.
23. Bausch JR, de Lange C, Davidson CL. The influence of temperature on some physical properties of de Lange C, Davidson CL. The influence of temperature on some physical properties of dental composites. J Oral Rehabil 1981; 8:309-317.
24. Wendt SL. The effect of heat used as a secondary cure upon the physical properties of three composite resins. I. Diametral tensile strength, compressive strength and marginal dimensional stability. Quintessence Int 1987; 18(4):265-271.
25. Donly KJ. Composite resin inlays: A single appointment technique. Am J Dent 1990; 3:181-184.
26. Mitchem JC, Gronas DG. The use of dentures for the evaluation of the abrasive wear of composites. J Dent Res 1990: 69: 126 Special Issue Abstr. No. 142.
27. Anderson DAF, Ferracane JL, Zimmermann ER. Cytotoxicity of combinations of dental composite components. J Dent Res 1987; 66:133 Abstr. No. 214.
28. Ferracane JL, Condon JR. Rate of elusion of leachable components from composite. Dent Mater 1990; 6:282-287.
29. Titus HW, Chan DCN. A comparison of gingival marginal gap formation in composite inlays using three different fabrication techniques. Texas Dent J 1992; 3:13-16.
30. Belvedere P. Heliomolar: over a decade of success with Heliomolar, Signature, Spring 1995: 14- 17.
31. Jackson R. Concept and Empress - an interview with Dr. Ronald Jackson. Signature, Spring 1995: 6-13.
32. Dickerson WG. Improving the Concept restoration. Dent Today 1995, 14:103-104.
33. Goulet MK. Use of the Empress all-ceramic restoration system. Current Opinion on Cosmetic Dentistry, Philadelphia 1997: 64-68.
34. Shannon A. Indirect posterior restorations: steps to clinical success. Current Opinion in Cosmetic Dentistry, Philadelphia 1997; 4: 40-44.