CONSERVATIVE DENTISTRY:
INDIRECT AESTHETIC RESTORATIONS

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CONTENTS

INTRODUCTION

The search for a tooth coloured, metal – free restorative material is undoubtedly one of the greatest challenges of current dental research (1). The following case study deals with the replacement of defective amalgam restorations with tooth coloured metal free restoration as well as the replacement of a missing upper premolar.

Traditionally, crown and bridge restoration have been fabricated almost exclusively of porcelain-fused-to-metal (PFM) combinations and seated without adhesive bonding techniques (5). Over the past decade, dramatic improvements have been made in the materials available for conservative posterior aesthetic restorations. The advent of more predictable dentin bonding has encouraged the use of bonded-all-ceramic (33) restorations in the posterior segment. Consequently, clinicians have numerous material and technical options when selecting the appropriate restorative material for each clinical indication (34).

This paper discusses, in relation to the case study described below, the material properties and aesthetic characteristics inherent to ceramic optimised polymers (ceromers) and fiber-reinforced composite materials and all ceramic systems as well as their appropriate preparations and adhesive techniques for inlay/onlay restorations and bridges.

The case study: a patient with amalgam phobia presents at your dental practice. They request your guidance and expertise to advise on the replacement of the amalgams in her mouth with direct and /or indirect tooth coloured restorations. Upon examination, several of the amalgam restorations display ditching, overhangs, marginal discolouration and leakage and are in need of replacement. The amalgams vary in size from one surface restorations to four surface restorations. In the first quadrant the 15 has a vertical root fracture and cannot be saved. The 16 has a mesio-occlusal-palatal amalgam and the 14 has an occlusal amalgam. There are no financial constraints for this patient.

Patient Evaluation and Examination

Patient awareness and expectations have increased recently to the point that less than optimal aesthetics is no longer an acceptable outcome. (7). In fact one might even ask; Is beauty in the eye of the beholder? It seems as if the modern age with all its technological advancements and media bombardment has set the standards of what is aesthetically pleasing to man. One might even ask the question; is aesthetic dentistry a health science and a health service? (8), or is it the epitome of vanity working its way into a superficial society.

The answer lies in the fact that looking one's best has a direct and an indirect effect on a person's self image, which in turn relates to a good mental health. Therefore today, dental aesthetics is founded on a more ethically sound basis, the general improvement of health.

When planning treatment involving aesthetics it is essential to carefully understand the patients needs, requirements and desires for their teeth. It is extremely important to establish good communication between the clinician and patient early on so that both can work towards the same goals. Excellent communication leads to treatment acceptance (9) with patient understanding the benefits and risks, advantages and disadvantages of each treatment option that is available.

Amalgam Phobia "Fact or Fiction"??

It is therefore crucial to treat the needs of the patient but at the same time to try and explain to the patient that Amalgam can be indicated as a material of choice. This will enable the patient to give the clinician informed consent.

Medical History

A patient's medical history should be carefully assessed. Any relevant medical condition may complicate perioperative or post-operative treatment.

Dental History

Any relevant information may influence future treatment for example any recent treatment or trauma.

Intra-oral Examination

Periodontium

The patient must have a periodontal screening probing to assess their periodontal status. Any inflammation involving the gingival scaffold must be removed prior to treatment. The interface between dental restorations and the surrounding soft tissue is of critical importance for restorative success (10). The performance of aesthetic dental procedures requires as a pre-treatment imperative, the presence of a sound periodontal infrastructure.

Teeth

Assess *Vitality* – cold testing , electric pulp tests etc..

Defective restorations need to be noted and any other *carious lesions* detected need to be charted.

Smile Analysis

The components of a smile consist of the *facial components* (facial features, tooth visibility, upper lip curvature, negative space, smile symmetry and occlusal line) as well as the *dental components* (the dental midline, axial alignment, tooth arrangement, gradation, shape of teeth, contact points and the gingival morphology and contour) and the *physical components*. (11).

There are many factors to consider when conducting a smile analysis: the shape and length of teeth, the lip line, the smile line land the occlusal relationship of the teeth. Each element is an important feature, but only when all of these features are interwoven, aesthetic harmony can be created. (12).

Occulsal Analysis

The occlusion must be assessed whether it is stable or not. The working and balancing cusps of the teeth to be restored must be identified as this will influence the cavity design (for example overlay/onlay preparations as opposed to inlay preparations).

Extra-oral Examination

Besides assessing any of the landmarks and studying different proportions, the patient must be assessed for any regional lymph-adenopathies and associated pathologies. The temporomandibular joint must be examined for any dysfunction.

Diagnostic Wax-up will aid in determining the type of material to be used with respect to the bridge connector dimensions.

Radiographic Examination

Bitewing radiographs need to be taken in order to detect if any interproximal decay is present. Periopical films/radiographs are taken to rule out any pathology associated with any of the teeth to be treated, as well as to determine the Root configuration of Tooth 15.

After an extensive examination a comprehensive treatment plan can now be formulated. Today an increasing number of patients base their selection of a restoration on aesthetic considerations, as well as on holism, since Amalgam and non-precious fusing metals for dental applications have become controversial (17). Even though, porcelain-fused-to-metal (PFM) materials have been clinically proven for individual crowns as well as for multi-unit bridges (2), the metal frame works, are not translucent. This results in a great challenge in the search for a tooth, coloured, metal-free restorative material.

Treatment Options

- The teeth with one surface Amalgam restorations may be replaced with either direct composites or indirect inlays. The latter option may either use all ceramic or ceromer type restorations.

  The teeth with the larger Amalgams can be restored by preparing inlays or onlays (also all ceramic or ceromer restorations can be used). Note in the smaller two to three surface Amalgams can also be replaced by using direct composite materials with the pallodent matrix systems.

  The larger 4 surface amalgams may require full coverage. In such a case all ceramic or ceromer crowns can be used. Note PFM (porcelain-fused-to-metal) crowns may also be indicated in the more posterior high stress areas where aesthetics may not be a concern and high strength is indicated.

- Tooth 15 must be extracted either by a simple extraction forceps or alternatively a surgical removal may be indicated. In the first quadrant many treatment options (for example, three-unit fixed partial dentures, FPDs implant-supported crowns) are available to replace the missing 15. Three-unit metal ceramic, FPDs and implant supported crowns have demonstrated high long-term success rates and are considered the standard care for replacing a missing tooth (20).

  Resin-bonded and fiber-reinforced FPDs have had lower long-term success and may, therefore, be considered as less predictable treatment modalitites (21). Several systems for the fabrication of all-ceramic FPDs have been scrutinized in clinical studies for their success and predictability (22) and since clinical data is limited caution should be exercised when planning these types of restorations (23).

  The missing 15 area can be replaced by either:

  a. a plastic partial denture
  b. an implant

c. a 3 unit bridge using tooth 16 and 14 as abutments

In the case of bridge option a conservative approach can be taken, where the Tooth 14 which has an occlusal amalgam can be used as an abutment by preparing an inlay abutment and the 16 can have an onlay or full coverage.

Treatment Plan

In this case study the following treatment options are to be taken:-

The small one surface Amalgams are to be replaced by direct composite (hybrid type) composite material.

The smaller 2 – 3 surface Amalgams are to be restored with inlays. All ceramic materials are to be used. Or alternatively a ceromer material can be used

The larger faulty Amalgams are to be replaced by preparing overlays (onlays) using all ceramic materials. Or alternatively a ceromer material can be used

A more conservative approach to replace the missing 15 is favoured. An inlay abutment is preferred with regards to the 14 and a full coverage with the 16. Types of material will be discussed in a later section.

Treatment

The initial step consists of removing the defective restorations and eliminating carious tissue. A caries indicator can be used to facilitate removal of all infected tooth structure. After all the decay is removed it should be assessed as to whether any crown lengthening is necessary due to any subgingival decay present. Areas where the decay is subgingival may only require electrosurgery gingivectomy/ensuring proper access to the cervical margin, provided the biological width is not violated.

A multi disciplinary approach can be taken, whereby a periodontist can perform crown lengthening procedures where necessary. The 15 can also be removed by the periodontist or

maxillo facial system. The clinician involved can also assess as to whether the future pontic site may require any soft tissue augmentation procedure in order to enhance the aesthetics.

Preparation Choice

Adherence to a proven clinical protocol and preparation design is critical to the success of inlay/onlay restorations. When selecting either an inlay or an onlay preparation design, the clinician can follow the " ONE-HALF Rule" (3), when the isthmus width is equal to or greater than one half of the buccal lingual intercuspal distance, or in which the preparation finish line falls on or above the halfway point of the cuspal incline ridge, an onlay design is indicated. Other parameters such as occlusal function, position of tooth in the arch and degree of enamel support must be considered.

Preparation Guidelines for Inlays and Onlays

- Smooth finish lines with rounded and soft internal line angles are required for properly fitted inlay and onlay restorations.

Preparation of axial walls should provide roughly 10 degrees to 15 degrees of taper, which can be determined with a 10 degree tapered diamond bur.

Butt joints or shoulder margins are a necessity and must be placed supragingivally. Finish lines should be prepared at 90 degree angles and should not exceed 110 degrees. Beveled and feathered edges should be avoided.

Gingival floor depth should be 1.0 mm to 1.5 mm to provide for interproximal and marginal ridge material strength.

Isthmus width should be 1.5 mm to 2.0 mm in premolar region, molars require 2.5 mm to 3.0 mm.

Pulpal floor depth should be reduced by 2.0 mm to 2.5 mm to provide the technician ample space for aesthetic contours and characterization while maintaining material strength.

For onlay restorations all cusps should be covered with at least 1.5 mm to 2.0 mm of material while maintaining a minimum wall thickness of 1.0 mm to 1.5 mm for optimal strength. The working cusps should be covered by at least 2.0 mm.

The principles for ceramic inlays and onlays are the same as the design of ceromers. These inlay designs may not only be used for single restorations but may also be employed in short span bridges.

Clinical procedures of fixed partial dentures fabricated of ceromer (ceramic optimized polymer) / FRC (Fiber-reinforced composite) or the ceramic only bridge.

In ceromer / FRC bridge fabrication (5) or all ceramic bridges the existing cavities are used as abutments, thereby reducing the loss of substance from bridge preparation. Although in this case study the 14 will require an inlay preparation distally and the 16 will require an onlay preparation including the palatal cusp (working cusp). Cavities are generally box-shaped with diverging 4 degree taper towards the occlusal aspect, at least in the proximal areas. The inner edges as mentioned should be rounded. As the palatal cusp of the 16 should be prepared as an onlay. A crown preparation is unnecessary. If the amount of remaining tooth structure has been minimized full coverage may be required. In the latter case all inner areas should be rounded and the marginal areas chamfered.

The chamfer acts similarly to a short bevel. In an event that any of the teeth involved require endodontic treatment electively or due to a carious exposure the utilisation of contemporary metal free post and core systems can be used to facilitate the aesthetic restorations. White zirconium posts can be used as well as glass fiber posts. The latter allows for the aesthetic restorations to be achieved with success and predictability. It is important for the length, width, bone support and apical seal of the tooth involved to be evaluated. Half of the length of the post must be surrounded by alveolar crestal bone. For a full crown, however, chamfers are easier to prepare than bevels.

The treatment option for an inlay retained three unit bridge may be considered if the following clinical conditions are present:-

a. An aesthetic tooth replacement with conservative tooth reduction.
b. Pontic width of 9 – 12 mm.
c. Implant is not desired by patient or contra-indicated.
d. Metal is contraindicated as a substrate.
e. Caries involvement is minimal.

An important aspect of this preparation is that the tooth position in the arch must allow for wide embrasure reduction as the weak point of the prostheses will be at the interproximal contact points.

Treatment

When selecting the type of material for the FPDs it must be clear that fracture resistance is related to the size, shape and position of the connectors, as well as the span of the pontic. To prevent failure the connectors of the all-ceramic and ceromers, FPDs must be sufficiently high and wide, and in addition the span of the pontic should not exceed a certain length (usually the length of a first mandibular molar). Impressions are taken according to the state-of-the-art crown and bridge principles. Prior to the impression taking, it is advisable to seal dentin tubules with a hybrid layer to protect the pulp from micro organisms and to reduce sensitivity during temporization (13).

Provisionalization (5)

The provisionalization phase is relatively brief, since the restorations are fabricated in the laboratory without an extensive waiting period.

For short-term single-tooth provisional restorations, an elastic light-curing resin (for example, Fermit® Ivoclar willliams) is preferred. In order to prevent this material from adhering to the adhesive, that seals the cavity, the cavity is isolated with a thin water-soluble glycerine gel layer. Elastic provisional restorations may be applied only if the dentin is sealed as they don't seal the cavity.
Full coverage crown preparations, in which the dentin should not be sealed prior to provisionalization, conventional provisional restoration are cemented with eugenol-free temporary cements.

Bridge preparations must be secured with a provisional prosthesis, even for brief periods of time, to prevent movement of the abutments, which could compromise the fit of the definitive restoration.

For short-term provisional inlay bridges, this requires an FRC (Fiber-reinforced composite) pontic to be placed in the prepared cavity and secured with an elastic light-cured resin. For long-term provisionalization , conventional provisional restorations are recommended, to be sealed with eugenol free temporary cements.

Types of Provisional restorations:-

Polymethyl methacrylate (SNAP), and Bis acryl resin composite (Protemp)

SNAP

Advantages:-	Disadvantages:-
Easy to trim	Low surface hardness
Good polishability	Fracture toughness
Minimal exothermix reaction	Durability
Good stain resistance	
Low shrinkage	

Protemp

Advantages:-	Disadvantages:-
Good marginal fit	Surface hardness
Low exothermic reaction	Less stain resistance
Good abrasion resistance	Limited shade selection
Low shrinkage	Limited polishability
	Fracture toughness not high

Shade Selection

Precise colour communication is integral to the development of aesthetic harmony and overall restorative success. The shade of the restoration is made up by three elements. These are:

The hue – the name of the colour; the chroma – saturation or amount of the hue and the value – brightness and darkness.

Technology-based shade selection systems afford the dental community with the necessary information required for predictable shade determination (14). (Examples of digital shade systems are Xrite, shade scan, clearmatch and vita easy shade systems). The vita pan 3D master system is a system used "manually" by the dentist and or the technician which helps to establish the shade by a process of elimination and eventually zoning into the correct shade.

Cementation

The teeth are isolated by means of a rubber dam and the provisional restorations are then removed (15). The cavities are cleaned using hand and sonic instruments and rinsed thoroughly. The restorations are evaluated for marginal integrity and adaptation, appropriate

contact and colour match. In order to avoid post operative sensitivity overdrying and dessication of the preparation is prevented. Once properly fitted, the restorations require surface conditioning. The internal surface is washed and conditioned by either 37% phosphoric acid or sandblasting and thereafter thoroughly rinsed, dried and coated with silane for 60 seconds (4). Tooth preparations are acid-etched with 37% phosphoric acid for 10 to 15 seconds using the total-etch technique to facilitate proper bond strengths (16).

The dentin primer is placed and allowed to penetrate for 30 seconds. A dual-cured bonding resin (optibond, kerr, orange, CA) is applied to all internal surfaces of the preparations as well as the bonding surfaces of the surface conditioned restorations. A mixture of dual-curing, radiopaque and fluoride releasing luting cement (Variolink II Ivoclar vivadent NY) is placed into the preparations and the restorations are sealed. Excess material is removed with an initial cure and thereafter a final curing is performed. Excess cured cement at the margins is removed.

When inlays are placed with the adhesive technique, the weakened cusps are splinted by the bond between ceramic, composite and enamel. The strength in this way is comparable to that of caries-free-teeth (Morin 1988, Jensen 1987) (1).

Restorative Materials

In this case study several options of restorative materials exist. It is not in the scope of this paper to go into great detail of all the material types and their properties. Rather a summary of the different types will follow with a description of which materials were utilized in this study and the reason for their choice.

ALL - Ceramic Restorations

Classification of ALL – ceramic systems:

conventional powder slurry ceramics (optec HSP, Duceram LFC)

castable ceramics (Dicor-glass ceramic material)

machinable ceramics (CAD – CAM restorations, Cerec vitablocs Mark I, II)

pressable ceramics (IPS Empress)

infiltrated ceramics (In-ceram)

The IPS Empress and the In-ceram restorative materials were the options of the all ceramic materials in this study.

The IPS Empress technique was presented as a new method for fabricating all ceramic crowns, inlays and veneers in 1987 (18). IPS Empress is a glass-ceramic material. Once the material has been pressed, leucite crystals measure 54m micro meters in length are homogenously distributed in a glass phase. Therefore the material is called "leucite-reinforced glass-ceramic". In abrasion tests, polished or glazed IPS Empress restorations (16) demonstrated the same properties as natural enamel (19) compared to other ceramics IPS Empress exhibited the most favourable results with regard to marginal leakage. The technical processing of IPS Empress ceramics favourable influences costs. The IPS Empress system has been successfully used in the university of Zurich's dental school since 1988 (1).

In Ceram

This ceramic material is composed of an infiltrated core, veneered with a feldspathic porcelain. The core is initially extremely porous and is composed of either aluminium oxide or spinel (a composition containing aluminium oxide and magnesium oxide). This porous structure is subsequently infiltrated with molten glass. The spinel cores are more translucent than the aluminium oxide cores, but some strength has been sacrificed for translucency (24).

The core is made from fine grained particles (25) that are mixed with water to form a suspension referred to as a "slip" (26). The slip is baked at 1120°C for 10 hours to produce an opaque porous core. Glass powder is then applied to the core and baked 1100°C for 4 hours. During this process, the molten glass infiltrates the porous alumina core by capillary action.

The restorations produced with aluminum-oxide-infiltrated cores have extremely high flexure strength (in the 450 Mpa range (27)); this is the strongest all ceramic dental restoration presently available.

The core is so dense that traditional internal surface etching to improve the bond-to-tooth structure is not possible (28) (The manufacturer recommends sandblasting and the use of a resin cement such as Panavia 21TC for final cementation.) These restorations provide an accurate fit. Because of the opaque alumina core, the translucency of the final restoration may not be as life-like as that seen with other systems. The stronger In-Ceram material would best be suited in the high stress bearing posterior teeth and the softer materials should be used in situations in which tooth abrasion may be critical.

Both the In-Ceram and Empress systems require a recommended connector height of 4mm – 5mm and width of 3mm – 4mm and total surface area of 12mm 2 – 20mm^2 in all-ceramic FPDs.

Ceromers/Second-Generation Indirect Composita Restorations

Due to the limitations in wear and colour stability the 1st first generation indirect composites were gradually abandoned.

A new generation of materials, classified by Toyati as "second-generation laboratory composites" or ceramic optimized polymers (ceromers), has been recently introduced (29). Ceromers are filled as a hybrid material, containing ceramic fillers of different submicrometer sizes. These fine ceramic particles are infused with an organic matrix, yielding a homogenous three-dimensional in organic structure. As a result, these restorations exhibit natural aesthetics, reliable function, wear compatibility and improved wear abrasion.

These attributes are as a result of the enamel-like hardness of the ceromer and its high flexural strength providing the material with a greater ability to withstand heavy occlusal loads and yielding more biocompatible cuspal support (30).

In the larger onlay restorations the ceromer material can be combined with fiber-reinforced composite sub-structure, a light activated, translucent, tooth-coloured framework material. The material exhibits strength and fracture resistance comparable to conventional porcelain-fused-to-metal (PFM) restorations. Those properties, in conjunction with modern bonding systems provide enhanced cuspal support in inlay and onlay restorations (31).

Ceromers/FRC are indicated in areas where the margins of the cavity preparation are supragingival and where a minimum thickness of 1.5mm to 2.0mm in functional areas is attainable. Even though resistance and retention is attained through adhesion, a short clinical crown is contra-indicated.

The Belle Glass (Kerr) and the TARGIS (Ivoclar) can be utilized in this case study to replace the defective amalgams where inlays or onlays are needed. The ceromers can also be considered as an option to replace the missing 15 provided the pontic size has a width not > 9mm. Due to the decreased abrasive wear the ceromers are indicated in areas where tooth "wear" must be guarded.

Belle Glass

Micro hybrid composite which is 74% filled by weight

Comprised of a combination of 2 different materials for dentin and enamel. *Dentin* – barium alumino sillicate glass fillers in BIS GMA resin. *Enamel* – boro sillicate glass fillers in an aliphatic and urethane dimethacrylate resin.

The filler and matrix composition of each material differs.

Polymerization combines 2 different curing systems – Dentin (conventional curing light), Enamel (cured in an oven at 135° C at a pressure of 80 psi in a N_2 environment.

Elimination of O_2 during polymenization enhances the opital properties.

Fiber Reinforcement (connect TM) made up of braided weave of cold glass plasma treated with polyethylene fibres which is twirled around the dye.

Targiss 99

The Targiss 99 is an updated version of Targis. This ceromer is double the flexural strength of ceramics and composites. It is a highly filled system (86% ceramic material). Its durability and fracture toughness is combined with its reparability. The higher filler content provides aesthetics similar to that of traditional feldspathic porcelains. When combined with a fiber-reinforced composite substructure (vectris) it can be utilized for larger onlay restorations.

CONCLUSION

As numerous patients request aesthetic, metal-free posterior restorations, tooth colour restorations are playing an increasing important role in restorative dentistry. The success of the procedure is dependant upon proper case selection, a thorough knowledge of the restorative materials and an understanding and use of meticulous clinical technique. Therefore adherence to a proven clinical protocol and preparation design and material choice is critical to the success of each treatment choice.

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