

**Aesthetic Restorative Dentistry with a
Focus on Indirect Restorations –
A General Dentist's Perspective**

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Introduction

The search for a tooth coloured, metal free, restorative material is undoubtedly one of the greatest challenges of current dental research.¹ Today a vast majority of patients want their amalgam restorations changed to tooth coloured restorations and thus dentists should have the knowledge and a lucid understanding of what materials are available and the techniques involved, whether direct or indirect restorations are required, or a combination of both, so that aesthetic harmony in the mouth can be achieved.

One must bear in mind that aesthetic restorative dentistry can never be learned by means of fixed rules, recipes or patterns. There are simply too many variables. All signs, symptoms and special test information must be considered in the light of basic science knowledge and then analysed logically where the “dis-ease” is located.

Aesthetic restorative dentistry is a very dynamic and an important field in operative dentistry and we as dental care providers can play a major role in improving the appearance of our patients as well as educating our patients to a certain degree as to what is aesthetically pleasing.

Case Study

Let us look at a case study:

A patient with amalgam phobia presents at your dental practice. The patient requests your guidance and expertise to advise her on the replacement of the amalgams in her mouth with direct and/or indirect tooth coloured restorations. During examination, several of the amalgam restorations display ditching, overhangs, marginal discolouration and leakage and are in need of replacement. The amalgams in the mouth 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. The patient has no financial constraints.

In order to compile a treatment plan, a thorough medical and dental history, an intra-oral and extra-oral examination and special diagnostic tests should be done.

Patient Medical and Dental History

A full medical history should be carefully assessed and any relevant information should be recorded, for example, allergies should be noted. Unfavourable gingival reactions to alloys used in the oral environment have been documented. In addition, certain metals have been shown to leak out from alloys used for indirect restorations. Nickel-containing alloys appear to carry the greatest risk. It should be noted that alloy reactions responsible for aberrant gingival changes still appear to be very rare. Salivary glycoproteins may neutralise some of the effects of alloy hypersensitivity. Since contact dermatitis is the most common mode of adverse reactions, the removal of the offending restoration should result in rapid resolution of the gingival irritation.²

Patients smoking habits and diet should also be assessed, since they can cause discolouration to certain restorative materials. The patient's current medications need to be recorded. For example, a patient on hormone therapy can cause an exaggerated gingival response.

The medical history should be followed by a dental history. Careful communication between patient and dentist is essential for the dentist to determine what the patient would like to achieve and if his or her expectations are realistic. Steven Morrow, DDS, Oakland, California, reminds us to maintain complete records. In a court of law, there is no substitute for accurate records.

The oral hygiene care, for example brushing and flossing, of the patient is very important to assess, since the maintenance of the restorative dentistry, especially indirect restorations, for example a bridge's survival and longevity, is going to be reliant to a large extent on home care and maintenance by the patient. The oral hygiene status and patient attitude can help guide us as to what restorations and materials should be used.

After listening to the patient and having recorded down all relevant information, one can proceed to an extra-oral and intra-oral examination, keeping in mind that there is a patient behind the teeth.

Extra-oral Examination

Patients are very sensitive to oral stimulation, so one should use a gentle touch. Placing a hand on their shoulder, for example, works wonders. A gentle touch says “I have to do this to help you, but I care about you”.

After one has donned his gloves, he can no longer place a kind hand on the patient’s non-sterile shoulder. Face masks, eye protection, gowns and gloves tend to depersonalise the dentist/patient relationship, so one should take a moment to establish the “I care” feeling before donning one’s infection barriers.

Firstly a thorough extra-oral examination should take place. One should look for symmetry of the face and the ability to open and close the mouth. Feel for swollen glands and lymph nodes and temporomandibular joint dysfunction. Reference points such as the interpupillary line, the upper lip line, the lower lip line and vertical facial lines should be noted.

During the extra-oral examination, it is an opportune time to evaluate the aesthetic zone. The perfect smile requires an optimal relationship between the lip, gingival scaffold and the teeth.

When a person is smiling, generally the cusps of the upper maxillary teeth should touch and follow the lower lip, and the necks of the upper teeth should follow the upper lip. About $0\pm 1\text{mm}$ of gingiva can be showing between the upper lip and the necks of the upper maxillary teeth. When the patient is smiling, the buccal corridor can be assessed as well as the golden proportion. The golden proportion is a mathematical formula regarding the relationship between harmony and beauty, which was attributed to

Pythagorus. Basically, the golden proportion is a ratio of 1:1.618.³ for example, the width of a lateral incisor is \pm two thirds of the width of the central incisor. This should be kept in mind during the operative stage of treatment.

Intra-oral Examination

In the mouth, examine the soft tissue, the palate and the teeth.

A thorough oral hygiene evaluation and a full occlusal analysis should be done. Ideally a stable occlusion is needed. It is important to note that hyper-occlusion may cause even a normal tooth to be sensitive. When examining the teeth, a full charting should be done.

The following information is vital in helping us establish a treatment plan:

- Position of the teeth in the arch
- Any missing teeth
- Texture of the teeth – attrition – can be due to toothbrush abrasion
- Shape of the teeth – the sex of the patient
- Colour of the teeth – assessing the shade
 - if discolouration exists, a careful detailed examination can be done to determine if possible, the exact aetiology, so that the discolouration can be treated effectively
- Decay, secondary decay – status of existing restorations, especially the amalgam restorations
- Opposing dentition – since these are the teeth the new restorations will chew on, their status is vital
- Rotation/migration of teeth
- Assessing crown lengths
- Vitality testing – on all the teeth should be undertaken. This can be done by using heat, cold or electric pulp testing

If no bleaching is required, then the colour of the patient's teeth should always be recorded before treatment commences. For various cases I get my technician to come into my surgery and help me assess the shade of the patient's teeth. Not only is it beneficial for the technician to assess the colour, but also the shape, size and emergence profile of the teeth to be restored and for the technician to get an idea of what he is going to be working with so that a more knowledgeable indirect restoration can be manufactured. It is vital that a high level of communication between the dentist and dental technician exists.

The study of colour and shade taking is a vast subject in itself and selecting the appropriate shade has always been difficult, as it is dependant on so many factors.

To make things easier for the dentist, there is the new Vita Pan 3D master shade guide, which helps one select shade by lightness, saturation (chroma) and the hue of the tooth. With the developing technology in dentistry, there are new digital shade taking instruments such as x-rite, the shade scan system, the clear match system and vita-easy shade.

Factors that determine shade are:

- The amount of natural light in the area where the shade is taken
- The hue of the tooth colour (yellow or blue range)
- The value of the colour i.e. the lightness and brightness
- Chroma: the strength or weakness of the colour

There are three dimensions of colour: hue, chroma and value.⁴ Hue is the pigment or most commonly called the "colour". Chroma denotes the strength or concentration of the hue and may also be referred to as the colour saturation. Value is the relative whiteness or blackness of a colour and is a qualitative assessment of the grey component. Value is independent of hue or chroma and, in dental shade matching, it is the most important of the three dimensions of colour. Value should be selected first. Rearrangement of the colour guide from the lightest to the darkest shade is recommended to avoid distractions.

Hue selection should be undertaken next. The basic hue can be seen in the middle and cervical thirds. Chroma variations can be perceived within the same tooth. The cervical third usually presents higher than the middle third. The incisal third often presents a lower value when compared with the middle and cervical thirds.⁵

Never forget that it is important to still be communicating with your patient and discussing the patient's perception of aesthetics. If possible, extra-oral cameras and computer imaging can be useful in illustrating to the patients so they can better understand what we as dental care providers are trying to achieve.

The gingival scaffold should be carefully assessed.

One must bear in mind that the composition of a beautiful smile, the form, balance, symmetry and relationship of the elements make it attractive or unattractive. An expanse of soft tissue should not be considered to be unaesthetic per se, but the way this soft tissue is arranged, relative to the teeth and lips, is of aesthetic concern. Thus a high lip line or gummy smile may not be unaesthetic, but due to today's mass media influence, many people consider even the slightest excessive display of gingival tissue unattractive.

Diagnosis is vital in formulating a treatment plan. For example, the gummy smile may be due to either altered passive eruption or vertical maxillary excess. Thus, in a proper diagnosis, one would know to refer the vertical maxillary excess gummy smile for orthognathic correction, whereas the altered passive eruption "gummy smile" could be corrected by gingival surgery.

In our case study the 15 cannot be saved. When assessing that area in the mouth, it should be understood that the loss of tooth 15 since it has a vertical root fracture, is likely to lead to changes in the dimension of its residual ridge. The preservation of facial bone in the maxillary area of 15 is vital to maximise the aesthetic potential of this area to act as a future site, for example a pontic.

Gingival irregularities should be corrected surgically in the area where missing teeth are to be replaced. For aesthetic purposes, the pontic should make light contact with the mucosa of the alveolar ridge. This contact should always be with keratinised attached gingiva. Sometimes the pontic has to be extended over an area of the ridge that is not covered by attached gingiva, then a free gingival graft can be placed to cover this area prior to placement.

To help with formulating a treatment plan, one should do a full mouth radiological assessment. The x-rays should be carefully assessed for any pathology whether bony pathology, dental caries or periapical pathology.

Impressions for study models should be taken. If necessary, a diagnostic wax-up can be done to show how the teeth will appear after completion of treatment, this is done generally for anterior aesthetic dentistry, but can sometimes be used in our case to show the patient what bridge 14-15 would look like, if this was the desired treatment.

One must bear in mind that probably one of the most important principles in maintaining periodontal health around a restoration is the biologic width, which is a measurement from the gingival margin to the crest of the osseous bone. The distance of the biologic width can vary from 2-5mm. Encroachment of a restorative margin results in the initiation of gingival inflammation and bleeding and alternatively leads to gingival recession, apical migration of the junctional epithelium and alveolar bone loss. The biologic width cannot be ignored when any restorations are taken into account.⁶ Thus, all dental restorations should comply with established requirements for the periodontal physiology and health with regard to both surfaces and functional characteristics.⁷

Thus taking everything into account such as the medical and dental histories, the extra and intra-oral examinations, we can finally compile a treatment plan. Our primary treatment objectives are to attain occlusal stability, harmony between gingiva and teeth and the final restoration of the teeth to be treated, bearing in mind that minimum invasive dentistry should try and be achieved.

Treatment Plan

It is important to note that sometimes, for optimal treatment, a multidisciplinary approach involving an orthodontist, a periodontist, an orthognathic surgeon and a restorative dentist should always be kept in mind.

Good communication should exist between the patient and dentist at all times and the treatment plan should be carefully explained to the patient. There should always be signed consent by the patient when the treatment plan has been finalised and explained to the patient.

The following is a brief description of the proposed treatment plan to be done. Please note that in the “materials of choice” section, a more in-depth explanation of some of the treatments done and materials used will be discussed.

Most, if not all, the following procedures should be performed under rubber dam to ensure safety to the gingival tissues and other oral tissues as well as allowing restorative dentistry to be effective, since bonding is very technique sensitive.

1) The Extraction of tooth 15 – If it appears complicated, one should not hesitate to extract the 15 surgically. It might be appropriate to refer to a maxillo-facial surgeon for surgical removal, since ridge augmentation may be implicated. Also, if the patient is happy to have an implant, then the maxillo-facial surgeon would discuss the surgical implications there-of. An implant would prolong the treatment of this patient and so the patient should be informed.

Once the patient has had 15 removed, a provisional restoration should be sought. There are numerous ways of closing the space 15 has left behind. They are:

- An immediate acrylic partial denture
- An immediate temporary bridge, depending on what preparations one has decided for tooth 14 and 16. One could either do a full coverage temporary bridge or an

onlay/inlay prepped 3 unit temporary bridge. One could also do an immediate permanent bridge and cement with temporary cement. Allow for healing and then do a pick up impression, so that the technician could add onto the pontic area to improve aesthetics and make the bridge more oral hygiene friendly.

In our case study, the 14 has an occlusal amalgam and it would be preferable to do an inlay preparation, whereas for the 16 it would be preferable to do an overlay preparation. Healing of the extraction site should be optimal before final cementation of bridge 14-16.

2) Teeth needing root treatments should be treated before restorations are done. Also, root canal filled teeth that show no evidence of healing and those with inappropriate fills should be evaluated for retreatment before restorative therapy.⁸

3) Generally periodontal treatment should proceed operative care, especially when initial scaling and polishing can create a more desirable environment for performing operative treatment. Also, any surgical intervention i.e. gingivectomies or clinical crown lengthenings should be prior to the restorative phase of treatment. One should bear in mind that only when old restorations are removed can one make a decision if surgical intervention should be carried out.⁸

4) If discoloration exists, bleaching should be done before any direct or indirect restorations are to be done. Wait at least two weeks before composite restorations can be done, since bonding is reduced just after bleaching.

5) The patient should be aware that the replacement of the amalgam fillings can take several appointments. Each amalgam that is to be replaced by a tooth coloured restoration should be carefully removed and the loss of tooth structure carefully examined. This will give us an indication of what type of restoration is needed, whether direct or indirect restorations are to be done. For the single surface amalgams, they can be replaced by direct composite restorations. For the 2 surface to 4 surface amalgam restorations, depending on existing tooth structure, overlays, inlays or full coverage crowns can be done. In the next section on “materials of choice” I will give the detail of cavity design and materials used.

6) Provisional restorations will have to be done for the indirect restorations, since it might be 1 week to 10 days before the work is back from the laboratory for final cementation after impressions are taken.

7) Ideally, root treated teeth should either be overlaid or have full coverage crowns, probably porcelain-fused-to-metal crowns. Also post and cores might have to be done. This can be done by stainless steel posts and amalgam, glass ionomer or composite cores. An option is the new aesthetic posts and cores. The posts are bonded into the prepared canals and composite cores are then built up. The new aesthetic fibre posts are viable alternatives to metal posts with regard to strength, rigidity, aesthetics, retrievability and resistance to erosion and fatigue. They are mainly used for anterior teeth. The increased use of all porcelain and ceromer crowns has led to an increased need for tooth coloured post and cores. There are two main types of aesthetic posts, either ceramic posts or fibre posts. The latter is divided into carbon fibre, glass fibre and quartz. One must remember that devitalised teeth are extreme cases of large cavities with undercuts. In the majority of these cases root canal posts are not indicated for the adhesive type of restorations, as they tend to weaken the tooth without providing additional retention.⁹

8) For deep cavities that are close to the pulp, I would place calcium hydroxide covered by a glass ionomer material. If full coverage crowns are indicated and core build up was necessary, I would use either glass ionomer material such as ketac molar or a hybrid composite material.

9) Contouring of restorations/or teeth if necessary – It is important to note that overcontouring of restorations or faulty placement of contour is a much greater hazard to periodontal health than lack of contour, since both supra-gingival and sub-gingival plaque accumulation may be enhanced by overcontoured crowns because an inadequate amount of facial tooth substance was removed during the preparation. Such an overcontour interferes with the sealing effect of the gingiva against the tooth and the self-cleansing mechanism of the gingival sulcus. Another common error is when the technician makes the crown short of the cemento-enamel junction, which results in an anatomically abnormal relationship among the contour of the patient's tooth, the restoration and the gingiva, leading to increased plaque retention at the dento-gingival junction. Overcontouring of composite restorations and bulging and thick margins on crown inlay

and onlay restorations may change the anatomy of the interdental space, enhancing plaque retention there.

10) Permanent bridge 14-16. This can be a fibre reinforced bridge, or an overlay/inlay prepped ceramic bridge, or a full coverage porcelain-fused-to-metal bridge. (details to be discussed)

11) Cementation – the cementation of the inlays, overlays and 3 unit bridge is very technique sensitive. Thus it is imperative here to use a rubber dam. It is important to note that the cementation of the indirect restorations might take several appointments.

12) Once all the restorations are complete, I like to give my patient a light scale and polish. I also spend time at the final cementation visit showing the patient the importance of oral hygiene home care, especially how to maintain a good oral hygiene status for the bridge 14-16.

13) Post operative x-rays are important to take. In this way, one can monitor the teeth treated and to discern if there has been any change at a later appointment.

14) Recall and maintenance

Replacement of the Single Surface Amalgam Restorations

Manufacturers and researchers are always trying to develop materials with the same properties as tooth structure.

Ideal properties of an ideal material are:

- Excellent aesthetic qualities
- Marginal adaptation
- Flexural strength
- Biocompatibility with surrounding tissues
- Abrasion similar to tooth structure
- Affordability
- Easy to manufacture
- Repairable in the mouth

Choosing the material for one's restorations remains a difficult task.

For the replacement of the single surface amalgam restorations, I would use direct composite restorations. One must make sure in the cavity design that there are rounded internal line angles. The walls of the cavity should be divergent. The cavo-surface margins should have no occlusal interferences.

Etching agents used here would be 37% phosphoric acid. Enamel should be etched longer than dentine. Excessive etching of the dentine can produce poor bonding when collagen fibres at the base of the demineralised dentine are not completely impregnated with resin. Furthermore, there is a risk of collagen collapse after etching. Moisture control has been shown to be critical under such clinical conditions. One approach to prevent the risk of defective dentine hybridisation is the use of self etching adhesive systems.⁷

Enamel bonding is predictable after etching with 37% phosphoric acid. The etch creates irregularities in the enamel into which the resin can flow and thus leads to micro-mechanical interlocking after polymerisation. Dentine bonding on the other hand is unpredictable. Dentine is highly permeable, the smear layer, open tubules of dentine and the fact that the pulp is nearby makes bonding to dentine difficult.

I usually use Prime and Bond[®] NT[™] 2:1 by Dentsply as an adhesive. This is a self-priming dentine/enamel bonding agent. Light cure and dual cure with one system. Use a curing light for one-bottle performance. No multiple brushes, mixes and wells are necessary. Acetone based effectiveness for minimal moisture uptake, low film thickness and quick evaporation for a strong dentine structure. There is complete dentine seal. The Prime and Bond[®] NT[™] by Dentsply is a fifth generation bond. It has a thinner hybrid layer (exposed collagen of superficial dentine + adhesive = hybrid layer). It is an improvement on the third generation. The smear layer is either modified or dissolved. There is good demineralisation of the collagen fibres so that the resin can infiltrate, but

the depth of the demineralisation is a lot less than the depth of the demineralisation of the fourth generation, thus causing a lot less sensitivity. It should be noted that we are into our sixth generation of bonding systems. These bonding systems are characterised by the possibility to achieve a proper bond to enamel and dentine using only one solution. Bonding can determine the outcome of the composite resin restoration. Thus, the ideal bonding system should be biocompatible, bond indifferently to enamel and dentine, have sufficient strength to resist failure as a result of masticatory forces, have mechanical properties close to those of tooth structure, be resistant to degradation in the oral environment and easy to use for the clinician.⁹

I would use composite and/or compomers as the filling material for direct restorations. The composites I use for posterior restorations are TPH Spectrum from Dentsply and Restorative Z100 from 3M and Dyract from Dentsply. Also depending on the depth of the cavity, I sometimes use Synergy flow and Dyract flow.

Composite Materials

Although many materials are available on the market, most dentists limit their choice to a few brands. The factors influencing the selection of materials are complex, but cost, ease of manipulation combined with effective marketing by distributors appear to be important factors in the ultimate choice. In this case study, I would use either Dyract (a compomer) or a hybrid composite, depending on the severity of the occlusal stress. It seems that there are however very interesting products out there that I have seen demonstrated but have not yet used.

The composition of resin based composites consist of:

1. Organic phase – which is the matrix and consists of the monomer (Bis GMA), initiator, polymerisation inhibitors and pigments for different shades.
2. Dispersed phase – which is the filler and consists of quartz, alumina silicate, borosilicate glass for strength/reinforcement and barium strontium, zirconium and zinc for radiopacity.

3. Interfacial phase – which consists of coupling agents which connects the resin matrix to the inorganic filler.

Composites are often subdivided into two categories: hybrids and microfills. The successful restoration of a patient's condition often requires the use of both these materials. Hybrid composites consist of several types of filler particles – a glass in the 1 μ m to 3 μ m range that contains radiopaque oxides (e.g. strontium, barium or zirconium) and silica, which generally have a size of a 0.04 μ m. Though noted for their strength and polishability, the initial luster attained on these composites diminishes over extended function. Hybrids provide ease of use, natural refractive indices (that allow light to blend into the tooth) and enhanced physical properties.¹⁰ The hybrid composite resins exhibit superior tensile strength and improved abrasion resistance as well as reduced polymerisation shrinkage, coefficient of thermal expansion and water sorption; they also exhibit greater fracture resistance as well as a result of the inclusion of heavy inorganic fillers.¹¹

Compomers

A compomer is a water free single component, light cured composite consisting of polyacid modified dimethacrylate monomers reinforced with strontium or barium aluminosilicate glass particles. Compomers are very popular because of their unique combination of ease of use, fluoride release, aesthetics and physical properties and the fact it was marketed as a hybrid of composite and glass ionomer cement. The initial setting reaction occurs through light activation of the resin matrix as in a composite. An acid-base reaction between the strontium and the carboxylic groups occurs in the presence of water within the oral cavity, which leads to further cross-linking of the polymer and the release of fluoride.

The following are the advantages and disadvantages of compomers¹²:

<i>Advantages:</i>	<i>Disadvantages:</i>
<ul style="list-style-type: none"> • Ease of placement 	<ul style="list-style-type: none"> • Limited clinical experience and few long term clinical trials
<ul style="list-style-type: none"> • No mixing 	<ul style="list-style-type: none"> • Require boning agent like composites
<ul style="list-style-type: none"> • Easy to polish 	<ul style="list-style-type: none"> • More marginal staining and chipping
<ul style="list-style-type: none"> • Good aesthetics 	<ul style="list-style-type: none"> • Wear more than composites
<ul style="list-style-type: none"> • Excellent handling 	<ul style="list-style-type: none"> • Enormous variation of the products makes longevity difficult to predict
<ul style="list-style-type: none"> • Less susceptible to dehydration 	<ul style="list-style-type: none"> • Weaker physical properties than composites that decrease over time
<ul style="list-style-type: none"> • Radiopaque 	<ul style="list-style-type: none"> • Clinical significance of fluoride release undetermined

Replacement of the Two to Four Surface Amalgam Restorations

For our case study I would do indirect aesthetic restorations to replace the 2 to 4 surface amalgam restorations. There are a number of choices of materials to use. One should use what they are accustomed to, but on the other hand, if one is too scared to lose sight of the shore, one might never discover new horizons.

If inlays or onlays were required, I would either use all ceramic indirect restorations or second generation indirect composites. However, if full coverage crowns are indicated, then I would probably use porcelain-fused-to-metal crowns, but I would consider full coverage second generation composite crowns or full ceramic crowns. This would depend on the amount of stress the teeth implicated would bear.

All Ceramic Restorations

The all ceramic restorations are indicated where aesthetics is needed and when the preparation exceeds the limit for use of direct composite resins.

Classification of All Ceramic Systems¹³

- conventional powder slurry ceramics
- castable ceramics
- machinable ceramics
- pressable ceramics
- infiltrated ceramics
- new groups developing

As you can see, the choices are many. For our case study, I would use the pressable ceramics for example Empress. Empress ceramic comes in ignots of various shades and is melted at high temperatures and then pressed into a lost wax mould. It is veneered with conventional feldspathic porcelain where colour can be added to this. One could also add stains and glazing.

Today we use IPS Empress II, which is a lithium disilicate ceramic and is tightly packed. It has an improved property of fracture resistance. Other properties of Empress ceramic which are really the properties of most ceramics are:

- Excellent aesthetics (no real deterioration over time)
- Clinically very stable
- Thermal conductivity and coefficient of thermal expansion is similar to that of enamel and dentine
- Etchability (ability to be bonded)

The pressed ceramic material is distinguished for its optimised homogeneity, since it is free from porosity and bubbles. This quality is difficult to achieve with other sintered ceramics, even when they are processed with utmost care.¹

It should be noted that with pressable ceramics the flexural strength has been shown to improve under subsequent heat treatments as a result of the growth of additional leucite crystals.¹ The leucite crystal is a result of the reaction of potassium, feldspar and glass matrix. This gives the ceramic good optical profile, strength and helps the thermal expansion of the material.

Its drawbacks are that it lacks fracture toughness, which can lead to micro-cracks. On cooling you find porcelain contracts and can crack on the inside because of low thermal conductivity. It is possible to fix the cracks on the outside by glazing, but cracks on the inside are impossible to fix. The other drawback is the potential to cause abrasive wear of opposing tooth structure.¹

Nevertheless the IPS Empress System has been successfully used at the University of Zurich Dental School since 1988.^{14,15} The results published after three years of clinical work demonstrated a survival rate of 98% for inlays and onlays and 95% for crowns made of the material (Lehner 1992, Studer 1992).

Cavity Design for All Ceramic Restorations

There is no conclusive guideline on when an inlay should be converted to an overlay. The “one half rule”¹⁶ is a good rule to follow. If the isthmus width is greater than half the buccolingual dimension of the tooth, or if the preparation finish line ends on or above the halfway point of the cuspal inclinal ridge, then the restoration should be converted to an overlay.

For onlay preparations the gingival floor has to be a wide gingival floor of at least 1-1.5mm. It must be supra-gingival, to aid in bonding techniques. The cavity must have a butt joint. The isthmus width should be ± 1.5 mm in premolars and can be extended in

molars to 3mm. The cavity should have rounded internal line angles. The depth should be 1.5mm. When overlaying functional cusps, reduction should be ± 2 mm. This allows for thicker ceramic material for increased strength. The gingival box walls should be 60-80° divergent.

The inlay preparations for these materials are similar to that of the overlay preparations. The isthmus width should be 1-1.5mm, with a depth of 1.5mm. There should be a wide gingival floor of 1-1.5mm. If full coverage Empress crowns were indicated, the preparation design is very similar to that of porcelain-fused-to-metal crowns. The crown preparations should have uniform axial reduction of 1-1.5mm. The angle of convergence should be 10-20°. The margin should be placed 0.5mm subgingivally only in aesthetic areas. Occlusal reduction should be 1.5-2mm, remembering to reduce 2-2.5mm on the functional cusps.

It is important to note that when trying in the inlay and overlay of all ceramic restorations, the margins can break off because of sharp internal and external line angles. Therefore, sometimes temporary overcontouring can be done and can be removed after cementation. All IPS Empress restorations should be seated with a translucent or a slightly tooth coloured dual-curing composite cement. An advanced dentin adhesive that closes the dentin tubules should be used to avoid post-operative sensitivity. To achieve an optimum bond to the luting composite, the IPS Empress ceramic is air-abraded or etched with a special buffered hydrofluoric acid. Subsequently, a silonizing agent is applied.¹

When inlays are placed with the adhesive technique, the weakened cusps are splinted by the bond between the ceramic, composite and enamel. The strength achieved in this way is comparable to that of caries-free teeth.^{17,18} The ceramic inlay is also reinforced with the adhesive cementation and demonstrates a higher degree of fracture resistance (Derand 1989).

It should be noted that the dentin adhesive does not have to be specially pre-cured for cementation, since there is little information about the layer formed during this process.

The application of even a small amount in the cavity can prevent the correct sealing of a restoration. The weakest part of a seated IPS Empress restoration is the composite material in the marginal gap.

The technical work of the IPS Empress ceramic in the laboratory is easy to learn and is carried out with minimal effort. The main problems are of a clinical nature; the modified preparation technique for the all ceramic material on the one hand and the sealing of the restorations using the adhesive technique on the other. Never-the-less, if all the guidelines are observed, patients can be assured of satisfaction from all ceramic restorations since over the past years they have been proven successful.

Second Generation Indirect Composite Restorations

Clinical features of the first generation composite resins¹⁹ and the limitation of ceramic materials necessitated the development of improved aesthetic materials for indirect use such as: Artglass (Hareus-Kulzer), Belle glass HP (Kerr), Targis Vectris (Ivoclar), Gradia (GC), Simfony (3M ESPE) and Sculpture (Teneric/Pentron).

Improvements have occurred primarily in three areas, structure and composition, photo polymerisation and fibre reinforcement.

For our case study I would use Belle glass as my choice to replace the 2 surface to 4 surface amalgam resorations.

Belle Glass is a microhybrid containing only small diameter mineral fillers. It is a combination of 2 different materials for dentine and enamel. Polymerisation combines two different curing systems. For the dentine we use a conventional curing light and for the enamel it is cured in an oven at 135°C and pressure of 80psi in a nitrogen environment. The elimination of oxygen during polymerization enhances the optical properties. Its fibre reinforcement is Connect™ branded weave of cold gas plasma treated polyethylene fibres. While fibres imbedded in a resin matrix have been

demonstrated to increase the mechanical strength trials are not as yet available to anticipate the long term performance of these materials.¹⁹

Its properties are:

- Highly opalescent and translucent
- It has a dense surface with a low wear rate
- Highly flexible
- Has a good marginal resistance
- Has a good density

The cavities are prepared according to the preparation design for all ceramic restorations. Care is exercised to ensure adequate stability and an accurate fit for the restoration while preserving the sound tissue.

Immediately following the preparation, the dentin must be protected with a hybrid layer. A total etch technique is subsequently employed for 15 seconds using a 37% phosphoric acid gel. The cavities are rinsed and slightly air dried. A thin layer of primer is applied with a brush on the preparation surfaces for 30 seconds, then dried for 10 seconds. The primer is covered by a thin adhesive layer and light cured for 20 seconds. Prior to taking the impression, it is essential to seal the dentin tubules with a hybrid layer to protect the pulp from the invasion and advance of micro-organisms and to reduce sensitivity during temporisation.

In the laboratory the inner surfaces of the restorations are sandblasted with 50µm aluminium oxide at the lower pressure of 60 psi. At the cementation stage the preparations are rinsed thoroughly to alleviate all abrasion particles. The restorations are tried in and the contact points are adjusted. At this step of the procedure, it is still possible to modify the restorations.

An adhesive resin and the composite resin are used for bonding. Despite the popularity of monocomponent acetone-based adhesive, in an article by Paul Miara, DDS, 1998,¹⁹ the author prefers to use two or three component adhesives with water or alcohol solvents.

The acetone-based adhesive requires accurate moisture control, which is difficult to secure. The excess lack of water may significantly alter the adhesion to the dentine or enamel. The adhesive solvent ensures the rehydration of the collagen. The dual cure composite resin is used as a cementation material. A total etch procedure is performed using 37% phosphoric acid gel. The cavity is rinsed and slightly dried.

The three adhesive component of the system utilised are applied separately and dried slightly. The adhesive is not cured. The inner surfaces of the inlays are sandblasted a second time and coated with saline for 1 minute.

The colour is determined and the dual cure luting resin is prepared. A high viscosity catalyst is recommended. The adhesive of the system has not been polymerised and its polymerisation is initiated by the activation of the photo-inhibitors of the cementation composite. Prior to finishing procedures, the margins and surface defects must be carefully sealed. All the accessible margins are etched and then sealed with a flowable resin. If the layering is properly respected, a satisfactory aesthetic result can be achieved.

Second generation composite material were developed to address the limitations that compromised the success of the previous restorative systems. While the majority of the indirect composite materials are light cured, the Belle glass system has the additional benefit of polymerisation under inert gas pressure.

Porcelain-Fused-to-Metal Crowns

Another option for full crown coverage especially on teeth bearing high occlusal stress would be porcelain-fused-to-metal crowns. The porcelain-fused-to-metal systems are up to 3X stronger than all ceramics. These crowns have a metal substructure with porcelain fused onto it. The Omega 900 metal ceramic has a fine grained structure similar to Empress, which results in high material strength. It has good abrasion characteristics and has excellent chemical resistance in the mouth. The crown preparations are very similar to that of the full ceramics and second generation composite restorations.

Treatment for the Replacement of Tooth 15

My treatment of choice for the replacement of tooth 15 would either be an all ceramic inlay/onlay prepped bridge or a fibre-reinforced inlay/onlay prepped bridge. When utilized in conjunction with adhesive luting techniques, exceptional bridge restorations can be achieved.²⁰ However there are clinical considerations to take into account. The treatment option may only be considered if the pontic width is 9-12mm wide, caries involvement is minimal, metal is contra-indicated as a substitute and that an implant is contra-indicated or not desired by the patient. These types of bridges are also contra-indicated if the mobility of the abutment teeth are >1mm, if they have short clinical crowns and if para-functional habits exist.

The cavity design for this bridge, whether all ceramic or second generation indirect composites, would follow the same guidelines as discussed previously for all ceramic indirect restorations. Also the cementation techniques for these bridges have been discussed previously. An important aspect of the preparation for these is that the tooth position in the arch must allow for wide embrasure reduction; as the weak point of the prosthesis will be at the interproximal contacts. Thus, the critical connector dimensions are very important. We should try and match the 6.25mm surface area at the connection of porcelain-fused-to-metal crowns for the ceramic and ceromer bridges. Available space intra and inter-occlusally should be evaluated.

Three Unit Fibre-Reinforced Bridge

Fibre-reinforced composites have the advantages of aesthetics, low wear of the opposing dentition and the ability to bond the prosthesis to the abutment teeth, thereby compensating for less than optimal abutment tooth retention and resistance form.²¹

The commercially available systems for the laboratory fabrication of fixed prostheses are composed of glass fibres that are impregnated with resin matrix, resulting in strength properties comparable to those of alloys. Non-impregnated materials that are available

for the fabrication of the substructure include polyethylene weaves such as Ribbond (Ribbond, Seattle) and Connect (Kerrlab, Orange, California), and glass weaves such as Glasspan (Glasspan Inc; Exton, PA).²¹

The fibre reinforced prosthesis can either be made with full coverage, partial coverage or a combination of both. The fibre reinforced bridge allows for conservative tooth preparation design when the abutment teeth have modest intercoronal restorations, like in our case study where the 14 has an occlusal amalgam. For our case study I would use Belle glass as the material of choice in the construction of this 3 unit bridge 14-16.

For these bridges, clinical performance is likely to be a function of substructure design. In the mouth, these bridges are subject to complex loading and this is difficult to simulate in the laboratory. Overall concerns regarding these prostheses include their survival time when subjected to moisture and to repeated loads in the intra-oral environment. Specific objective clinical parameters that need to be evaluated are the loss of the structural and marginal integrity, resistance to the occlusal wear and colour stability.

For our case study, we would fabricate a high volume substructure design for the fibre reinforced composite. Previously we have discussed the composition and properties of the second generation composite materials.

In the high volume substructure design, a substantial amount of the fibre-reinforced composite was added to the pontic component. The most recent evaluation of this design now includes a circumferential vertical wrap of the final fibre reinforcement strip in the pontic area, providing an outer layer of fibres that is perpendicular to the majority of the pontic fibres.

It is important to note that width and depth at the connection area of the pontic to the abutment inlay/overlays is very important. In the posterior areas there should be 4mm in length and 4.5-5mm in width.

Also one must bear in mind that ceromer bridges can adapt better to malaligned abutments than conventional bridges or ceramic bridges.

In summary current indications for extra-coronal and intra-coronal polymers prosthesis made with a high volume substructure composed of pre-impregnated, unidirectional fibre reinforced composite are for short span tooth placement. Specifically, these prostheses are indicated when a metal substructure is not desired, when abutment teeth exhibit poor geometric retention form and when abutment teeth are minimally restored.

All Ceramic 3 Unit Bridge

My other material of choice to replace the missing 15 would be an all ceramic 3 unit bridge such as Empress II ceramic.

The fracture resistance of these bridges is related to the size, shape and position of the connectors as well as the span of the pontic. For Empress II the recommended connector height is 4mm-5mm and the recommended width is 3mm-4mm, thus having a total surface area of 12-20mm². The properties and composition for Empress has been discussed previously.

These bridges provide minimal wear to the opposing dentition. It has core material that can be glazed or polished and can touch the soft tissue without causing gingival irritation. The preparation for the cavity design and the cementation technique follow the same guidelines of the all ceramics discussed previously.

Provisional Restorations

Provisional restorations should be mechanically strong and aesthetic. Temporary restorations will always be a source of gingival irritation if they are extended subgingivally. Rough surfaces and rough margins on temporary restorations also will

enhance plaque accumulation and predispose to gingival irritation, even if the restoration does not come into direct contact with the gingival tissue.

Ideal properties for provisional restorations are:

- Convenient handling
- Biocompatible
- Dimensional stability during solidification
- Ease of contouring and polishing
- Adequate strength and abrasion resistant
- Aesthetic colour that is stable
- Good patient acceptance
- Ease of adding to and repair

I mainly use Snap, which is a polymethyl methacrylate. An index impression is taken prior to the preparation with alginate or silicone. Snap has a good polishability, it undergoes minimal exothermic heat increase, it has good stain resistance and has low shrinkage. The disadvantages of Snap is that it has a surface hardness and has a transverse strength and fracture toughness.

There are new and improved provisional materials out there on the market which I would like to try use pretty soon, such as Protemp which is a Bis-acryl composite. The advantages of Protemp are that it allows for good marginal fit, has low exothermic heat increase, has good abrasion resistance, good transverse strength and low shrinkage. The disadvantages of Protemp are that it has surface hardness, is less stain resistant than Snap, has a limited shade selection, has limited polishability and has fracture toughness. I usually use a polycarboxylate cement for my provisional restorations (One should always use a non-eugenol temporary cement).¹⁶

These new provisional materials have cartridge delivery systems which is very advantageous because of the easy automatic mixing and reloading of the syringe with

direct delivery. They are more expensive than the older temporary materials, but the time saved in manufacturing these temporaries justifies their expense.

Conclusion

No current available restorative system can be considered the ideal replacement for natural tooth structure. However, in recent years there has been a great amount of attention given to research on and development of all ceramic and fibre reinforced second generation systems for restorative use.²²

As we grow in years and looking back at dental school days, we can see the rapid advancements in dentistry. It is imperative to keep up and maintain the knowledge that is being developed, as this is constantly changing and growing.

Since every patient case might be different, the dentist has to use his knowledge of aesthetic restorative dentistry in assessing each case. Hopefully with an in depth knowledge and understanding of the mechanisms, techniques and materials involved in aesthetic dentistry will be able to provide optimal treatment and satisfaction for his/her patient.

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