CONSERVATIVE DENTISTRY:
DIRECT AESTHETIC RESTORATIONS

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INTRODUCTION

The following paper discusses the aetiology of tooth discolouration and the management of a case with generalised tooth discolouration and faulty restorations in the " appearance zone". When treating the anterior maxillary segment it is vital to achieve optimal aesthetics while maintaining function.In today's age of "adhesive dentistry " several advances have allowed the dentist to uncover and discover different and new treatment modalities.The aesthetic landscapė has changed for the restorative dentist. More conservative approaches can achieve optimal results both aesthetically and functionally when combining bleaching techniques with anterior direct resin restorations. .

The patient involved in this case presented with intrinsic discolouration of their teeth. In order to establish this , one must be certain that no extrinsic discolouration is involved. The clinician must have a thorough knowledge of intrinsic and extrinsic types of staining. The following classification (see Table 1.1 next page) (3) can help the clinician to make a correct diagnosis and choose the correct treatment plan.

TABLE 1.1 AETIOLOGY OF TOOTH DISCOLOURATION

Extrinsic stains

- Plaque, chromogenenic bacteria, surface protein denaturation
- Mouthwashes, e.g. chlorhexidine,
- Beverages (tea, coffee, red wine, cola)
- Foods (curry, cooking oils and fried foods, foods with colorings, berries, beetroot)
- Dietary precipitate
- Illness
- Antibiotics (erythromycin, amoxicillins)
- Iron supplements

Intrinsic stains

Pre-eruptive

Disease:

Haematological diseases

Liver diseases

Diseases of enamel and dentine

Medication:

Tetracycline stains

Other antibiotics use

Fluorosis stains

Post-eruptive

Trauma

Primary and secondary caries

Dental restorative materials

Ageing

Smoking

Chemicals

Some food stuffs (long-term use causes deeper intrinsic staining)

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THE AETIOLOGY OF TOOTH DISCOLOURATION

Tooth discolouration is a common problem that affects people of various ages. It may occur in both primary and secondary teeth.

The aetiology of dental discolouration is multifactorial. Different parts of the tooth can take up different stains. Extrinsic discolouration increases with age and is more common in men (2). It may affect 31% of men and 21% of women (3).

STAINS DURING ODONTOGENESIS (PRE-ERUPTIVE)

Enamel and dentine of permanent teeth are involved. Enamel defects can be caused by amelogenesis imperfecta, dentinogenesis imperfecta and enamel hypoplasia. The defects in enamel are either hypocalcific or hypoplastic (4).

Enamel hypocalcification is a distinct brownish or whitish area found on the buccal aspects of teeth. The enamel is well formed and the surface is intact. Many of these white and brown discolorations can be removed with bleaching in combination with micro abrasion.

Enamel hyperplasia is developmentally defective enamel. The surface of the tooth is defective and porous and may be readily discoloured by materials in the oral cavity depending on the severity and extent of the dysplasia. The enamel surface may be bleached with varying degrees of success.

Fluorosis

This staining is due to excessive fluoride uptake with the developing enamel layers. The fluoride source can be due to the excessive ingestion of fluoride in the drinking water or from overuse of fluoride tablets or fluoride pastes. It occurs within the superficial enamel and appears as white or brown patches of irregular shapes and form. The acquisition of stains however is post-eruptive. The teeth are not discoloured on eruption, but as the

surface is porous they gradually absorb the coloured chemicals present in the oral cavity (4). Staining due to fluorosis manifests in three different ways:

1. A simple fluorosis
2. Opaque fluorosis
3. Fluorosis with pitting (5)

Simple fluorosis appears as brown pigmentation on a smooth enamel surface, while opaque fluorosis appears as grey or white flecks on the tooth surface. Fluorosis with pitting occurs as defects in the enamel surface and the colour appears to be darker. No intra-oral discolourations occur from topical use of fluoride at low concentrations.

Tetracycline

Tetracycline is a broad spectrum antibiotic used to treat a variety of infections. It is well known that the administration of tetracycline during odontogenesis causes unsightly discolouration of both primary and secondary dentitions. The discolouration varies according to the type of tetracycline used. The staining effects are due to the chelation of the tetracycline molecule with calcium ions in hydroxyapatite crystals primarily in the dentine (6). The tetracycline is incorporated into the enamel and dentine. The chelated molecule reaches the mineralising predentine-dentine junction via the terminal capillaries of the dental pulp (7). The brown discolouration is due to photo-oxidation, which occurs on exposure of the tooth to light. Staining can be classified according to the developmental stage, banding and colour (8).

First degree (mild tetracycline staining) is yellow to grey, which is uniformly spread through the tooth. There is no banding. Second degree (moderate staining) is yellow brown to dark grey. Third degree (severe staining) is blue grey or black and is accompanied by significant banding across the tooth. Fourth degree (intractable staining) has been suggested by Feinman et al (1987) (9), designated for those stains that are so dark that bleaching is ineffective.

All degrees of stains become more intense on chronic exposure to artificial light and sunlight. The severity of pigmentation depends on three factors; time and duration of administration, the type of tetracycline and the dosage (10).

First and second degree staining are normally amenable to bleaching treatments (11). Prolonged home bleaching has been reported in literature to be successful for tetracycline cases. This may take between three and six months or longer.

Illness and trauma during tooth formation

The effects of illness, trauma and medication (for example; porphyria, infant jaundice, vitamin deficiency, phenylketonuria, haematological anaemia) have a cumulative effect creating stains and defects, which cannot be altered by bleaching. With coagulopathesies, discolouration can occur due to the presence of blood with the dentinal tubules (12).

STAINS AFTER ODONTOGENESIS (POST ERUPTIVE)

Minocycline

Minocycline is semisynthetic, second-generation tetracycline derivative (13). It is a broad-spectrum antibiotic that is highly plasma bond and lipophilic (14). The drug is used to treat acne and various infections. After oral administration the minocycline concentration in saliva is 30 – 60% of the serum concentration (14)

Minocycline is absorbed from the gastro-intestinal tract and combines poorly with calcium. Adolescents and adults who take the drug are at risk from developing intrinsic staining on their teeth, gingival, oral mucosa and bones (15). It causes tooth discolouration by chelating with iron to form insoluble complexes. It is also thought that the discolouration may be due to its forming a complex with secondary dentine (16). This discolouration does not resolve after discontinuation of therapy. The resultant staining is normally milder than that from tetracycline and may be amenable to bleaching and lightening, although it is case specific.

Pulpal changes

- Pulp necrosis – this can be the result of bacterial, mechanical or chemical irritation to the pulp, via the dentinal tubules. Substances can enter and cause the teeth to discolour. These teeth will require endodontic treatment prior to bleachng, the latter using the intracoronal method or the outside/inside technique.

- Intrapulpal haemorrhage due to trauma – accidental injury to the tooth can cause pulpal and dentinal degenerative changes that alter the colour of the teeth. Pulpal haemorrhage may occur giving the tooth a grey, non-vital appearance (17). The discolouration is due to the haemorrhage, which causes lysis of red blood cells. Blood disintergration products such as iron sulphides enter the dentine tubules and discolour the surrounding dentine, which causes discolouration of the tooth (18). Sometimes the tooth can recover from such an episode (19) and the discolouration can reverse naturally without bleaching. These discoloured teeth should be vitality tested, because those that are still vital can be successfully bleached using the home bleach technique (see later)

- Dentine hypercalcification – this is due to excessive irregular dentine in the pulp chamber and canal walls. There may be temporary disruption in blood supply followed by the disruption of odontoblasts (4). Irregular dentine is laid down in the walls of the pulp chamber. There is a gradual decrease in translucency of these teeth, which results in yellowish or yellow-brown discolouration. These teeth can be bleached with good results,

Dental Caries

Dental caries may confer a discoloured appearance (20), occurring around areas of bacterial stagnation or leaking fillings. Arrested caries has a brown discolouration because the breakdown products react with decalcified dentine, similar to the discolouration of the pellicle (2).

Restorative materials and dental procedures

Eugenol causes an orange-yellow stain. Endodontic materials and pulpal remnants may cause a grey or pink appearance. Darkening of tooth crowns following root canal treatment has been attributed to silver containing endodontic sealer. Silver amalgam may cause the tooth to take on a grey appearance due to the silver salts that get incorporated into the dentinal tubules. Discolouration in the tooth may be due to the physical presence of the amalgam, corrosion products or secondary decay (21). Colour change alone next to the margin of a restoration should not justify replacement (21). Leaking composite restoration can cause the tooth to appear more yellow (22). Several types of stain adjacent to tooth-coloured restorations are recognised by clinicians. Open margins may allow chemicals to enter and discolour the underlying dentine (4). There may also be white or brown spots of secondary caries. Metal pins and prefabricated posts when placed in the anterior teeth can become visible underneath composite restorations. This causes discolouration of teeth. Removal of these pins and replacement of leaking restorations is indicated.

Ageing

Colour changes in teeth occur from surface and subsurface changes (23). The following factors are encountered with increasing age:

- Enamel changes - thinning and texture changes may occur (24)
- Dentine deposition – second degree and third degree dentine deposition, pulp stones and dentine aging all cause the tooth to appear darker
- Salivary changes – the composition and content of saliva may change with advancing age (23). Bleaching treatment is normally successful in this age group provided there is sufficient enamel available to bleach

Functional and parafunctional changes

Tooth wear may give a darker appearance to the teeth, because of the loss of tooth surface.

- Erosion is the progressive loss of hard dental tissues by a chemical process which causes the tooth or teeth involved to become discoloured as the dentine is more yellow in colour.
- Attrition is defined as the wear of the occlusal surfaces or approximal surfaces of the tooth caused by mastication or contact between occluding surfaces (25).
- Abrasion is defined as the loss of wear of tooth substances or a restoration by factors other than tooth contact (25). It is often caused by "habitual biting" (pipe, hairclip) and is most often by vigorous tooth brushing (26). This loss of enamel causes exposure of dentine which makes the tooth appear more yellow.

Daily acquired stains

Daily acquired stains are typical or the extrinsic stains. They cause superficial colour changes, which are removed by prophylaxis.

- Pellicle – pellicle and calculus on the tooth surface can give a yellow appearance
- Tobacco use- a brown/black appearance due to the products of tobacco penetration in the pits and fissures
- Poor oral hygiene – may result in green, black/brown and orange staining which is produced by chromogenic bacteria (27)

Chemicals

- Chlorhexidine – mouthwash containing chlorhexidine causes superficial black and brown staining of the teeth. The staining is enhanced in the presence of tea and coffee.
- Metals – copper nickel and iron can cause staining of teeth. Workers in copper and nickel industries have shown green staining on the teeth (28). The combination of plaque occurring around metallic orthodontic brackets can cause green line staining. Excessive iron intake can cause cervical staining – usually dark brown or black in colour. The taking of iron supplements can cause black staining of teeth and tongue (29)

- Tanning and chromogens – some stains are easier to remove than others. Different stains required different approaches to removal (12). Biological and environmental variables affect the tenacity of different stains. Tannin stains from tea and coffee are more tenacious and may take three or four power bleaching sessions or a longer period of home bleaching to remove. Tannins are composed of polyphenols (such as catechin and lencoanthocyanins). The gallic acid derivatives in the polyphenols cause yellow-brown stains. The tannins also act as stain promoters (2)

  It may be that tea and coffee in the freshly prepared state cause more staining of teeth and dental restorations than "instant" brands (30). Tea stains glass ionomers more than coffee (31). Chlorhexidine in combination with tea may cause more staining than in combination with coffee.

Before commencing bleaching treatment it is essential to question the patient to determine the aetiology of the discolouration. In some circumstances there may be a multifactoral component as the discolouration can be due to the accumulation of stains and dietary factors over many years.

Patient awareness and expectations have increased recently to the point that less than optimal aesthetics is no longer an acceptable outcome (32). 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? (33) 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. The eyes may be the windows of the soul, but the mouth is the centre of a person's universe. We speak, eat,

smile, breathe through our mouths. Sheets (1987) states that " an impaired self-image may be more disabling developmentally than the pertinent physical defect." (34).

Therefore today, dental aesthetics is founded on a more ethically sound basis: the general improvement of dental health.

When planning treatment involving aesthetics it is essential to carefully understand the patient's needs, requirements and desires for their teeth. This can be achieved by undertaking a full and comprehensive dental and oral examination. It is extremely important to establish good communication between the dentist and patient early on so that both can work towards the same goals. Excellent communication leads to treatment acceptance (35) with the patient understanding the benefits and risks, advantages and disadvantages of each treatment option that is available.

PATIENT EVALUATION AND EXAMINATION

Medical History – patient's medical history should be carefully assessed. Any relevant medical condition may complicate peri-operative or post-operative treatment. Besides a general medical history a more specific history can be taken when assessing a patient with tooth discolouration (see Figure 4.1) (1).

Patients who are pregnant or breastfeeding should be excluded from bleaching procedures because there is a lack of information concerning possible effects on the developing foetus (36)

Dental History- Aetiology of discolouration needs to be assessed because different causes (caries, trauma, internal resorbtion) necessitate different treatments. Extrinsic staining is usually removed with a good dental cleaning and prophylaxis.(Also see Figure 4.1)

SMILE ANALYSIS AND AESTHETICS

The components of a smile consist of the facial components (the facial features, tooth visibility, age, 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 (38).

There are many factors to consider when conducting a smile analysis: the shape and length of teeth, the lip line, the smile line and the occlusal relationship of the teeth. Each element is an important feature, but it is when all of these features are interwoven, aesthetic harmony is created (39).

Tooth Bleaching Questionnaire

I understand that you are interested in having your teeth bleached. Please would you kindly complete the details below so that we can help you to achieve successful whitening of your teeth and a happy smile!

Medical History	Yes	No
1. Are you allergic to plastics or peroxides?		
2. Did you ever take tetracycline antibiotics for any period of time?		
3. Are you taking drugs that dry the mouth?		
4. Are you taking hormones that cause bleeding?		
5. Do you ever have any of the following medical conditions?		
5.1 Any genetic diseases, cystic fibrosis, cerebral palsy		
5.2 Kidney damage		
5.3 Rocky Mountain spotted fever		
5.4 Acne		
As a child		
6.1 Was there any Rh incompatibility when you were born?		
6.2 Did you ever receive a head or neurological injury?		
6.3 Did you ever take fluoride tablets?		
6.4 Did you ever live in a high fluoride area?		
6.5 Did you ever have a vitamin deficiency?		
6.6 Did you ever have any blood diseases such as erythroblastosis fetalis, porphyria, haemolytic anaemia?		
6.7 Did you ever have infant jaundice?		
Do you smoke?		
7.1 If yes how many?		
7.2 How long have you smoked?		
7.3 Have you ever smoked?		
Dental History		
1. Did you ever receive a blow to the face or teeth?		
2. Did you ever have any accidents involving the teeth?		
3. Have you ever bought any over-the-counter bleaching kits?		
4. Are any of your teeth sensitive? Some?.....All?.....		
4.1 Type of toothpaste used		
5. Have you been told or are you aware of any gum recession?		
6. Do you use any mouthwashes on a regular basis?		
7. Have you noticed that your teeth have become more yellow over the last few years?		
8. Do you grind your teeth?		
9. Do you suffer from facial pain?		
10. Do you have temporo-mandibular dysfunction?		
11. Do you wear a bite plate?		

Diet	Yes	No	Amount per day
Do you eat any of the following?			
1. Curry			
2. Berries when in season			
3. Fried foods			
4. Which oil do you use to fry your food?			
Do you drink any of the following?			
5. Coffee			
6. Regular tea			
7. Herbal tea			
8. Coca-cola or Diet Coke			
9. Red wine			

Figure 4.1

Tooth bleaching questionnaire.

Component of a smile

Garber and Salama (1996) (40) discuss three essentials of a smile involving the relationships between the three primary components.

1. The teeth – the shade and shape
   position, length and axial alignment
   tooth surface characteristics and morphology
   the shade and shape of opposing teeth
   the occlusion and occlusal line
   the dental midline; this is an imaginary line that separates the two central incisors
   the surface texture, for example, perikimata stippling, rippling. (Note the surface texture will NOT change with bleaching).

When establishing beauty and harmony of a smile, the "golden proportion" (1:1, 618) can be utilized for the relationships of the widths of the anterior teeth. The central and lateral incisors are found to show this golden proportion.

2. The lip line – the amount of tooth exposed during a smile
   - the smile line, a hypothetical curve line drawn along the edges of the four anterior maxillary teeth that should run parallel with the curvature of the inner border of the lower lip (38)
   - the upper lip curvature, the position of the upper lip height relative to the teeth
   - negative space- the dark space that appears between the jaws when laughing and speaking
   - the smile symmetry, the symmetric placement of the corners of the mouth in the vertical plane.

3. The gingival scaffold
   the gingival height of contour (canines and centrals same length)

appearance of gingival tissues

symmetry of the heights of the central incisors

incisal and gingival embrasures.

Extra-oral Examination

Besides assessing any of the landmarks and studying different proportions the patient must be assessed for any regional lymph adenopathies as well as the temporomanidbular joint for any dysfunction.

Intra-oral Examination

The existing condition of the teeth and periodontium needs to be examined prior to further treatment. Defective restorations need to be noted. The teeth need to be assessed for:

- Thickness of enamel
- Existing gingival, cervical recession
- Existing sensitivity prior to bleaching needs to be noted
- The translucency of teeth. Translucent teeth still remain their "blackish" look after bleaching (36). Patients need to be told of this to avoid disappointment
- White spots or opacities, these do not disappear during bleaching and in early stages of bleaching may become more visible. Patients need to be warned about this.
- Teeth that are banded due to tetracycline staining or desiccation still retain their banded appearance after bleaching
- Although bleaching teeth improves gingival health, bleaching treatment should not be attempted on teeth surrounding gingivitis or more severe gingival problems (41)

Periodontal probing is one of the most neglected of the diagnostic tests (42). As mentioned previously one requires a healthy periodontium to optimise aesthetic dentistry.

Therefore any inflammation involving the gingival scaffold must be removed prior to treatment.

Occlusion

An occlusal analysis must be performed to assess whether the occlusion is stable or not.

Special Tests

Vitality testing of all teeth to be treated should be undertaken. This can be done by using the temperature tests such as heat or cold or through electric pulp testers. All tests need to be recorded.

Radiographs – recent radiographs need to be used to check for pathology or existing decay of all teeth prior to treatment. Teeth with existing periapical pathology can develop exacerbations after bleaching, which may be difficult to treat endodontically. Single dark teeth or a darker tooth may be non vital and may consequently change the sequence of treatment. Size of pulp can also be assessed which may contraindicate bleaching if the pulp is very large

Diagnostic wax-up – this may be necessary inorder to communicate to the patient how the teeth may appear after total treatment.

Photographs - pre operative photographs can aid the dentist to evaluate the smile and the different proportions of the patient's general aesthetics.

TREATMENT PLANNING

After a comprehensive examination, one should be able to reach a diagnosis and formulate a treatment plan with the different treatment options. The information for this case study was as follows:

- Generalised intrinsic discolouration
- Discoloured composite restorations on the mesial and distal surfaces of the maxillary anterior teeth
- Tooth 11 is non vital and slightly discoloured than the rest. The endodontic treatment of 11 is acceptable.
- Tooth 12 is vital and has a porcelain fused to metal crown. The colour of the crown is in "harmony" with the rest of the discoloured teeth.

The following treatment options are suggested:

1. Generalised discolouration is to be bleached, either using just a home bleaching technique or a power bleaching , In-office technique. The latter can be combined with home bleaching programs (43)
2. The restorations of teeth 13 | 21: 22, 23 should be replaced: direct bonded restorations can be performed either using composites or compomers. It should be noted depending on the remaining tooth structure other types of restorations may be indicated. Where there has been large tooth destruction full coverage restorations may be required.
3. The non vital tooth 11 will require non vital bleaching;
    (a) a walking bleach should be attempted first for the intra-coronal bleaching or
    (b) the inside/outside bleaching technique also known as the modified walking bleach technique (44) (refer to Clinical Procedures later) After bleaching the access cavity can be filled with a glass ionomer or composite restoration. (note tooth 11 may require full coverage and possibly a post-core, depending upon the remaining tooth structure available)
4. Tooth 12 must be replaced with a new crown

It is very important that the different procedures are in the correct sequence. Placements of restorations should be delayed for at least 24 hours after completion of the bleaching (45). Ideally it should be postponed for one week after treatment (46). Several studies have shown a decrease in bond strength for teeth bonded immediately after bleaching (47). Delaying bonding procedures is also important to compensate for the possible shade relapse after bleaching treatment is completed. It is essential to warn the patient that bleaching will not change the shade of the composites even though sometimes those composites that have a black edge appear whiter because the blackening disappears after bleaching.

An approach involving a combination of bleaching and resin restorations is more conservative and less expensive than treatment with porcelain laminates or crowns. Composite restorations may also be repaired or replaced with minimal difficulty and little tooth loss.

CLINICAL PROCEDURES (1)

A conservative approach should be communicated to the patient. An alginate impression should be taken of both the maxillary and mandibular arch in order to construct customised bleaching trays. The trays are trimmed horizontally 2 –3 mm from the gingival margins in order to enhance the seal. A high viscosity, 10% carbamide peroxide gel (opalescence) is used to ensure retention of the gel). The patient is instructed to apply the gel for 8 hours daily. The home bleaching regime is followed for 3 weeks. The patient must come in weekly for a control examination. The vital bleaching technique should eliminate/improve the generalised discolouration. One may also perform a combination of power bleaching (in office) with home bleaching treatments. This procedure is commonly used to motivate the patients to comply with home bleaching protocols and continue the process at home. Normally one or two power bleach in-office sessions are undertaken. The patient is then given the home bleaching instructions, the tray and sufficient material to continue the bleaching process at home. The non vital tooth 11 can either be treated concurrently with the vital bleach by means of the

inside/outside bleaching technique (modified walking bleach technique). This technique combines the intra-coronal bleaching technique with the home bleaching technique. After barrier replacement the access cavity is left open so that the bleaching material, which is normally 10% carbamide peroxide can be placed into the pulp chamber while the bleaching tray is applied to the tooth to retain material on the tooth. Bleaching can thus take place internally and externally simultaneously.

Alternatively a non-vital bleaching technique with 35% hydrogen peroxide can be used. The tooth is isolated by rubber dam, then access to the root canal is obtained. A glass ionomer approximately 2mm thick is used to cover the Gutta Percher. A paste of 35 % hydrogen peroxide and sodium perborate is mixed and applied inside the pulp chamber. A glass syringe with hydrogen peroxide is used to rinse the paste which is reapplied four times. At the last application the paste remains inside the coronal part of the tooth and a temporary filling is left in place. The procedure is repeated in 5 days.

Once the "bleached" shade of the teeth is established a colour is selected for the final restorations, involving the mesial and distal surfaces of the anterior maxillary teeth.

Factors involved in shade determination

There are three dimensions of colour: hue, chroma and value (48). Hue is the pigment or commonly known as the colour, chroma denotes the strength or concentration of a hue and may also be referred to a colour saturation, value is the relative whiteness or blackness of a colour and is a qualitative assessment of the grey component. The value should be selected first, then hue and lastly the chroma. The shade should be taken for the future composites while the rubber dam is off as the teeth dehydrate and change shade while under isolation.

While under rubber dam, the old composite restorations are removed with a high speed drill with copious water spray. Any recurrent decay is removed. Facial and lingual bevels are placed with a medium grit diamond stone at slow speed. After 37% phosphoric acid is applied and then removed by water spray to the cavity and its margins.

One must be careful not to over dry the cavity causing the collapse of the collage fibers and thereby decreasing the bond strength. A bonding agent, such as a 5th generation one bottle solution, is then applied and light cured. Either a composite or compomer is then placed in increments no thicker than 2mm. Each increment is polymerised for 20 seconds with a visible light curing unit (blue light). Initial finishing is accomplished with aluminium oxide discs. Excess cervical margins and line angles are removed with a number 12 scalpel blade. The interproximal areas are finished and polished with different grades of aluminium strips. Finally, the restorations are to be polished with different grades of silicon dioxide rubber cups.(1)

Tooth 12 will be replaced with either a crown with a porcelain core or a metal fused to porcelain crown. It is not within the scope of this discussion to describe materials of choice.

MATERIALS AND THEIR PROPERTIES

The materials of choice in the management of the discoloured dentition and the restorations of the teeth can be divided as follows:

- Bleaching agents
- Anterior direct aesthetic restorative materials
- Bonding agents
- Etching liquid/gels

Bleaching Agents

Carbamide Peroxide – Carbamide peroxide in a 10% aqueous solution is used in most of the home bleaching kits. This breaks down to a 3.35% solution of hydrogen and 6.65% solution of urea. A 35% solution of carbamide peroxide is also available to be used by dentists as in office procedure prior to the patient using the home kit. The 35% solution yields 10% hydrogen peroxide which can cause soft tissue damage and therefore using a rubber dam or a soft tissue protectant is essential.

Hydrogen Peroxide- most bleaching agents contain hydrogen peroxide in some form. The hydrogen peroxide breaks down into water and oxygen. It is the oxygen molecules that penetrate the tooth and liberate the pigment molecule causing the tooth to whiten

Thickening agent – Carbopol (carboxypolymethylene) helps release oxygen slowly. The slow solutions require 2 – 3 hours for maximal oxygen release, but remain active for up to 10 hours (50). The Carbopol enhances the viscosity allowing better retention of the slow releasing gel in the tray. The viscosity also improves adherence to the tooth. Carbopol retards the effervescence because it retards the rate of oxygen release. The increased viscosity seems to prevent the saliva breaking down the hydrogen peroxide.

Urea – urea is used in bleaching kits to stabilise the hydrogen peroxide (51). It elevates the pH of the solution and enhances other desirable qualities such as anticariogenic effects, saliva stimulation and wound healing (52)

Vehicle – (Glycerine) Carbamide peroxide is formulated with glycerine base that enhances the viscosity of the preparation and ease of manipulation. This may dehydrate the tooth and when swallowed may cause throat irritation.

Surfactant – the surfactant functions as a wetting agent allowing the hydrogen peroxide to diffuse across the gel-tooth boundary.

Mechanisms of Bleaching

Peroxide solutions flow freely through the enamel and dentine due to the porosity and permeability of these structures. The free movement is due to the relatively low molecular weight of the peroxide molecule and the penetrating nature of the oxygen and superoxide radicals. The hydrogen peroxide acts as an oxygenator and an oxidant. Generally the hydrogen peroxide oxidises the pigments in the tooth. The yellow pigments are oxidised to white pigments. The oxidants react with the chromophores which are the colour radicals to cleave the double bonds.

Carbamide peroxide is a by-functional derivate of carbonic acid. The hydrogen peroxide breaks down to water and oxygen and for brief periods forms the free radical perhydroxyl. The free radical is very reactive and has a great oxidative power (1).

With in office or power bleaching, a high concentration of hydrogen peroxide is administered to the teeth with an activating or promoting method (for example heat, light, laser) to expediate the whitening effect.

Anterior direct aesthetic restorative materials

Composite restorative resins

Three phases comprise the foundation of composite resins:

- The organix phase(matrix)
- The dispersed phase (filler)
- The interfacial phase (Coupling agents)

Bis-GMA (bisphenol A glycidyl methacrylate) is a high molecular weight monomer that comprises 80% to 90% of most commercial dental composite (53). Other matrix components include an initiator (for example benzoyl peroxide for chemical activation and camphoroquinone for visible light activation) , co-inhibitors, polymerisation inhibitors (to extend working time and storage stability) and various pigments (54)

In dental composites, fillers provide strength and reinforcement to the matrix (55). Fillers include ground quartz, alumina silicate, pyrolytc silica, lithium aluminium silicates, borosilicate glass and other types of glass that may contain oxides of heavy metals (for example; barium, strontium, zinc, aluminium) for radiopaque characteristics (56). These fillers vary in particle size depending on the manufacturing process (57). *Alteration of the filler* component remains the most significant development in the evaluation of composite resins (58). In general, mechanical and physical properties of composite material improve in proportion to the volume of filler added. Numerous mechanical properties including compression strength, flexural strength, elastic modules, co-efficient of thermal expansion, water absorption and wear resistance depend on this phase.

Since the filler particle size, distribution and the quantity incorporated dramatically affects the mechanical properties and clinical success of composite resins (59). Several classification systems have been based on these characteristics. Composites materials are often subdivided into two categories:

- Hybrids
- Microfills

Hybrid composites consist of several types of filler particles, a glass in the 1-micrometer – 3 micrometer range that contains radio-opaque oxides (strontium barium or zirconium) and silica which generally have a size of 0.04micrometers.

Hybrids provide

- Ease of use

- Allow light to blend into the tooth
- Exhibit superior tensile strength
- Exhibit improved abrasion resistance as well as reduced polymerisation shrinkage, co-efficient of thermal expansion and water sorbtion (59)

They also show greater future resistance as a result of the inclusion of heavy inorganic fillers (60). These materials are well suited for Class I, II, IV restorations (Filtex Z 250, 3M ESPE, St Paul, Mn)

Microfills.

Microfills are composed of sub-microscopic silica particles that average approximately 0.04 micrometers in size. The production of a homogeneous, non-adherent composite paste requires increased volume of filler particles in the composite. The agglomeration occurs through the wetting of the fillers with resins that are then polymerised together. As a result of the difficulty in wetting these small particles, the filler concentration is strictly limited (35% by weight) (59). Consequently, homogeneous materials that allow a higher proportion of filler to be incorporated (45% - 80% by weight) have been developed. This type of microfill composite (Filtek A110 3M ESPE, St Paul, Mn) is often used as a restorative material. The resin rich environment results in excellent polish-ability and allows the restoration to retain a surface smoothness over function (61)

The limitations of micro-filled composites include high water sorbtion, lack of radiopacity, and the tendency to have lower compressive strength, fracture resistance, fatigue strength and hardness. Therefore these materials are contraindicated for high stress bearing restorations (Class IV).

It can therefore be understood that the hybrid material provides an excellent underlying layer when a microfill is used as the surface in anterior restorations (62). Flowable light curing, radiopaque fine particle hybrids can be used for restorative therapy allowing optimum wetting of the tooth (Tetric® flow).

Compomers

With the combination of composite and glass ionomer technology a compomer was developed. It was marketed as a hybrid of composite and glass ionomer cement combining the advantages of each. Compomer is a water free, single component, light cured composite consisting of poly acid modified dimethacrylate monomers reinforced with strontium or barium aluminosilicate glass particles. Compomers have been reported to have the anticariogenicity and bonding ability similar to glass ionomers cement while maintaining the high aesthetic qualities of composite resins (63).

Compomers (Dyrac®AP Dentsply, DeTrey)

Advantages

- Ease of placement
- No mixing
- Easy to polish
- Good aesthetics
- Excellent handling
- Less susceptible to dehydration
- Radiopaque

Disadvantages

- Limited clinical experience and few long term clinical trials
- Require a bonding agent like composites
- More marginal staining and chipping
- Wears more than composites
- Weaker physical properties than composites that decrease over time

Bonding Agents

Today we are in the age of "adhesive dentistry". It is desirable to bond restorative materials to enamel and dentine. Bonding adhesive resin to acid-etched enamel is

regarded reliable and reproducible. However, bonding to dentine is more complicated and far more challenging.

Many changes and advances have developed since the first generation adhesive "coupling" agents of Buonocore and his colleagues in 1956. As dentine bonding improved, removal of the smear layer (the smear layer is the organic debris that remains on the dentine surface after tooth preparation) was necessary but not without controversy (64). The bonding mechanism to dentine was effective and predictable when the smear layer was completely dissolved, intertubular and peritubular dentine was dissolved, collagen fibers exposed and after infiltration of resin monomers, a hybrid layer formed. This bonding mechanism was evident from 4th to 6th generation of enamel dentine bonding systems.

The 5th generation bonding agents consists of two different types of adhesive materials, the so-called "one bottle" systems (Optibond Solo Plus, Prime and Bond NT®) and the self-etching primer bonding systems. To facilitate clinical use "one bottle" systems combined the primer and the adhesives into one solution to be applied after etching enamel and dentine simultaneously with 35 – 37% phosphoric acid. These bonding systems create a mechanical interlocking with etched dentine by means of resin tags, adhesive lateral branches and hybrid layer formation and show high bond strength values to the etched enamel and dentine (65).

Self etching bonding primer – the combination of etching and priming steps reduces the working time and eliminates the washing out of etchent and the risks of collagen collapsing. A disadvantage is that the solution must be refreshed continuously as it's liquid formulation cannot be controlled and often a residual smear layer remains between the adhesive material and the dentine. A more reliable and durable bond occurs when the smear layer is removed by introducing a separate etching step prior to the bond. (65)

Sixth Generation – adhesive materials also achieve proper bonding to enamel and dentine by using only one solution. These non rinse conditioners seem to have satisfying dentine bond strength but research results suggest that bonding to dentine need to be improved (64).

Etchent Materials- Phosphoric acid (35-37 wt % in water) is used to etch the enamel and condition the dentine. This gel/liquid is used in conjunction with direct aesthetic restorations. The application time is for 15 seconds, thereafter the etchent must be thoroughly rinsed with a water spray. The tooth is then dried with care not to dehydrate the dentine. The etched enamel surface should have a chalky white appearance.

CONCLUSION

An approach involving a combination of bleaching and resin restorations is more conservative and less expensive than treatment with porcelain laminates or crowns. Composite restorations may also be repaired or replaced with minimal difficulty and little tooth loss. We have the potential to achieve minimally invasive dentistry with maximum functional and aesthetic results.

In extensive restorations the hybrid composite materials can be successfully used for anterior restorations and a restoration where a high amount of stress is anticipated. This material can be complemented with a superficial microfiller particle composite to enhance aesthetics.

The clinical performance of current adhesives has significantly improved allowing resin restorations to be placed with a high predictable level of success. The all in one self etching/self primer bottle systems are relatively new and need more research before they can be advocated as the agent of choice.

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