

Management of tetracycline discoloured teeth

Philip RH Newsome and Linda H Greenwall examine the effects of tetracyclines on teeth and the treatment that follows



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Figure 1: The typical appearance of tetracycline-affected teeth a combination of brown/yellow/grey banding together with hypoplasia

Tetracycline broad-spectrum antibiotics were introduced in 1948 for use in the treatment of many common infections found in both children and adults. All tetracycline compounds consist of four fused cyclic rings, hence the name tetracyclines. They have been found to have a number of systemic side effects – for example, pregnant women are particularly susceptible to tetracycline-induced hepatic damage (Madison 1963). These drugs also cross the placenta and can have toxic effects on the developing foetus, and are therefore contraindicated during pregnancy. There has been a resurgence of interest in the tetracycline group of drugs since their recommendation for use in combination therapy for bone metastasis (Saikali 2003) and in the treatment and prophylaxis of tuberculosis, anthrax and malaria. Tetracycline antibiotics are still commonly used in the treatment of acne in adolescents and young adults. This long term used of tetracycline in particular Minocycline (Minocin) which is a semi synthetic tetracycline derivative can also cause staining of the adult teeth (Cheek and Heymann 1999).

Effects of tetracyclines on teeth

One of the most obvious and well-documented side-effects of tetracycline use is its incorporation as a fluorescent pigment into tissues that are calcifying at the time of administration (Figure 1). It has the ability to chelate

calcium ions and to be incorporated into teeth, cartilage and bone, to form a tetracycline-calcium orthophosphate complex (Eisenberg 1975) resulting in discoloration and enamel hypoplasia of both the primary and permanent dentitions if administered during the period of tooth development. The ability of tetracycline to intrinsically stain teeth during odontogenesis has been well-known for almost five decades (Schwachman 1956; Davies 1962).

The severity of the discoloration is considered to be related to dose, frequency, duration of therapy and critically the stage of odontogenesis. The calcification of deciduous teeth begins at approximately the end of the fourth month of gestation and ends at approximately 11–14 months of age. Permanent teeth begin calcifying after birth and are not affected by exposure to tetracycline during the prenatal period. The calcification of permanent teeth is completed at seven to eight years of age with the exception of the third molars (Jackson 1979; Mello 1967). Therefore, the administration of tetracycline to pregnant women must be avoided during the second or third trimester of gestation and to children up to eight years of age because it may result in discoloration and enamel hypoplasia (Conchie 1970). Enamel hypoplasia may, of course, be also the result of childhood disease, hereditary defects in enamel formation or prematurity of the child; all of which are known to cause enamel

defects. Tetracyclines are excreted in urine and faeces, with the urinary route being the most important for the majority of these drugs. The drugs should not be given to nursing mothers, as they are also excreted in human milk (van der Bijl 1995). Adult-onset tooth discoloration following long-term ingestion of tetracycline (Di Benedetto 1985) has also been reported. The prevalence of tetracycline discoloration has ranged from 0.4% to 6% in various studies (Martin 1969; Suckling 1984; Berger 1989) the actual figure clearly being a reflection of the prevailing prescribing habits of medical practitioners in any particular region at any given time. For example, it has been reported to be over 16% in Hong Kong (King 1989)

The ensuing discoloration is permanent and varies from yellow or gray to brown depending on the dose or the type of the drug received in relation to body weight. After tooth eruption and exposure to light, the fluorescent yellow discoloration gradually changes over a period of months and years to a non-fluorescent brown color. The labial surfaces of yellow-stained anterior teeth will darken in time while the palatal surfaces and buccal surfaces of posterior teeth will remain yellow. These changes are thought to be the result of an oxidation product of tetracycline, which is light induced (Bevelander 1961; Atkinson 1962) The affected teeth will also fluoresce bright yellow under UV light in a dark room.

Minocycline hydrochloride, a semi-synthetic derivative of tetracycline often used for the treatment of acne, has been shown to cause pigmentation of a variety of tissues including skin, thyroid, nails, sclera, teeth, conjunctiva and bone (Rosen 1989). A further side-effect of minocycline on the oral cavity is the occurrence of 'black bones', 'black or green roots' and blue-gray to gray hue darkening of the crowns of permanent teeth. Minocycline differs from other tetracyclines in that it is well absorbed from the gastro-intestinal tract and chelates with iron to form insoluble complexes, and this may provoke the tooth staining.

Diagnosis

It is important to recognise other causes of tooth staining in order to discriminate among tetracycline staining, minocycline staining and other extrinsic or intrinsic teeth staining problems (Table 1).

Treatment

Nowhere does the old adage that an ounce of prevention is better than a pound of cure apply better than here, not only from the patient's point of view but also from that of the clinician - especially when one takes into account the

Extrinsic factors	Characteristics
Chromogenic bacteria stains	Green, black-brown and orange
Tobacco	Black, brown
Amalgam	Black, grey
Medicaments	Silver-nitrate: Grey black Stannous-fluoride: Black brown Chlorhexidine: Black brown
Foods and beverages	Coffee, tea, wine, berries etc: Colour of food item
Iron	Black cervical discolouration
Intrinsic factors	Characteristics
Dentinogenesis imperfecta	Yellow or grey-brown
Amelogenesis imperfecta	Yellow-brown
Dental fluorosis	Opaque white to yellow-brown patches
Sulphur drugs	Black staining
Tetracyclines:	
Chlortetracycline	Grey-brown hue
Oxytetracycline	Brown-yellow to yellow
Tetracycline HCL	Brown-yellow to yellow
Dimethylchlortetracycline	Brown-yellow to yellow
Minocycline	Blue-grey to grey
Doxycycline	No change
Dental trauma	Transiently red through to black
Hyperbilirubinemia	Yellow-green to blue brown and grey
Erythropoietic porphyria	Red or brown
Ochronosis	Brown

Table 1

medico-legal implications. A legal precedent was set in 1982 when tetracycline was alleged to have caused discolouration of the teeth of two children with a subsequent legal, successful, action being brought against the general medical practitioner (Medical Protection Society, 1982).

When actual treatment is sought, and this is almost always for aesthetic reasons, there are a number of possibilities. These are (with increasing degrees of invasiveness) as follows:

- 1) Tooth whitening only
- 2) Composite bonding full or partial over discoloured areas
- 3) Combination treatment starting with tooth whitening and continuing to direct veneers.
- 4) Laminate veneers (with or without prior tooth whitening)
- 5) Full coverage restorations

Tooth-whitening

The treatment of tetracycline staining using tooth whitening and tooth bleaching has been used with varying degrees of success over the last 40 years. The success of the treatment with tetracycline staining depends on the

depth, severity and degree of the discolouration (Greenwall 2001). For the purposes of undertaking tooth bleaching it is best to understand the classification of the staining on the teeth (Jordan and Boksman 1984).

1. First Degree. **Mild tetracycline staining.** This staining is yellow to grey with no banding and is uniformly spread throughout the tooth. See Figure 2a.
2. Second Degree. **Moderate tetracycline staining.** This is yellow brown to dark grey staining.
3. Third degree. **Severe tetracycline staining.** This is blue grey or black and is accompanied by significant banding across the tooth. See Figure 3a.
4. Fourth degree. **Intractable staining** is that staining that is so severe that bleaching is ineffective.

Normally bleaching can be successful with the first three classifications mild, moderate and severe. The best is to explain to the patient that attempts will be made to undertake the bleaching treatment for the patient. Types of bleaching treatment for tetracycline staining are as follows:

1. Home bleaching. This is the most predictable option to try.
2. Combination bleaching or deep bleaching. This may work using both home and chairside treatments.
3. Power bleaching. This will offer limited success for patients with tetracycline staining and this method may require multiple visits. The bleaching gel is not able to penetrate the dentine sufficiently deeply during the one hour power bleaching session.
4. Intentional devitalisation and internal non vital bleaching. (Abou-Rass 1982). This method was recommended for severe tetracycline staining prior to the introduction of Night Guard Vital Bleaching. This method advocates devitalising the teeth and thereafter undertaking non vital bleaching using hydrogen peroxide. This method is now not recommended and there are now more predictable ways using home bleaching.

The treatment regime for bleaching tetracycline teeth

As Haywood (1997) has shown that it takes longer to whiten tetracycline stained teeth than teeth with age yellowing, it is necessary to set up a treatment programme for these patients. Patients should be seen for an initial assessment and photographs, radiographs and full detailed intraoral examination should be undertaken. The discolourations should be classified in terms of the severity. Normally all the options are fully discussed with the patients and the result is always underestimated to the patient. All the options from bleaching, bonding (Haywood and Pohjola 2004), porcelain veneers and full coverage are discussed and the treatment is undertaken in a sequential manner. Patients are told that according to the research the treatment can take up to three, six, nine or twelve months. Once the decision is made to undertake whitening the review date is normally set for two to three weeks initially to assess how much lightening can be achieved in that amount of time. Normally the upper teeth are whitened first using the home bleaching tray. Patients are instructed about the treatment options for self managing any possible sensitivity (Greenwall 2006).

At the review appointment the lower whitening tray is dispensed and the next review date is set depending on the amount of lightening that has been achieved. The patient is given sufficient material to treat both the upper and lower teeth and to last for one month. Low concentrations of carbamide peroxide are used initially to prevent the patient from terminating treatment due to sensitivity. If the patient has



Figure 2a: Mild Tetracycline type 1 staining. The patient was treated with six weeks of 10% carbamide peroxide in the bleaching tray for at home use.



Figure 2b: The results after six weeks of night time home bleaching treatment using the tray system



Figure 3a: Tetracycline type 3 discolouration with severe banding. Before treatment is the result after whitening for 6 months. Although the banding has not disappeared there has been an excellent improvement in the lightness and the patient has gone from an A4 shade to a B1 shade



Figure 3b: The result after six months of treatment



Figure 4a: Tetracycline staining severe banding - before treatment. It was thought that this discolouration would be impossible to treat and further options were discussed with the patient. The whitening occurred within three months and was very rapid using 10% carbamide peroxide in the trays



Figure 4b: The results after three months of treatment. The patient was very happy with this result. After a period of two weeks further composite bonding was undertaken to improve the shape of the upper left central incisor.

experienced no sensitivity, the patient may then be given 15% carbamide peroxide gel to use. Most of the home gels incorporate densitisers such as potassium nitrate, fluoride or amorphous calcium phosphate to reduce the incidence of sensitivity (Greenwall 2006). At the one month review appointment the amount of lightness is assessed. Shades are taken using the Vita Porcelain shade guide and photographs are taken. Depending on the result the patient is then seen one month later and thereafter once a month until bleaching treatment is completed. The patient is told that the process of tetracycline bleaching is quite lengthy and normally they are delighted with the result. Often much of the initial lightness can be seen rapidly within the first six weeks and thereafter the whitening process may be a little slower. Further treatment may need to be undertaken and these decisions are assessed together with the patient.

Laminate veneers

The use of laminate veneers (usually ceramic)



Figure 5: The patient is shown exactly how much gel to place into the bleaching tray to get accurate placement and to ensure that the patient does not use too much gel which could cause sensitivity.

is probably the most commonly-used way of treating tetracycline-discoloured teeth although some of the newly developed indirect composite materials (for example Shofu's Ceramage) are showing considerable promise. Directly-applied composite is by and large inadequate to mask tetracycline discolouration (Figure 5).

Difficulties exist in using thin ceramic veneers to mask what are usually extreme lev-



Figure 6a-e: Direct composite has been placed, unsuccessfully, at some point in the past to try and mask tetracycline discoloration. E.max press veneers using opaque ingots combined with a covering layer of more aesthetic porcelain were placed to produce a much more satisfactory result. Note the dark colour of the prepared teeth

Figure 7: An occlusal view showing the huge difference in colour between ceramic veneers and the underlying tetracycline-affected teeth. It is important that such transitions are kept out of sight as much as possible

els of discolouration and increasingly, their use is combined with tooth-whitening conducted over a considerable period of time (as described above) prior to tooth preparation. Should bleaching be carried out is important to leave a period of at least two weeks between the final bleaching and bonding otherwise the bond strength will likely be compromised (Titely 1988). It is now generally accepted that the highest levels of retention occur when a veneer is bonded to a predominantly enamel substrate (Friedman 1998). While this is usually no problem and perfectly manageable in 'normal-coloured' teeth, in tetracycline-affected teeth, however, there is considerable risk that the dark shade of the underlying preparation will shine through the relatively translucent porcelain. Ways around this include using more opaque ceramics and luting agents, cutting deeper into the tooth to allow a greater thickness of overlaying ceramic or manipulation of the prepared tooth to lighten its shade. Each one of these is not without problems. Thus, opaque porcelains and luting agents can, without care, appear rather lifeless and any visible transition between veneer and underlying tooth can be extremely noticeable (Figure 7). Many patients however, are just relieved to free of the stigma of dark teeth, relieved simply to have 'white teeth' at last and often do not comment negatively about such lack of characterisation. In other words, our expectations as professionals may differ from those of our patients. The second alternative is to cut deeper into tooth tissue in order to

create more space for the ceramic, thus allowing the technician to maximise the aesthetic possibilities provided by modern porcelain materials. The difficulty with this approach is that dentine provides a weaker bond and there is a greater risk of failure. Another significant issue is that as one cuts further into tetracycline-affected dentine the darker it usually becomes (Figure 8). Attempts have been made to overcome these difficulties by cutting a standard veneer preparation and then either bleaching the tooth prior to cementation (Sadan 1998) or carrying out what is referred to as sub-opaquin i.e. the selective removal of the darkest bands of dentine and replacement with a lighter composite (Nixon 1996). The latter can be done either at the tooth preparation phase or, as has been advocated recently, at the cementation phase, in order to a) prevent the provisional veneers adhering to the composite restoration and b) enhance the bond strength achieved by removing the need to etch and silanate the freshly-placed composite (Lowe 2005).

Should veneers be the treatment of choice then the question arises as to which ceramic system is the most appropriate (Newsome (a) 2008). Clearly, in most cases, highly translucent ceramics are not recommended and for this reason moderately filled glasses materials such as IPS Empress I (now branded as Empress Esthetic) are unsuitable as they allow too much of the underlying discoloration to shine through. More opaque systems such as IPS Empress 2 (E.max Press) and Procera

Alumina (Nobel Biocare) are better placed to mask out dark underlying hues. While zirconium-based polycrystalline ceramics such as 3M's Lava and Dentsply's Cercon are totally opaque they cannot be etched to provide a micromechanical bond and so are not used in laminate veneers. It is beyond the scope of this paper to give a detailed account of veneer preparation but whichever ceramic system is chosen the normal principles of veneer preparation should be followed (Newsome (b&c) 2008) paying particular attention to the following:

- Preparation margins should be placed slightly sub-gingivally and interproximally to hide the transition between veneer and dark tooth.
- If using a material such as Procera, which requires the model to be scanned, make sure that all margins are very clear, that the chamfer does not become a weak 'J' margin with unsupported enamel that the scanner cannot register. Similarly, it is usually advisable to break the contact points so that the scanner can detect the margins fully. This also helps to hide the interproximal margins.
- The shade of the prepared tooth (if possible together with photographs) should be sent to the laboratory to help them achieve the best possible result.
- At the bonding stage it is vital to use a selection of different water-soluble try-in pastes to determine the most appropriate shade of luting cement. The more translucent the veneer the more critical this step becomes.



Figures 8a and b (left and centre): The same patient as shown in Figure 1 following tooth preparation. Notice the dark colour of the prepared teeth and the small areas of exposed dentine. These need to be covered with dentine bonding agent as soon as possible to reduce post-operative sensitivity



Figure 9: This Cercon crown has sufficient buccal porcelain to produce a very aesthetic result despite the extremely opaque nature of the zirconium core

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Full coverage restorations

The inherent difficulties of using laminate veneers to mask tetracycline discolouration outlined above have led many to abandon their use in all but the mildest cases and opt for full coverage. Doing so allows the teeth to be more aggressively prepared so that the covering layer of porcelain is thicker. Full coverage also places less reliance on bonding as a means of retention. Although there are usually more aesthetic alternatives for anterior teeth, zirconia crowns are useful in the treatment of tetracycline teeth, especially if the preparation has a deep enough chamfer to allow a sufficiently thick veneering layer of esthetic porcelain (Figure Z). The need to use porcelain fused to metal crowns would appear to be limited except in the most extreme cases where great strength is an advantage, for example when parafunctional habits, such as bruxism, are combined with deep tooth discoloration.

Conclusion

The management of tetracycline-discoloured teeth poses a number of problems. As with treatment of any kind, the most conservative option should be used first. Here this means tooth whitening and it is becoming clear that excellent results can be achieved by means of long-term home bleaching. Even if this approach does not yield the desired result then sufficient improvement in tooth colour can usually be achieved to make the task of masking the discolouration by means of ceramic restorations easier. Care must be taken, especially when using veneers, to balance the desire to remove sufficient tooth structure to provide enough thickness of ceramic to mask discolouration with the need to maintain enamel for bonding purposes.

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