Endodontic aesthetic iatrodontics

By Professor Laurence J. Walsh and Dr Basil Athanassiadis

While many practitioners will be familiar with procedural hazards of a mechanical nature during endodontics (for example instrument separations and root perforations), there is less awareness of chemical factors which can contribute to adverse aesthetic outcomes for endodontics. This short article highlights several chemical reactions which can contribute to tooth discolouration as a consequence of endodontic treatment. Practitioners should be aware that these reactions can contribute to tooth discolouration, and where possible, treatment should be sequenced so that these reactions do not occur, particularly where endodontic therapy is being undertaken on anterior teeth.

Chlorhexidine
Chlorhexidine is becoming more commonly used in every day endodontics as the search for the ideal intra-canal antibacterial medicaments continues unabated. While chlorhexidine has only limited effects against some gram-negative bacteria, its efficacy against certain gram-positive bacteria, particularly Enterococci, make it an attractive inclusion in modern endodontic protocols. Chlorhexidine is available in a range of forms, and those with higher concentrations, for example 2% or 5%, are becoming more popular for use as intra-canal medicaments, particularly in cases where re-treatment is being undertaken and there is a suspicion that Enterococcus faecalis is present in the root canal space.

A particular problem which is related to the substantivity of chlorhexidine can occur when sodium hypochlorite is used in combination with it. Chlorhexidine adsorbs strongly to dentine surfaces. Therefore, once used as a root canal irrigant, bound chlorhexidine will be present on the radicular dentine surface, even if vigorous rinsing is undertaken. If sodium hypochlorite is used subsequently to chlorhexidine, a reaction occurs between the two, with cleavage of the two benzene rings from the chlorhexidine. One of the resulting chemical products is 4-para-chloroaniline (PCA), a darkly brown coloured substance (Figure 1). PCA also has significant sensitizing and chemically irritant properties, which may not be relevant as the material is bound strongly onto the radicular dentine surface. It is of interest that PCA is one of the ingredients from which chlorhexidine is manufactured, and if chlorhexidine breaks down, the presence of PCA can be easily seen because of its intense brown colour (Figure 2).

Sodium hypochlorite
Sodium hypochlorite interacts chemically with a number of other materials that may be used as root canal irrigants (Table 1). For example, sodium

Table 1. Summary of key chemical interactions between endodontic materials

<table>
<thead>
<tr>
<th>Chemical Interaction</th>
<th>Reaction</th>
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<tbody>
<tr>
<td>Sodium hypochlorite + EDTA</td>
<td>Release of chlorine gas</td>
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<tr>
<td>Sodium hypochlorite + hydrogen peroxide</td>
<td>Release of oxygen gas</td>
</tr>
<tr>
<td>Sodium hypochlorite + chlorhexidine</td>
<td>Parachloroaniline (brown)</td>
</tr>
<tr>
<td>Ledermix (tetracycline) + dentine + light</td>
<td>AODTC (coloured)</td>
</tr>
<tr>
<td>AH26 (Bismuth trioxide) + moisture</td>
<td>Bismuth compounds (coloured)</td>
</tr>
</tbody>
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hypochlorite catalyses the breakdown of hydrogen peroxide resulting in oxygen release. The combination of sodium hypochlorite and EDTA is also of interest, since under acidic pH environments, the hypochlorite will break down to elemental chlorine which will be released as a gas.

**Tetracyclines**

Tetracyclines are a second group of medicaments which are of interest in terms of iatrodontic endodontics. They bind strongly to dentine through chelation, and the work of Paul Abbot and others has shown that tetracyclines used within the root canal system bind and can discoulour over time, particularly upon exposure to light. When used as an intracanal medicament, it is important to remove any traces of Ledermix” and Endopaste" from the coronal aspects of teeth, since exposure to sunlight will cause dark grey-brown staining of the crowns. Placement of the paste must be restricted to below the gingival margin, with particular care to remove any remnants left on the walls of access cavities.

This light-driven reaction of tetracyclines that are bound to apatite mineral results in the production of a range of compounds which have a red/purple/brown colour. Various chemical analyses suggest that a major compound is 4 alpha, 12 alpha-anhydro-4-oxo-4-dedimethylaminotetracycline (AODTC). In an ideal world, the requirements to use antibiotics which can bind and potentially discoulour teeth would not exist, and it is noteworthy that a range of organisms found in root canals can be resistant to tetracycline, for example Enterococcus faecalis. In the future, it is likely that improved medicaments will be developed which will not contain tetracycline, but will use biocides so that antibiotic resistance is not a problem.

**Contrast agents**

The third potential reaction relates to the presence of high molecular weight radiographic contrast enhancing agents, which are used in many endodontic materials but are present at high concentrations in root canal sealers. A typical example is AH26, the powder component of which contains bismuth trioxide (typically 80% by weight), which is used as a bulk filler.
and to provide radio-opacity to the material. As the epoxy resin sets over time, the presence of natural moisture in the root canal system, together with the elevated temperature of the human body, triggers a chemical reaction which results in conversion of the filler to a range of bismuth compounds which become a green and then a black colour (Figure 3). For this reason, at the obturation visit, it is important to remove AH26 from the coronal aspects of tooth structure, lest this discolouration become visually apparent over time (Figure 4).

Careful study of the discolouration reaction indicates that changes can be seen as early as 4-6 weeks, and these become progressively noticeable over time with the progression from green to black occurring over a 12-24 month period. AH Plus, while having an epoxy resin base, uses zirconium oxide as the radiographic contrast agent and filler. This material has a white colour, but more importantly does not undergo the chemical reactions that bismuth does (Figure 5), and long-term stability of the colour of the root canal sealer can be tracked over extended periods of time (Figure 6). Research into root canal sealing materials will no doubt continue in the future, and novel materials which do not discolour will likely become prominent.

References

About the authors
Professor Laurence J. Walsh is the technology editor of Australasian Dental Practice magazine. He is also a noted commentator on and user of new technologies and is the Head of The University of Queensland School of Dentistry.

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Figure 5. Sectioned roots which had been filled with AH26 or an identical composition to AH Plus (bismuth trioxide replaced with zirconium dioxide) and kept in 100% humidity for one year. The darkening of the AH26 is the same as seen in the bulk sample in Figure 3.

Figure 6. Luminosity histogram analysis using Adobe Photoshop, showing the intensity difference between AH26 (on the left) and AH Plus (on the right) two years after mixing. The AH26 curve has been approaching the black end of the scale, while the AH Plus sample has remained at the white side of the scale.