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EDGE**

# New developments in tooth whitening. The current status of external bleaching in orthodontics

**Eleanor Thickett and Martyn T. Cobourne**

Department of Orthodontics and Craniofacial Development, Kings Dental Institute, King's College London, London, UK

This article provides a contemporary view of external tooth whitening procedures currently available, with particular reference to bleaching. The various techniques and products are described, with their advantages, disadvantages, mode of action and the current legal stand-point discussed. The results of a British Orthodontic Society survey of Specialist and Practitioner Groups regarding current usage patterns of tooth whitening products are presented.

*Key words:* tooth, whitening, bleaching, orthodontics

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## Introduction

The natural colour of teeth within the permanent dentition varies between individuals and represents a balance between the pale yellow of dentine and translucency of the overlying enamel. In the United Kingdom around 28 per cent of adults express some dissatisfaction with the appearance of their teeth when questioned<sup>1</sup> and up to 50 per cent of people think they have some kind of tooth discolouration.<sup>2</sup>

Tooth discolouration or staining can be broadly classified as extrinsic or intrinsic<sup>3</sup> (Table 1). Extrinsic staining occurs when external chromogens are deposited on the surface of the tooth or within the surface pellicle and can be direct or indirect. Direct extrinsic stains, such as those caused by food stuffs or tobacco, arise from the basic colour of the chromogen; whilst indirect extrinsic stains, such as those caused by the cationic antiseptic chlorhexidine, result from a chemical interaction at the tooth surface. Intrinsic staining is a permanent tooth discolouration arising from a change to the structural composition of the tooth. This can occur during tooth development, as a result of inherited or metabolic disease or from the ingestion of certain chemical substances, or be acquired as a result of caries or vitality loss. Intrinsic staining cannot be removed without the destruction of tooth tissue. Direct extrinsic staining is usually amenable to removal by professional cleaning and scaling; however, for indirect extrinsic staining, a number of different externally-applied

tooth-whitening products are now available to improve the appearance of the teeth. Increasingly, these products are also being used to whiten teeth in the absence of staining, in an attempt to improve dental appearance. The majority of these products utilize bleaching to increase whiteness of the dentition and can be applied directly by the dental surgeon or by the patient at home, having being dispensed by the dentist or purchased over-the-counter.

There is an increasing vogue towards having whiter teeth and a significant number of patients now request information on the methods available for tooth whitening. This article summarizes the different methods of external tooth bleaching that are currently available and discusses the current legal standing with regard to these procedures. In addition, the results of a recent questionnaire are presented, which suggest that significant numbers of Specialist Practitioners and General Dental Practitioners with an interest in orthodontics are now providing tooth bleaching for their patients.

## How does tooth bleaching work?

The exact mechanism underlying the process of tooth bleaching is not fully understood. However, the bleaching agent produces oxidizers as part of a chemical reaction and these are able to diffuse along a gradient within enamel micropores, gaining direct access to the underlying dentine. Oxidizers can cleave double bonds within pigment molecules, which results in their

Anionic dissociation producing a strong free radical in the presence of a high

pH and accelerator

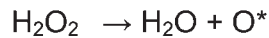
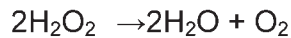


Photo dissociation producing a weak free radical via light and heat

Photo dissociation:



Using light and heat:



**Figure 1** The breakdown of hydrogen peroxide into reactive free radicals

breakdown and diffusion into the external environment, or a size reduction sufficient to cause them to absorb less light and appear lighter. Carbamide peroxide is a product consisting of hydrogen peroxide compounded with urea, and in the presence of water readily breaks down to release free radicals, which can act as oxidizing agents. This breakdown is achieved by

anionic-dissociation photo-dissociation or a combination of these two reactions (Figure 1).

## Constituents of bleaching gels

Tooth bleaching gels have a number of constituents but the active ingredient is the bleaching agent itself. Most home bleaching kits use an aqueous solution of 10 per cent carbamide peroxide ( $\text{CH}_6\text{N}_2\text{O}_3$ ), which breaks down into a 3.35 per cent solution of hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) and 6.65 per cent solution of urea ( $\text{CH}_4\text{N}_2\text{O}$ ). Stronger solutions of 15 and 20 per cent carbamide peroxide are also available for dentist-supervised home bleaching procedures and a 35 per cent solution can be used as part of a dental procedure, prior to using a home kit. However, this solution yields up to 10 per cent  $\text{H}_2\text{O}_2$ , which can lead to damage if exposed to the soft tissues and should be used in conjunction with rubber dam or soft tissue protection. Most bleaching products also contain  $\text{H}_2\text{O}_2$  in some form, which breaks down into water and oxygen as part of the reaction. The oxygen molecule penetrates the tooth surface and acts upon the pigment molecule, causing the tooth to lighten or whiten. In addition, a number of products are available that do not contain  $\text{H}_2\text{O}_2$ ; the active ingredient in these materials is sodium perborate. Supposedly, these products do not produce or contain  $\text{H}_2\text{O}_2$  and free radical formation is much reduced when compared to the carbamide peroxide gels.

Most proprietary bleaching agents also contain a number of other ingredients, which include thickeners

**Table 1** Types of tooth discolouration

<b>Extrinsic</b> (direct stain)
Tea, coffee, other foods
Cigarettes or cigars
Plaque and poor oral hygiene
<b>Extrinsic</b> (indirect stain)
Polyvalent metal salts
Cationic antiseptics
<b>Intrinsic</b>
Congenital
Metabolic
Congenital erythropoietic porphyria
Congenital hyperbilirubinaemia
Developmental
Amelogenesis imperfecta
Dentinogenesis imperfecta
Acquired
Tetracycline
Fluorosis
Vitality loss
Enamel hypoplasia
Aging

such as carbopol to enhance viscosity and limit the risk of saliva breaking down the  $H_2O_2$ , which can retard effervescence due to a reduced rate of oxygen release. Urea is also used as a buffer and stabilizer of  $H_2O_2$ , and has a number of other potentially desirable effects the oral cavity, including promotion of salivary stimulation, wound healing and anti-cariogenicity. The bleaching preparation itself is usually carried in a glycerine and glycol-based vehicle, which generally eases manipulation. Bleaching products also contain preservatives such as citroxian, phosphoric acid, citric acid or sodium stannate and flavourings. Their action is to sequester transitional metals such as iron, copper and magnesium, which accelerate the breakdown of  $H_2O_2$ . They also provide a mildly acidic pH, enabling the gels to have greater stability and durability.

### Which bleaching agent to use?

The choice of bleaching agent to use will be influenced by several factors. For specific staining it is important to determine the location and source, particularly whether it is within the enamel or extending into dentine.<sup>4</sup> The form, shape, depth and extent of the discoloration will also influence the type of bleaching to be carried out. The darker the stain, the longer it will take to bleach and the stronger the preparation that will be required. A number of patient factors also need to be considered when choosing a technique. These include the presence of any pre-existing tooth sensitivity, the patient's lifestyle, their dexterity and whether they are prepared to administer a preparation themselves. In addition, the chemical constituents of the base material ( $H_2O_2$ , carbamide peroxide or perborate), the dispensing method, tissue tolerance, ease of use, application and the flavour will all influence a clinician's choice of agent.

There are many types of bleaching product available on the market for use by the dentist or the patient at home. These include over-the-counter bleaching kits,  $H_2O_2$  strip systems, home bleaching, power bleaching, assisted bleaching techniques or waiting room bleaching techniques (Table 2). Currently, whilst there is some evidence that home-based tooth-whitening products do work when compared to a placebo or no treatment, there are differences in efficiency between these products. In addition, the studies carried out to date have been short-term and at a high risk of bias.<sup>5</sup>

#### *Over-the-counter bleaching kits*

These kits are readily available in pharmacies and supermarkets. The public are able to purchase them, take them home and apply the bleach as directed by the

instructions. These kits generally contain a citric or phosphoric acid rinse, which produces a working pH of 1–2 and is therefore potentially harmful to the dentition; the bleaching gel itself, which is usually applied to the dentition for a few minutes and a post-bleach polishing cream or toothpaste, which contains titanium dioxide. The effects of these systems have not been robustly investigated but they will give a temporary painted white appearance to the teeth.

#### *H<sub>2</sub>O<sub>2</sub> strip systems*

These are tray-less systems, which deliver a 5 per cent  $H_2O_2$  gel via a thin adhesive pre-coated strip. The backing is removed and the strip is placed on either the labial or palatal surface of usually, the six anterior teeth. The strip is worn for 30 minutes and then discarded. This process can be repeated twice a day for up to 2 weeks. Overuse of these kits has led to reports of erosion affecting the labial surfaces of the teeth, dissolution of enamel and loss of tooth anatomy.<sup>6</sup> In particular, patients may increase use of these kits beyond the recommendations of the manufacturer in order to speed up the whitening process, increasing the potential risk of damage to the dentition.<sup>7,8</sup>

#### *Home bleaching*

Home bleaching is a simple technique, which involves the dentist constructing a mouthguard for the patient to use for bleach application to their teeth at home following a specific protocol. The absence of direct supervision associated with the use of these kits means that they require a number of specific properties (Table 3). The tray containing the material (usually 10 per cent carbamide peroxide) is worn for several hours, depending on patient preference. The original term used was 'nightguard vital bleaching', as patients bleached the teeth at night while they slept with a tray in their mouths.<sup>9</sup> It is a predictable technique and success rates of 98 per cent for non-tetracycline stained teeth and 86 per cent for tetracycline staining have been reported in relation to clinical opinion on relative shade differences.<sup>10</sup> The greater the concentration of carbamide peroxide and the thicker the material, the quicker the bleaching will take place and the less the tray will need to be worn.

The main advantages of home bleaching are that it is simple, fast and can be carried out by the patient at their own convenience.<sup>11</sup> In addition, it is not usually painful, and patients can see the results relatively quickly. It is also cost effective because it is simple for dentists to

**Table 2** Commercially available bleaching kits

Technique	Product example
Over-the-counter bleaching kits	<i>Colgate Simply White</i> Colgate-Palmolive, UK <a href="http://www.colgate.co.uk">http://www.colgate.co.uk</a> <i>Crest night effects</i> Procter & Gamble, UK <a href="http://www.crestnighteffects.com">http://www.crestnighteffects.com</a>
H <sub>2</sub> O <sub>2</sub> strip system	<i>Crest Whitestrips</i> Procter & Gamble, UK <a href="http://www.crestwhitestrips.co.uk">http://www.crestwhitestrips.co.uk</a> <i>Rembrandt Whitening Strips</i> Johnson & Johnson <a href="http://www.rembrandtwhitening.com">http://www.rembrandtwhitening.com</a> <i>ON-THE-GO Whitening Click-Pen</i> Teeth Whitening Systems Corporation, USA <a href="http://www.teethwhiteningsystems.com">http://www.teethwhiteningsystems.com</a> <i>BriteSmile Whitening Pen</i> <a href="http://www.britesmile.co.uk">http://www.britesmile.co.uk</a> <i>Pola Paint Advanced Tooth Whitening System</i> <a href="http://www.polawhite.com">www.polawhite.com</a>
Home Bleaching	<i>Opalescence White</i> Optident Dental Products, UK <a href="http://www.optident.co.uk">http://www.optident.co.uk</a> <i>Nite White® ACP Bleaching Gel</i> <a href="http://www.nuwhite.co.uk">http://www.nuwhite.co.uk</a> <i>iWhite Light Activated Teeth Whitening Kit</i> <a href="http://www.remedent.be">http://www.remedent.be</a> <i>Aquafresh White Trays™</i> <a href="http://www.aquafresh.com">http://www.aquafresh.com</a> <i>Sapphire Professional Home Whitening System</i> <a href="http://www.sapphirewhitening.com/">http://www.sapphirewhitening.com/</a> <i>Pola Zing Advanced Tooth Whitening System</i> <a href="http://www.polawhite.com">http://www.polawhite.com</a> <i>Colgate Simply White and Visible White</i> <a href="http://www.colgate.co.uk">http://www.colgate.co.uk</a>
Power bleaching	<i>Zoom</i> Discus Dental, CA, USA <a href="http://www.zoomtraining.com">www.zoomtraining.com</a>
Assisted bleach technique or waiting room bleach technique	<i>BriteSmile</i> BriteSmile UK, London, UK <a href="http://www.britesmile.co.uk">http://www.britesmile.co.uk</a>
In-office dual-activated technique	<i>Hi-Lite material</i> Shofu Dental Corporation, Tonbridge, UK <a href="http://www.shofu.com">www.shofu.com</a>

**Table 3** Ideal properties of a home bleaching agent

Easy to apply to teeth for maximum patient compliance
Non acidic/neutral pH
Lightens teeth successfully and efficiently
Adjustable peroxide concentration
Uses minimum quantity of the bleaching agent to achieve the desired result
No irritation or dehydration of the oral tissues
No damage to teeth or the enamel to be etched

monitor without extended clinical time or expensive laboratory costs. However, patients need to participate actively in their treatment, as colour change is dependent on the length of time the trays are worn. Some patients can lack the necessary discipline to apply the bleach every day and the drop-out rate for home bleaching can be high. At the opposite end of the spectrum, the system may also be open to abuse, with some patients using excessive amounts of bleach for too many hours per day.<sup>12</sup>

### Power bleaching

This technique is similar to home bleaching, but is more suited for tenacious stains, which include developmental or acquired discolouration, yellow-brown stains in enamel and dentine, age-yellowed smiles and mild to moderate tetracycline staining. Several types of material are available for power bleaching, but they are generally based upon 35 per cent H<sub>2</sub>O<sub>2</sub> or carbamide peroxide preparations, which are liquid, liquid and powder or gel-based products. Dual-activated power bleaching systems also contain a 35 per cent H<sub>2</sub>O<sub>2</sub> gel, but this is both light and chemically activated.<sup>13</sup> The gel contains between 10 and 20 per cent water, which rehydrates the tooth as bleaching continues and reduces the incidence of desiccation. The consistency of the gel allows it to remain in intimate contact with the tooth and minimizes the possibility of soft tissue contact.<sup>14</sup> However, the presence of water in the gel reduces the shelf-life and some products require refrigeration.<sup>15</sup>

Patients often prefer power bleaching because the procedure takes less time and the results are almost immediate, which enhances the perceived value. It is particularly useful for the removal of yellow-brown stains without damaging the enamel. However, an inability to tolerate the tray can produce gagging and difficulty carrying out the procedure. Power bleaching takes more surgery time, is generally more expensive and there is an element of unpredictability, as it is not known in advance how much the teeth will respond to the bleaching. It can cause dehydration of the teeth, which can lead to further problems or false evaluation of the actual shade change. Rehydration of desiccated bleached teeth leads to a slightly darker coloration, which can be mistaken by patients as rebound discoloration,<sup>15</sup> although regression of colour change may occur much more quickly with this technique anyway.<sup>16</sup> Tooth sensitivity can also be a problem with power bleaching<sup>17,18</sup> and there are some serious safety considerations. The bleach is normally a stronger more caustic concentration and tissue burns can occur on the patient's lips, cheeks and gingivae if they come into contact with it. Protection of the patient's face, soft tissues, eyes, skin and lips is required. Currently, there is little in the way of clinical controlled studies to support power bleaching as being more effective than the home variety.

### Assisted bleach technique or waiting room bleaching

Assisted bleaching can be utilized for both vital and non-vital teeth. The 35 per cent carbamide peroxide (which breaks down to 10 per cent H<sub>2</sub>O<sub>2</sub>) is marketed as

a power bleaching agent and this can also be heated, by holding the syringe under hot running water for 2–3 minutes prior to use; which accelerates activity of the material before it is loaded into the mouthguard. The dentist applies the carbamide peroxide into a custom-made bleaching tray and excess material is removed, the patient returns to the waiting room for a period of about 30 minutes with the bleaching tray *in situ* and after this, the bleach is suctioned off the teeth before rinsing. Each tooth should then be thoroughly rinsed under high-volume suction.

### The in-office dual activated technique

The in-office bleaching system is formulated for both light and chemical activation. It includes ferrous sulphate, which serves as a chemical activator that completes the bleaching process in 7–9 minutes. The incorporation of manganese sulphate, which is light-activated, can accelerate the bleaching process to 2–4 minutes. This technique uses H<sub>2</sub>O<sub>2</sub> in a strong concentration of 19–35 per cent. A feature of Hi-Lite material (Shofu) is that it contains an indicator dye, which starts off as blue and changes to white as it becomes deactivated. This helps the dentist minimize the amount of time the bleach is kept on the teeth and maximize results. The process can be repeated again for up to six times per visit if necessary, depending on the type and severity of the stain.<sup>19</sup>

This technique has been shown to lighten teeth by up to two shades after each treatment session; generally requiring around one to three treatment sessions to achieve the desired results, except for severe tetracycline-stained teeth. Different concentrations of between 19 and 35 per cent H<sub>2</sub>O<sub>2</sub> have been tested, with no visible difference in the results. However, it takes slightly longer for lower concentrations of H<sub>2</sub>O<sub>2</sub> to effect similar changes in colour.<sup>13</sup>

## Side effects of bleaching

A number of potential side effects have been associated with bleaching and whitening of teeth (Table 4) with tooth sensitivity and gingival irritation being by far the most common (Table 5).<sup>20</sup> Around 67 per cent of patients may experience tooth sensitivity at some stage during the bleaching process<sup>21,22</sup> and this can be to varying degrees.<sup>23</sup>

Bleaching-associated sensitivity is different from single tooth sensitivity. If a patient presents with sensitivity affecting a single tooth, simple measures can be instituted, such as direct application of bonding agent,<sup>24</sup> fluoride varnish, or hema or oxylate preparations to the

tooth. There are two methods to consider for the treatment of generalized sensitivity during bleaching treatment, both passive and active. Passive treatment consists of altering the bleaching time, frequency or concentration to find a more comfortable solution for the patient. The active method employs the use of fluoride or potassium nitrate applied to the tray as a pre-treatment or at the onset of symptoms. Fluoride reduces sensitivity by blocking the dentinal tubules, which restricts the ingress of fluids according to the hydrodynamic theory of pain.<sup>24</sup> Potassium nitrate reduces sensitivity via chemical interferences that prevent repolarization of pulpal sensory nerves after initial depolarization<sup>25</sup> and aids the release of nitric oxide; many desensitizing toothpastes contain potassium nitrate.

Bleaching within the adolescent population is also increasing in popularity and has been advocated as a useful technique for the camouflage of white spot lesions after orthodontic fixed appliances.<sup>26</sup> There appear to be no difference in levels of sensitivity experienced by this population when compared to adults; however, some concern exists as to the potential negative long-term effect on surface micro-hardness of the teeth as bleaching products can decrease micro-hardness within sound enamel, and both sound and demineralized dentine.<sup>27</sup> In contrast, there is an increase in hardness associated with demineralized enamel, irrespective of the technique or product used.<sup>28</sup> In addition, whilst the micro-hardness of packable composite resins are

unaffected by carbamide peroxide-based bleaching, their surface roughness can be increased.<sup>29</sup>

## Is tooth whitening legal in the UK?

The supply of tooth whitening products containing more than 0.1 per cent H<sub>2</sub>O<sub>2</sub> present or released is an illegal act rendering the supplier open to prosecution. The maximum penalties for illegal supply are six months imprisonment and/or a fine of £5000. A House of Lords judgement in June 2001 confirmed that tooth whitening agents were covered by the European Union Cosmetics Directive, and not by the Medical Devices Directive. Practitioners considering the supply and use of such materials need to be aware of this issue. Trading Standards and Environmental Health Officers of Local Authorities are now being advised to actively enforce the law if they become aware that dentists are using a concentration of H<sub>2</sub>O<sub>2</sub> greater than 0.1 per cent in tooth whitening products. This is a significant change to the guidance given in July 2004, which suggested a low key approach to prosecution. The Defence Unions recommend that a fully documented consent procedure should be obtained and entered into the clinical notes, which states both the risks and benefits of any tooth whitening technique to be used, although this will not necessarily preclude a dentist from prosecution.

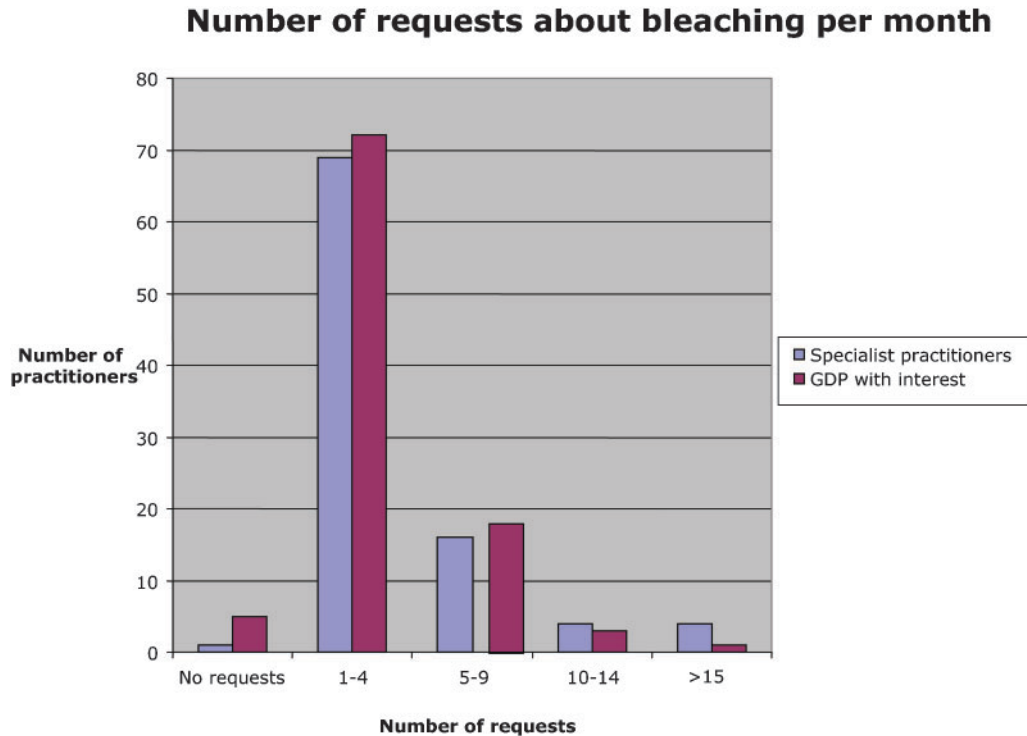
The British Dental Association has stated that there is nothing illegal or unsafe about the technique of tooth whitening, which was confirmed by the Chief Dental Officer in March 2000. It is simply that these products have now become subject to the European Union directive. The Department of Health has recently issued a statement updating dentists on the latest position: 'The use of a tooth bleaching technique is not itself illegal and the Department of Health would not seek to interfere with a dentist's therapeutic decision to utilize a

**Table 4** Side effects associated with bleaching

Gingivae
Tissue sloughing
Minor gingival irritation/ulceration
Change in gingival texture
Gingival soreness
Teeth
Bleaching may occur in an uneven manner
White spots may become more visible
There may be a visible demarcation line between the colour of the incisial tip and the cervical neck
Oral mucosa
Sore throat
Burning palate
Unpleasant taste
Pain and sensitivity
Teeth may become sensitive in particular at the cervical margin if gingival recession is present
Systemic
Mild laxative effect possibly due to the glycerine
Free radical formation during the bleaching process

**Table 5** Possible causes of tooth sensitivity and gingival irritation

Addition of carbopol and other thickening agents
Anhydrous-based whitening products
Chemical byproducts of carbamide peroxide
Concentration of whitening solution
Exposure time
Flavours added to the whitening solution
Frequency of application
Inherent patient sensitivity
pH of the whitening solution
Sex of the patient: women appear to experience more side effects than men
Age of the patient: patients under 40 experience more side effects
Tray material



**Figure 2** Number of bleaching requests per month

bleaching technique where a dentist considers this to be in the best interests of the patient's overall oral health'.

### Current use of tooth whitening by orthodontists

In view of the current climate a questionnaire was sent out to all Specialist Practitioners ( $n=594$ ) and General Dental Practitioners with a special interest in orthodontics (GDPs) ( $n=434$ ) registered with the British Orthodontic Society regarding their use of bleaching agents. The response rate was 54 per cent for Specialists and 48 per cent for GDPs, which was low and therefore questions how accurately the information reflects those groups being questioned. It might be postulated that a 50 per cent response means that half of those subjects questioned do not use, or have no interest in this technique. Whilst it is impossible to predict the influence of this 50 per cent, it was felt that the results were justified for presentation.

Among those that did respond, 70 per cent of Specialists and 63 per cent of GDPs did not suggest bleaching to their patients. However, 92 per cent of both groups stated that bleaching had been requested by patients, with over 60 per cent of both groups suggesting that between 1 and 4 requests were made per month. Interestingly, only 23 per cent of responding Specialists

carry out this procedure compared to 58 per cent of GDPs. Indeed, the majority (76 per cent) of Specialists refer patients back to their GDP for advice on these procedures. Of those who do carry out the technique, in both groups, 72 per cent prefer home bleaching compared to 28 per cent who use in-surgery techniques. The main reasons stated for this preference were cost, ease of use and reliability. The average age for bleaching was 13 years old for GDPs and 15 years old for Specialists, although the age range was wide, being from 10 to 30 years. The majority of Specialists (78 per cent) and GDPs (63 per cent) do not perform any form of microabrasion technique after orthodontic treatment for the removal of staining or white spot lesions.

### Conclusions

- A significant number of orthodontists encounter enquiries about tooth whitening during clinical practice.
- Only 23 per cent of responding Specialists carry out bleaching procedures compared to 58 per cent of General Dental Practitioners with a special interest in orthodontics.
- Of those who do carry out bleaching procedures, 72 per cent prefer home bleaching compared to 28 per cent who use in-surgery techniques.

- The supply of these materials is illegal although the technique itself is not.
- Over-the-counter products are potentially more detrimental to oral health.

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