Tooth whitening: the last 25 years

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The introduction of contemporary tooth whitening techniques was launched in 1989 with a research paper called 'Nightguard vital bleaching'. The authors, Van Haywood and Harald Heymann, described the use of a bleaching tray as a vehicle to place the whitening gel into the mouth for better retention and to give better long lasting and predictable results.

Further research by the authors showed the effectiveness, efficacy, predictability, longevity and reduction in side effects.

It has now been 27 years since that paper was published and this article will review how, in just a quarter of a century, tooth whitening has become a valued treatment service for patients with a vast body of scientific literature behind it.

Millions of people around the world have benefitted from the use of the tooth whitening materials and techniques over the last 25 years and its popularity continues to grow (Greenwall, 2001).

Although tooth whitening techniques were popular in the 1880s – using strong concentrations of hydrogen peroxide and a bleaching lamp – modern techniques focus on the use of a bleaching tray and applying products in the tray at home.

It was Bill Klausmier, an American orthodontist, who started using the technique in 1968 to help reduce the swelling on the gingivae post-orthodontic treatment. He advised his patients to use peroxyl mouthwash into the retainer to reduce the gingival hyperplasia (Haywood, 1991a). At the six-month recalls he noted that not only were the gingivae of the patient significantly better, but the teeth were also whiter.

This chance finding, similar to the invention of penicillin, has allowed many patients to benefit from these techniques. After using this technique for 40 years, he reported that nobody needed a root canal treatment, nor broke nor damaged a tooth following the use of peroxide in the tray. He advised his colleagues in a local study group to use this technique and subsequently passed it onto Dr Van Haywood who began research on the technique.

Early research

Early research focused on whether the whitening products were safe and effective. Professor Yiming Li from Loma Linda University has devoted the last 20 years of his research life investigating the safety of hydrogen peroxide. He has concluded that it is safe to use as a whitening agent in the oral cavity, as long as the products used are supervised and monitored by the dentist and the dental team (Li, Greenwall, 2013).

There was an explosion of research conducted on whitening in the early 1990s, and there are now thousands of articles published on all aspects of whitening.

There was extensive research conducted on the side effect of sensitivity, which occurs in up to 85% of patients. Research was conducted as to how and why the sensitivity occurred and how best to treat it.

It was discovered that whitening gel penetrates the tooth within five to 15 minutes of application. It is therefore essential to assess the pulps of all the teeth to make sure they are healthy prior to undertaking any whitening procedure. If whitening was to be undertaken in the presence of a non-vital area, the area will flare up and need a root canal treatment. It is best to plan a root canal treatment to be undertaken prior to starting any whitening treatment.

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Figure 1: An advanced whitening case with a diagnosis of fluorosis. The patient had direct composite bondings placed over the upper central incisor teeth to mask the discolouration, which were removed prior to whitening. Home bleaching was undertaken using 10% carbamide peroxide in a bleaching tray.

Figure 2: Result after whitening with carbamide peroxide for eight to 10 weeks.

Methods of whitening

There are two basic techniques for home bleaching, depending on the products:

- Night-time use, using a carbamide peroxide material
- Day-time use, using a hydrogen peroxide only material.

How have things changed?

Changes in the whitening legislation were introduced in 2011. The Cosmetic Products (Safety) (Amendment) Regulations 2012 (implementing Directive 2011/84/EU, which amends Directive 76/768/EEC) came into force on 31 October 2012.

The legislation specifies that products containing or releasing between 0.1% and six per cent hydrogen peroxide cannot be used on any person under the age of 18, except where such use is intended wholly for the purpose of treating or preventing disease.

Products containing or releasing less than 0.1% of hydrogen peroxide, including mouth rinse, toothpaste and tooth whitening or bleaching products, are safe and will continue to be freely available on the market.

Tooth whitening or bleaching products containing or releasing between 0.1% and six per cent of hydrogen peroxide may be used provided an appropriate clinical examination is carried out in order to ensure that there are no risk factors and any other oral pathology is ruled out.

The exposure to the whitening products should be limited to ensure that they are only used as intended in terms of frequency and duration of application.

Whitening products should be clearly labelled for their intended purpose of tooth whitening. The products should not be directly freely available to the consumer. Products may only be purchased through a dental practice and tooth whitening products containing or releasing between 0.1% and six per cent hydrogen peroxide may only be sold to dental practitioners.

For each cycle of use, the first use must be carried out by a dental practitioner or under their direct supervision if an equivalent level of safety is ensured. After the first cycle of use, the dental practitioner may give the product to the consumer to complete the cycle of use.

Concentrations exceeding six per cent of hydrogen peroxide remain prohibited unless wholly for the purpose of the treatment or prevention of disease. It is essential that dentists abide by the legislation, as Trading Standards can prosecute them if they use higher than six per cent hydrogen peroxide on a patient or if they intend to supply a patient with whitening gel stronger than six per cent hydrogen peroxide.

Bleaching single dark teeth

The treatment options for both vital and non-vital teeth have changed over the last 25 years with the introduction of whitening techniques.

These days a sectional whitening tray can be used to whiten a single dark tooth, whether vital or non-vital. It is essential to whiten the dark tooth first in order to establish the whitening potential and possibility. If the whitening of the dark tooth doesn't start first, the rest of the teeth will whiten quicker and the contrast of the dark tooth will look worse.

Table 1: Some of the changes that have occurred in tooth whitening over the last 25 years

How has tooth whitening changed over time?		
Patient factors	**Material factors**	**Technique factors**
Expectations increased	Two-week tray use now	Take home gels now fifth generation formulation
Seeking whiter teeth	Extended tray use	Introduction of soothers, potassium nitrate and fluoride and acp
Philosophy of perfection	Changes in tray designs	Concentrations of materials have changed
More difficult discolourations	Used with aligners	Power gels have changed
No age restrictions for older age patients	Therapeutic uses now introduced	Is light essential?
No age limit for under 18	Whitening strips introduced	Lights/no light?
Whitening maintenance		Heat/no heat?
Whitening for life		Lasers
Bleachorexia/bleachoholic		Ozone

Vital single dark teeth

When the patient receives mild trauma to an anterior tooth, the tooth tries to repair and heal itself by laying down extra secondary and tertiary dentine in the pulp chamber. The trauma results in bleeding into the pulp chamber and pulp canal. The blood products reorganise and break down into iron. The discolouration, which is a result of the bleeding and the formation of secondary and tertiary dentine, can be detected when the tooth is a different colour to its neighbour by about one or two shades only.

In the past it was thought that these teeth, which are diagnosed as having calcific metamorphosis (Haywood, 2010), need to have root canal treatments. However, this is not true – they need only be whitened.

Non-vital teeth

The techniques for non-vital bleaching have also evolved with the banning of sodium perborate by the scientific committee in Europe, which was concerned about the fetotoxic and cytotoxic effects.

The standard technique, which was called the Walking Bleach technique and first described by Nutting and Poe in 1965, was advocated by using sodium perborate mixed with 35% hydrogen peroxide.

The two products together act synergistically and create the equivalent of 50% hydrogen peroxide, which is too caustic for a root canal considering that it may be affected by trauma previously. High concentrations of hydrogen peroxide have been banned in Europe and it may only be possible to use six per cent hydrogen peroxide sealed into a root canal.

In addition, the strong concentrations of hydrogen peroxide in combination with previous trauma to the tooth may result in cervical resorption (Cvek, Lindwall, 1985; Hierthersay 1999), which has been extensively described in the literature.

There are new modifications for this treatment, which involve the use of a bleaching tray and a segmental bleaching tray. These days, 16% carbamide peroxide is sealed into the root canal and the patient uses the bleaching tray to whiten the external surface of the tooth, meaning that the tooth is effectively whitened from the inside and the outside with the same technique.

Dr William Liebenberg described a modification in 1997, in which he advocated leaving the access cavity of the non-vital tooth open so that the patient could apply the whitening syringe into the access cavity every two hours thereby whitening the tooth over the course of the weekend. The patient was to return at the end of the weekend and the access cavity disinfected and cleaned and the pulp chamber restored with glass ionomer.

Figure 3: This patient had a basic inherent grey shade to his teeth.

Figure 4: The result after whitening for six weeks with home bleaching trays for six weeks using 10% carbamide peroxide whitening gel.

The future: whitening varnish

There are exciting new developments in tooth whitening products with the introduction of whitening varnish. The tooth is coated with a varnish that contains six per cent hydrogen peroxide. This hydrophilic (moisture-loving) varnish adheres well to the tooth, delivering the active agent directly into the enamel and dentine. A second, sealant layer dries onto the tooth and locks the hydrogen peroxide layer in place. This varnish layer is hydrophobic (water repellent) and the two varnish layers are immiscible (do not mix) during application.

The varnish is left on the teeth for half and hour per day and then brushed off with a toothbrush.

There are also new developments with enzymatic bleaching where two products are mixed together to activate and speed up the process of whitening using a three per cent carbamide peroxide gel in combination with lactoperoxidase.

Increased patient expectation

With the introduction of new whitening treatments, patients are demanding whiter and whiter teeth. Patient expectations have increased – they now expect to have white teeth instantly, which are perfect in shape and size. They also expect that dentists will be able to achieve a whiter smile for them instantly.

Patients are seeking whiter teeth and, for some, this whiteness has reached extreme levels. There is a philosophy of perfection that has crept into popular culture and there is a certain fashion trend associated with whitening. The media shows whitening as a must-have item and the advent of the extreme makeover shows has led to unrealistic expectations.

A perfect smile with perfectly white teeth is not always possible and it is the responsibility of the dentist to explain the realistic expectations and outcomes they may expect. The dentist should be able to explain to the patient what they can, and cannot, expect to happen in terms of a uniform whiteness.

There is also the time factor associated with whitening – the darker the tooth, the longer it will take to whiten. Not all teeth can be whitened within two weeks. Darker and more difficult discolourations can be treated with home bleaching at 10% carbamide peroxide, but the treatment times are extended to between eight and 10 weeks.

Patients who have tetracycline-stained teeth will be able to achieve whitening but the treatment times are much longer. Severe discolourations can extend whitening treatment to up to 12 months.

There is no age restriction for older age patients to be able to whiten their teeth (Kelleher et al, 2011) and it is a factor of anatomy as to how quick the gel can penetrate into the tooth to permit whitening to take place. Older teeth are more heavily compacted with secondary dentine and so their teeth will take longer to whiten. Younger teeth will lighten quicker as their anatomy demonstrate open odontoblastic process and enamel is young. Despite the fact that there are larger pulp canals and pulp chambers, young patients who undertake whitening do not demonstrate more sensitivity than older patients (Greenwall, 2009).

Home bleaching

Research studies have demonstrated that, for a basic whitening case using the original protocol of Professor Van Haywood (Haywood 1991a,b,c), the total treatment time is about four to six weeks. Normally, the upper teeth are

Table 2: A selection of whitening materials containing carbamide peroxide for use in a bleaching tray

Carbamide peroxide whitening products		
10%	**15%**	**16%**
Polanight (SDI)	Opalescence PF (Ultradent)	Polanight (SDI)
Opalescence PF (Ultradent)	Illuminé (Dentsply)	Opalescence PF
Perfect Bleach (Voco)		Nitewhite (Philips)
Zaris White & Brite (3M)		Evolution Enlighten
Evolution (Enlighten)		Zaris White & Brite (3M)
Illuminé (Dentsply)		Evolution (Enlighten)
White Dental Beauty (Optident)		Perfect Bleach (Voco)
		White Dental Beauty (Optident)

whitened first for a period of at least two weeks and then re-assessed. Then upper and lower whitening may take place together for one week and thereafter the lower teeth are whitening for a further two weeks.

The upper teeth may take two to three weeks to whiten on consecutive nights. The upper teeth are whitened first as they whiten quicker and normally experience less side effects and sensitivity, the patient has a colour comparison when only the upper teeth are whitened first.

The lower teeth may take at least three weeks to whiten each evening. The lower teeth experience more sensitivity due to the tray contact with the lower premolar teeth and the cervical recession present on some teeth. There is thought to be washout with the salivary duct so whitening takes longer on the lower teeth.

Whitening maintenance

If the protocol is followed precisely, research has shown that whitening can last up to 17 years. However, some patents like to top-up their whitening after three years. It is not necessary to top-up each month. It is essential that during initial treatment the bleaching potential of the tooth be reached effectively.

Once reached, whitening maintenance only needs to be undertaken approximately three years later. When the patient rewhitens their teeth, they would whiten for a shorter period from three to seven days.

Whitening for life

It is expected that patients will whiten their teeth periodically to maintain a white smile. In a 25-year timespan, a patient may whiten four to five times. Maintenance is essential and involves regular professional oral prophylaxis treatment, the use of whitening toothpaste and sometimes a reduction in food and drink that cause staining.

The rise of bleachorexia

Over the last 25 years it has been possible to whiten the teeth beyond the original Vita classic shade guides.

New shade guides have been developed to match the new shades of white, and porcelain and composite shades have been introduced onto the market to be able to restore these teeth to the new whiter shade.

Some patients have developed a syndrome where they continually seek whiter and whiter teeth. This is also associated with body dysmorphic disorder and low self-esteem. The term has been described as bleachorexia (Kelleher, 2014), with patients referred to as being a bleachoholic.

It is essential that dentists know how to recognise the syndromes and not be seduced into undertaking unnecessary whitening treatment. These patients can usually be detected early, as their teeth are whiter than their sclera of their eyes, which is often used as a measurement of the whiteness that can be achieved.

It is essential that when whitening treatment is completed the patient is told that no further whitening is necessary at that point. Each whitening cycle will require the dentist to reassess the patient to assess whether further whitening is necessary.

Conclusion

The explosion in tooth whitening techniques research over the last 25 years has demonstrated that the whitening products are safe, effective, predictable to use and have many benefits for patients. Side effects such as sensitivity can be managed well as the newer generations of whitening products now contain extra soothers such as potassium nitrate, fluoride and amorphous calcium phosphate. Patients have benefitted from their new shade of white teeth and these treatments have improved smiles in a natural and non-invasive way.

Further clarification in the whitening legislation for under 18s (Kelleher, 2014) is being investigated by the CED in Europe, and these treatments may be able to be used for under 18s, provided they are being used for the treatment of disease, which they are.

It is expected that the amount of professional tooth whitening materials available will increase for patients to use under the direction of dentists. What's more, there are many new innovative whitening products that are being brought onto the market for patients to continue to enjoy a whiter, brighter smile.

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