Speed bleaching: the importance of temporary filling with hermetic sealing

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Abstract

The aim of this study was to demonstrate the influence of an adhesive temporary restoration on the effectiveness of the bleaching reaction, regardless of the concentration of the bleaching agent used. Every clinician involved in conservative dentistry understands the incompatibility between 'chemical bond' and 'oxygen.' This awareness often influences clinicians to decide on a temporary 'mechanical retention' filling that is unable to prevent the escape of oxygen ions, forcing the patient into more sessions and therefore raising the risk of complications. The scientific rationale behind the procedure described in this article is based on the bonding capacity of the coronal seal to maintain the rapid dissociation of the hydrogen peroxide exclusively within the pulp chamber, inducing an increase in the internal pressure and a consequent penetration of the oxygen-free radicals directly inside the dentinal tubules. In fact, avoiding the spontaneous dissipation of the oxygen-free radicals in the external environment may limit their effectiveness. This study aimed specifically to prove that it is possible to obtain a rapid bleaching reaction by observing a protocol based on the 'walking bleach' technique, specifically modified not so much by the typology of the mixture used but by fully exploiting the reaction yield of the hydrogen peroxide disproportionation. The results of the documented clinical cases presented here show the effectiveness of this method, which is achieved in a single session, therefore decreasing the possibility of the several operating phases that are necessary with the traditional procedure.

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Fig 1 Initial case.

Fig 2 The same case after a speed bleaching procedure.

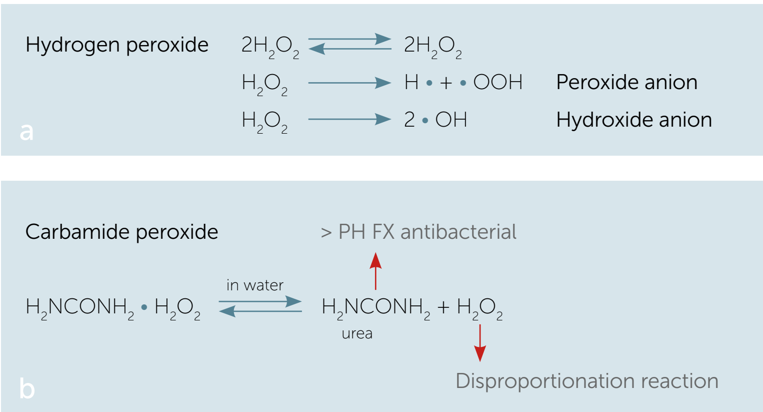

Fig 3 (a) Chemical reaction of the disproportionation of hydrogen peroxide. (b) Dissociation of the carbamide peroxide.

Introduction

The clinical method of internal bleaching was first applied toward the end of the 19th century. It was subsequently codified by several authors (Salvas in 1938,[1] Spasser in 1961,[2] and Nutting and Poe in 1967[3]) in the various well-described phases nowadays known as the 'walking bleach' technique. Each of these authors characterized the technique more specifically for use with a particular bleaching mixture.[1-4]

The walking bleach technique is particularly suitable for solving the appearance of dyschromia of intrinsic post-eruptive origin (Figs 1 and 2), and is linked to phenomena such as, for instance:

- Dental necrosis.
- Intrapulpal hemorrhage.
- Degeneration of the pulp tissue residues remaining after endodontic therapy.
- Endodontic materials rich in colorformers.

The classic technique consists of leaving a hydrogen peroxide-based gel bleaching agent in the pulp cavity of a dyschromic tooth for a few days and then replacing it until the desired result is achieved.[3]

In an attempt to obtain more effective and predictable results and to prevent possible complications, there have been various attempts to modify this method. Initially, these modifications concerned the chemical composition of the gel bleaching agent,[5] and thereafter its manipulation, first through exploited heat methods (thermocatalytic technique) and then by means of the photoactivation principle (photocatalytic technique) that uses a number of light sources, up to the use of laser radiation.[1,2,4]

In all cases, the active compound responsible for the bleaching reaction is hydrogen peroxide, whether used on its own or in combination with other compounds. Of particular importance is its spontaneous dissociation in water, and the fact that free oxygen radicals are exploited (Fig 3); it is precisely these radicals in contact with chromophore molecules that break the covalent bonds that stabilize them dimensionally, reducing them to substances with a lower molecular weight that are less reactive to luminous radiation, thus resulting in a lighter tooth shade.[6] The final products are therefore carbon dioxide, water, and carbonyl acid. These substances not only transform the appearance of the tooth, but also the internal tooth environment, which results in a constant drop of the pH and, consequently, an increased concentration of these substances (Fig 4).

The walking bleach technique is not risk free, and the most worrying complication is root resorption (Fig 5), which can be related to various factors, in particular the lowering of the pH value, but also to the excessive duration of treatment and the heating of the bleaching agent.[7] An acid pH stimulates the osteoclast activity responsible for aggression to dentin tissue, and, as this reaction is closely related to bleaching products such as carbonyl acid (HCOOH), it cannot be avoided. However, it is possible to intervene promptly once the required color value has been obtained, introducing calcium hydroxide into the pulp chamber, which can effectively buffer the pH value.[8,9]

A prolonged treatment can increase the likelihood of complications as it can extend the time of unfavorable conditions such as excessive acidity and inflammation that cause the disappearance of the root canal cementum and the subsequent osteoclast differentiation.[10,11] In addition, some studies have proven that the manipulation of bleaching agents using heat does not produce better results; moreover, this technique also produces hydroxyl radicals (OH), which are much more aggressive and, in particular, cause the degeneration of connective tissue.[12,13]

Taking all the scientific evidence into consideration, this article presents a rapid bleaching protocol called speed bleaching, which is safe, effective, and simple to execute (Fig 6).

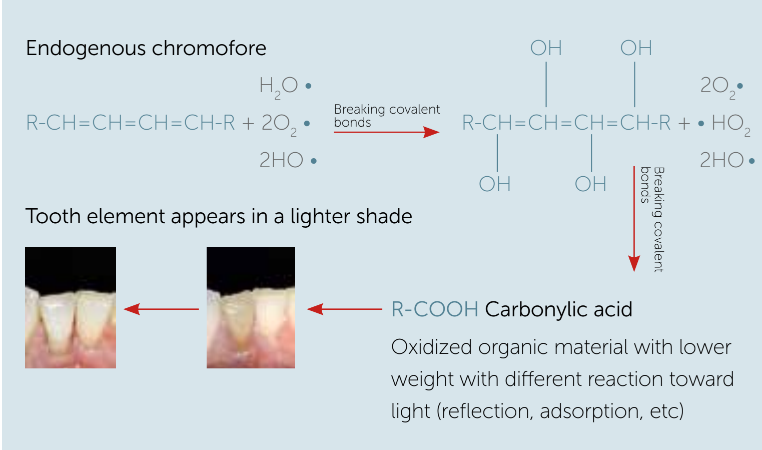

Fig 4 Physical-chemical dynamics of the interaction between the bleaching agents and the pigmenting substances.

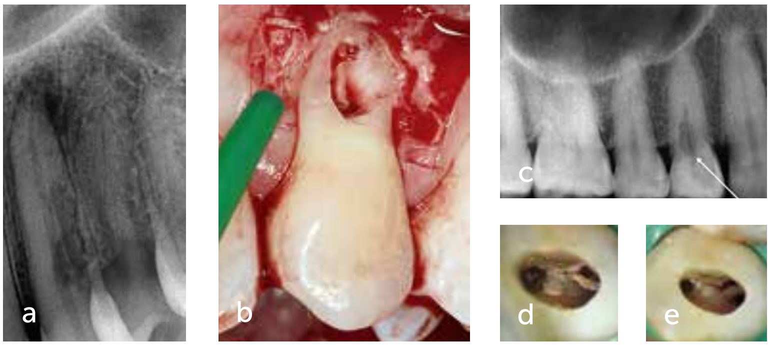

Fig 5 (a) Radiograph of an external root resorption on tooth 23. (b) Intraoperative view of the external root resorption on tooth 23. (c) Radiograph of an internal resorption on tooth 14. (d) Intraoperative view of the pulp chamber before detersion. (e) View of the internal resorption after detersion of the pulp chamber.

1 Endodontic retreatment

Preparation of the bleaching chamber:
2 Positioning of C.V.I substrate
3 Preparation of the coronal seal in composite

4 Placing of hydrogen peroxide
5 Sponge
6 Hermetic coronal seal

Fig 6 Clinical protocol of speed bleaching.

Materials and methods

At the procedural and clinical levels, the authors distinguish two situations in which the tooth to be bleached is identified: the endodontically treated element and the necrotic element.

Endodontically treated teeth

If previous endodontic therapy is radiographically inadequate or very old, the authors recommend that new endodontic therapy be carried out. The first reason is both an endodontic one and to assume full

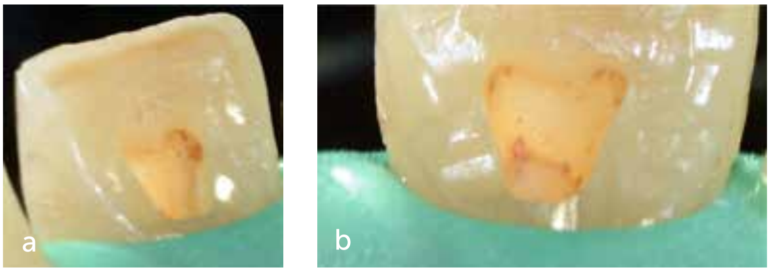

Fig 7 (a) Significantly enlarged image of the pulp residues in the pulp horn chamber. (b) Pulp horn chamber and pulp residues remaining after the previous root canal treatment.

Fig 8 Measuring the bleaching chamber depth with a plugger for the GIC substrate. 7 mm: measurement of the probing depth at the gingival margin; 9 mm: GIC barrier in place. 2 mm of gutta-percha has been removed apically to the gingival probing depth.

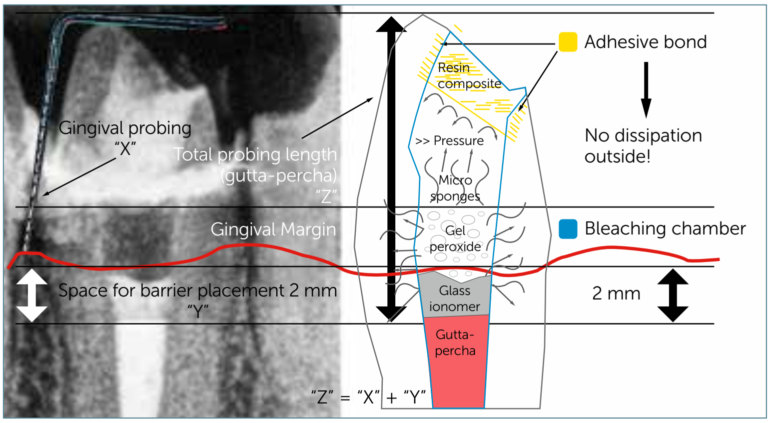

Fig 9 Dynamics of the reaction linked to the hermetic seal inside the pulp chamber.

responsibility for the treatment; the second is to eliminate any old endodontic material residues rich in metal salts or pulp tissue residues, which represent the primary cause of dyschromia or of its postbleaching recurrence.[4]

Necrotic teeth

In the case of necrotic teeth, it is advisable to perform root canal therapy comprising at least two sessions, to allow the root canal irrigants – sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA) – to properly eliminate all the necrotic pulp residues, as the *in situ* presence of these residues could cause postbleaching recurrence, especially at the pulp horn level (Fig 7).[14]

Preparation of the bleaching chamber

It is important to accurately delimit the area that needs to be involved in the bleaching reaction. Therefore, at least 2 mm of the most coronal portion of the root canal filling should be eliminated and subsequently filled with a glass ionomer cement (GIC). Due to its affinity to dentin, the GIC will prevent the penetration of the peroxide in the endodontic lumen, safeguarding the area most sensitive to root resorption.

The positioning of the GIC substrate is checked by using pluggers (Fig 8) or periodontal probes, allowing the clinician to accurately establish the bleaching apical limit. Usually, for prosthetic requirements, this limit exceeds the margin of the cemento-enamel junction (CEJ) by 1 mm; this is to solve the problem related to the projection of the underlying root dyschromia on the external gingival margin of the CEJ, which is difficult to mask prosthetically.

Regarding the technique for positioning the barrier material, for the speed bleaching procedure the authors use the well-known protocol based on the length of the vestibular clinical crown,[15] whereby the length of the clinical crown on the vestibular side is measured up to the gingival sulcus using a periodontal probe or an endodontic plugger. This measurement is then carried over inside the pulp chamber, to which 2 mm of necessary space is added to position the barrier, space that is obtained by removing approximately 2 mm of gutta-percha. This technique is suitable for periodontally healthy teeth (Fig 9). For periodontally diseased teeth, or in the case of gingival recession, the CEJ (not the gingival border) is the reference measurement. To scrupulously prevent the unwanted complication of internal and external bleaching (ie, radicular root reabsorption), the authors agree with suggestions in the literature to differentiate the height of the chosen barrier material in the interproximal areas compared with the vestibular area, taking into consideration the specific coronoapical direction of the dentinal tubules.[16,17] This procedure can be carried out using either a round bur in a vestibular-palatal/lingual direction on the cured barrier material (GIC or composite resin), or by using an endodontic plugger or a long and small ball dental burnisher, compressing the barrier material while it is being cured (GIC). The clinical case shown in Figures 10 and 11 illustrates this approach.

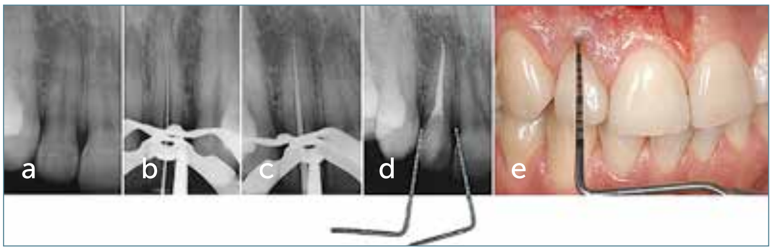

Fig 10 Endodontic treatment of a maxillary lateral right incisor due to a piercing trauma. (a) The initial case (necrotic tooth). (b) Working length. (c) Cone test. (d) End of the endodontic treatment: flowable resin barrier in a concave position over the gutta-percha (speed bleaching procedure); radiographic interproximal periodontal probing. (e) Vestibular periodontal probing of the Miller Class I recession present at the end of speed bleaching.

Fig 11 (a) Initial recession and presence of dyschromia. (b) Subepithelial connective tissue graft. (c) Final case after speed bleaching and mucogingival surgery.

Often, temporary filling materials need to be removed after the bleaching treatment. It is therefore very important that they are easily identified and are simple enough to remove. They should also not contaminate the radicular walls. GICs meet these requirements perfectly because their color can be easily distinguished from that of the radicular dentin. In addition, once cured, ultrasound devices and water can be used to easily clean any residue from the radicular walls above, as they do not include any contaminants. GICs also provide good protective action,[18] effectively insulating the canal lumen by means of a bland adhesive action. When bleaching has been completed, ultrasound devices can once again be used to safely remove the GICs, which is why they are also commonly used as a barrier in walking bleach procedures as well as intermediary filling materials. As an alternative to GICs, the latest-generation self-adhesive materials can also be used; they are easy to manipulate and devoid of tertiary amines. They are therefore chromatically more stable over time. As already mentioned, actual adhesive materials can also be used such as all flowable or traditional paste composites as well as zinc phosphate. However, zinc phosphate is a clear second choice to GICs and composite materials as it is difficult to work with, has an acidic pH, inferior sealing capacity, and virtually non-existent adhesive action.

What follows are a few comments regarding composite materials, in both paste and flowable forms: If they are used as barrier materials, given their superior sealing capability, it is essential to carry out the necessary adhesive procedures (etching and applying the chosen adhesive system) in advance. To be effective, these procedures must be carried out in an ultra-selective way, only at the opening of the canal lumen. If the adhesive system is accidentally applied in any other areas, the bleaching procedure will be compromised; as the resin-adhesive

Fig 12 Tooth 21 endodontically treated.

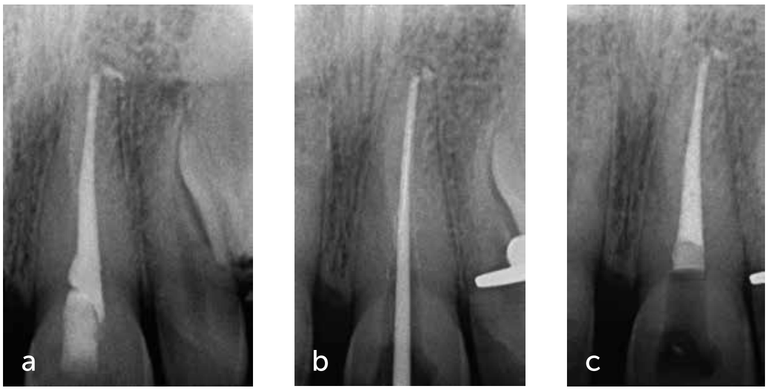

Fig 13 (a) Preoperative radiograph. (b) Cone test. (c) Accomplished reprocessing associated with a glass ionomer stop above.

system would be blocked, it would be impossible for the gel and the liberated oxygen to penetrate the dentinal tubules. The same is true when they are used as temporary filling materials such as in the procedure discussed in this article. Moreover, this precision regarding the positioning is also required (and proves indispensable) when using GICs. The authors therefore suggest using adequate sources of magnification plus light or an operating microscope in any case, together with very small and thin microbrushes, for the ultra-selective application of the adhesive system at the canal opening only, or at the enamel margin outside the opening of the pulp chamber. If flowable resins are used, great care should be taken due to their typical capillarity. The clinician should check their correct positioning only where necessary, and deal with the potential flow during use. As already mentioned, it is suggested for this purpose that adequate magnification sources (preferably prismatic loupes plus light or an operating microscope) be used, together with ultrafine microbrushes and the choice of chromatically contrasting masses (for example, 'intense-white') in order to make recognition easier in the event of reentry. It should be noted that the long-term success of cases of internal bleaching using the walking bleach technique can drop to close to 50% or lower.[19] Therefore, the real possibility of reentry due to relapse must always be taken into consideration in these procedures.

Composites as a barrier are more difficult to remove than GICs due to the way they are used for this function, ie, very apically in relation to the chamber floor, in very small quantities, and often not immediately or easily located. Other factors that make them difficult to remove are their color, which is often changeable, and their hard consistency. For total and nonpartial removal of composites it is advisable to use the appropriate magnification instruments already mentioned as well as small rose head burs with a long shank for gaining better access to deeper areas, especially for teeth with long clinical crowns, as well as the already cited sources of ultrasound, provided with dedicated and specific inserts.

After consolidating the floor of the bleaching chamber and thereby stabilizing the apical border, the clinician can proceed to build the hermetic coronal seal. Even before introducing the peroxide, the base for the seal should be prepared to avoid the adhesive bond being inhibited by the release of oxygen immediately generated from the bleaching agent. All the procedures for chemical adhesion should be put into practice: etching the enamel-dentin margins and applying the chosen adhesive system.

This phase ends with the addition of 1 to 2 mm of flowable composite resin to ensure a strong cohesive bond between the freshly prepared margin composite and the one that was stratified at the time the cavity was closed (Figs 12 to 14). At this point, the bleaching agent can be introduced into the pulp chamber. Care should be taken not to involve the composite resin margins (Fig 15). The filling will only affect 2/3 of the pulp cavity above the bleaching agent; a sponge should be applied in the middle, allowing the final composite filling material to find a base and to harden, thus hermetically closing the cavity (Figs 16 to 18).

In the cases described here, the bleaching agent comprises 35% hydrogen peroxide, in accordance with the European Directive 93/42/CEE.

Clinical rationale

The hermetic closure prevents the spreading of free radicals toward the outside environment, restricting them in their path within the dentinal tubules. Moreover, the ensuing increase in the internal pressure enhances the penetration of the radicals through the dentinal walls, which is another reason the authors advise against the use of temporary fillings with hydraulic closure, as they would not be able to prevent this pressure increase and would thus inevitably favor the dispersion of radicals, with a drastic fall in the bleaching reaction yield (Fig 9).

Fig 14 Preparation of the hermetic seal.

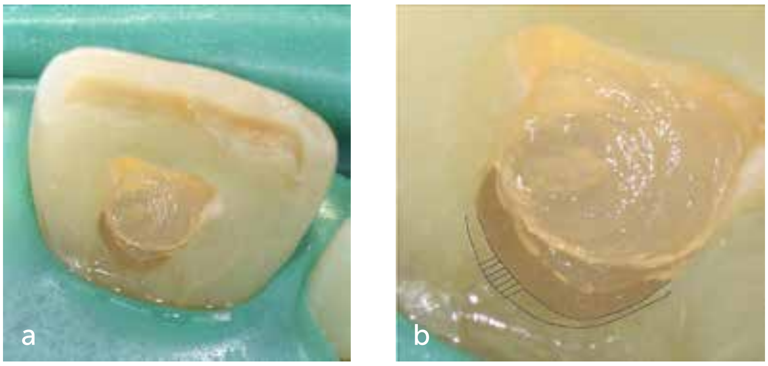

Fig 15 (a) 35% peroxide gel. (b) Significantly enlarged view of the enamel-dentin thickness treated for the adhesion of the hermetic seal.

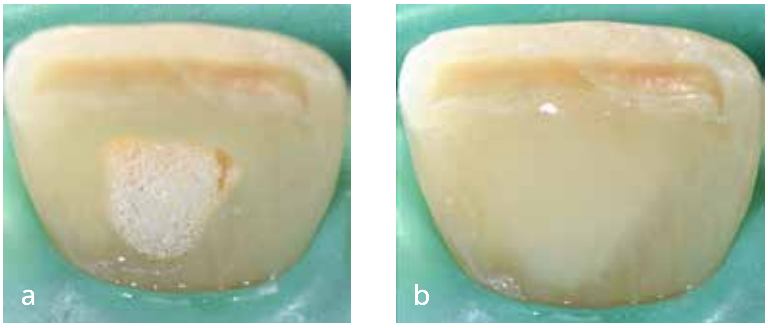

Fig 16 (a) Views of the sponge above the peroxide gel. (b) Composite hermetic seal.

Clinical case 1: endodontically treated tooth

A 39-year-old male patient presented at our dental office complaining about an esthetic problem with tooth 21 (Fig 12). The clinical examination showed a clear loss of vertical dimension, with an agenesis of tooth 23 and worn surfaces involving several teeth. The clinical history showed a previous endodontic treatment on tooth 21 that was carried out to treat the dental necrosis, probably caused by occlusal overload. The patient's only concern was solving the dental dyschromia.

Considering that the first root canal therapy was performed 20 years previously, and

Fig 17 (a) Preoperative image. (b) Result after 3 days of treatment. (c) Radiograph showing the GIC substrate. (d) Final posttreatment radiograph. (e) Radiographic follow-up at 6 months.

on examination poor compression of the gutta-percha was established, the authors preferred to initially carry out an endodontic retreatment (Fig 13). As per our protocol, 2 mm of GIC was used to protect the root canal lumen under the CEJ (Fig 13c). After the apical border had been established, the coronal dental margins were prepared, adequately beveled, and etched (Fig 14) to ensure that the enamel and dentin borders were of sufficient thickness to establish a solid bond with the composite used and be capable of resisting occlusal trauma.

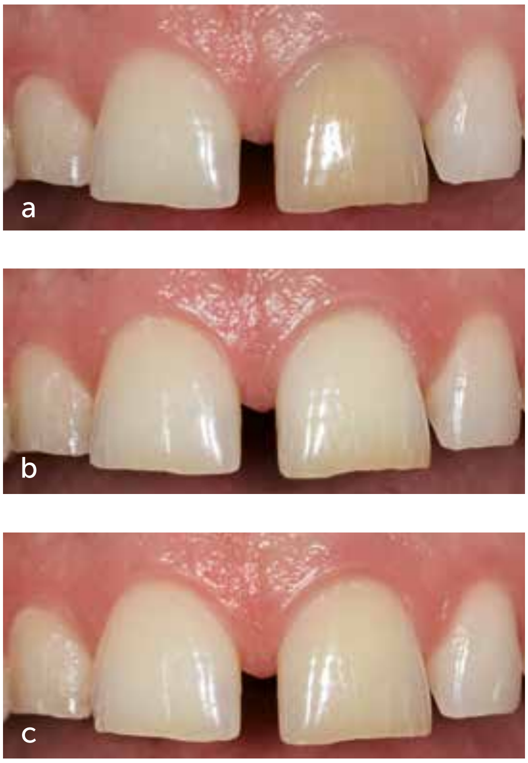

Fig 18 (a) Tooth 21 before bleaching. (b) Result of the accomplished bleaching. (c) 6-month follow-up.

The pulp chamber, in particular the area of the pulp horns, was inspected under strong magnification. Then, a mixture of 35% hydrogen peroxide was introduced to occupy 50% of the chamber volume (Fig 15), while the remaining part was filled with a sponge, the only function of which was to isolate the mixture from the composite. The sponge was therefore not immersed in the peroxide, but delicately placed to avoid the excess from wetting the margin, thereby preventing subsequent cohesion (Fig 16a).

In the final phase, the coronal access was rapidly closed with flowable composite placed on the margins and above the sponge. Once polymerized, a check should be carried out for any bubbles, which, if found, must be removed and filled with additional composite (Fig 16b). A check for occlusal interferences was then carried out using 40 µm articulating paper. Following this, the patient was discharged.

Three days later, the patient telephonically confirmed the result. Seven days after treatment, the patient returned to the dental office and safety procedures were applied to bring the pH back to neutral values. For this purpose, water and ultrasound were used to carefully clean the pulp cavity of all peroxide. Calcium hydroxide was introduced, and another temporary filling was made using composite. After an 18-day waiting period (the time required for the spontaneous elimination of the oxygen radicals), the final filling was made (Fig 17).[20] At the 6-month follow-up, the maintenance of the chromatic hue value that had been obtained in the single-session treatment session was observed (Fig 18).

Clinical case 2: necrotic tooth

Three months after a sports trauma had affected her face, a 29-year-old female patient presented at our dental office complaining of trouble with tooth 11. The clinical examination showed a clearly low chromatic value. The patient experienced pain on percussion and was insensitive to the thermal and electrical tests performed (Fig 19). In agreement with the patient, it was decided to carry out a root canal therapy, followed by an internal bleaching treatment performed according to the hermetic seal speed bleaching technique (Fig 20).

The control examination 7 days later showed a manifest hypercorrection of the dyschromia (Fig 21). After informing the patient that it was common to attempt to obtain an initial hypercorrection in order to better contrast any recurrences in the future, the authors continued in a single session to recondition the internal pH value, introducing calcium hydroxide inside the root pulp chamber, where it remained for a further 18 days. The filling in composite was then finally completed (Fig 22).

The patient returned after 8 months for a photographic check, where it was observed that the esthetic result obtained with the treatment had been perfectly maintained (Fig 23).

Fig 19 Dyschromia affecting tooth 11 following a pulp necrosis.

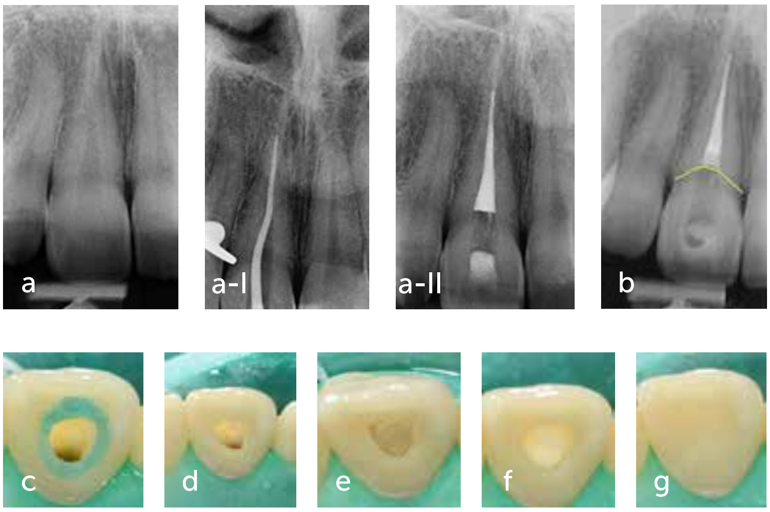

Fig 20 (a and b) Endoral radiographs of an endodontic treatment (necrotic tooth 11): (a) Initial case; (a-I) Cone test; (a-II) Endoral radiograph at the completion of therapy showing the GIC coronal seal. (c) Etching phase. (d) Preparation of the seal. (e) Filling of the root pulp cavity with 35% hydrogen peroxide. (f) Isolation with a sponge placed above the bleaching gel. (g) Hermetic seal in composite (temporary).

Fig 21 Result after 7 days highlights the hypercorrection.

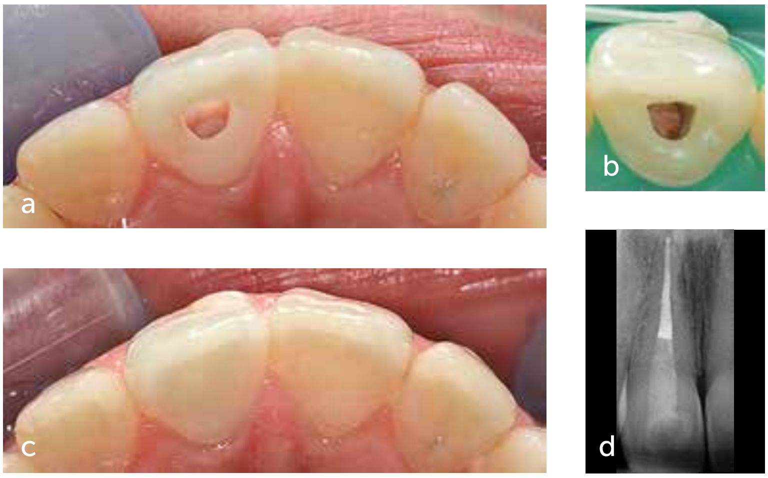

Fig 22 (a) View of the substrate. (b) Root pulp chamber with substrate removed. (c) Final filling in composite. (d) Final radiograph.

Fig 23 (a) Tooth before bleaching. (b) Result after bleaching. (c) Result at 8-month follow-up.

Clinical case 3: natural prosthetic abutments

Modern prosthetic dentistry disposes of the latest-generation ceramic materials because, despite their esthetic advantages, they require precise and significant enhancement of their chemical and physical characteristics as well as the presence of a root-gingival substrate in adequate chromatic condition. This means that, in the case of root dyschromia associated with thin gingival tissue, even with modern materials it may not be possible to mask the gingival manifestation of dyschromia. Therefore, internal bleaching plays a strategic role in ensuring a perfect esthetic integration.

A 52-year-old female patient presented at our dental office expressing the need to replace the prosthetic crown on tooth 22, which was performed several years previously and was no longer integrated chromatically (Fig 24). She wanted the new crown to be better integrated, and possibly without the metal interface. The underlying abutment appeared strongly dyschromic, also emphasizing the esthetic defect on the gingival side. In this case it was also decided to integrate the prosthetic treatment plan with one phase of speed bleaching; as already described, the technique can be integrated into the therapy plan without drastically extending the number of sessions. In all clinical cases in the presence of a dyschromic abutment, speed bleaching places the clinician in an ideal situation in terms of the choice of crown type to mask this defect. Usually, the imperfection, linked to the transmission of the root dyschromia through the gingival tissue, appears precisely at the time of the prosthetic finalization.

Endodontic retreatment was therefore performed, with the subsequent delimitation of the coronal border of the bleaching chamber by the placement of GIC, as already described. Particular attention was paid to exactly identifying the root-gingival area most affected by the transmission of the dyschromia (Fig 25a). The coronal seal was carefully prepared according to the speed bleaching protocol already described (Fig 25b to e, and Fig 26).

Seven days later, the abutment presented a chromatically reliable appearance. The peroxide was therefore removed and replaced with calcium hydroxide. Fifteen days later, the tooth was reconstructed with a glass fiber post (Fig 27a). For the prosthetic finalization of the case, a lithium disilicate ceramic crown was used to restore the structural characteristics of the tooth (in terms of biomimetics) as close as possible to the characteristics of a natural lateral incisor (Fig 27b and c).

In all three clinical cases described, calcium hydroxide was used to optimize the pH value before the final restoration and at the end of the speed bleaching procedures.

Further discussion

Although there are other substances that do the job, calcium hydroxide is best suited to the speed bleaching procedure because it is the most effective for raising the pH value. For example, as described by Forghani et al,[21] when compared with the closest alternative to the so-called CEM (calcium-enriched mixture) cements, calcium hydroxide remains constant for longer (approximatively 21 days), with pH values above 7.5/8. In addition, calcium hydroxide is relatively cheap, and is used and well known by all dentists. Numerous studies have shown that no techniques are capable of completely removing the substance from dentinal tubules at the microscopic level.[12,19,22-25] However, when used for the bleaching procedures described, the authors suggest that calcium hydroxide can be removed by alternating a physiological

Fig 24 (a) The patient's smile. (b) Detail of the prosthetic crown on tooth 22. (c) View of the abutment after the removal of the prosthetic device.

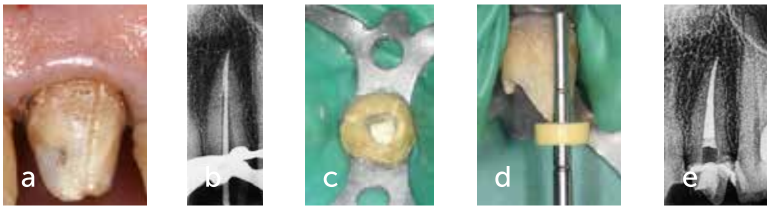

Fig 25 (a) View of the discolored prosthetic abutment after removal of the crown. (b) Endoral radiograph of the gutta-percha cone test. (c) Occlusal view of the GIC substrate. (d) Definition of the root area involved in the bleaching. (e) End-of-treatment radiograph showing the position of the GIC substrate.

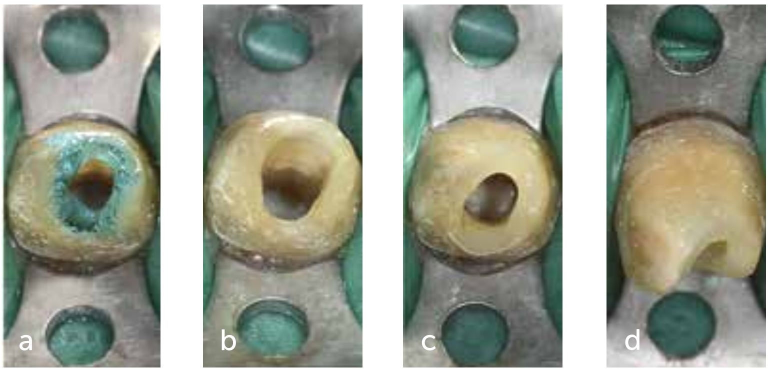

Fig 26 (a) Etching of the dentinal margins. (b) Application of primer and bonding. (c) Application of flowable resin. (d) Margin finishing.

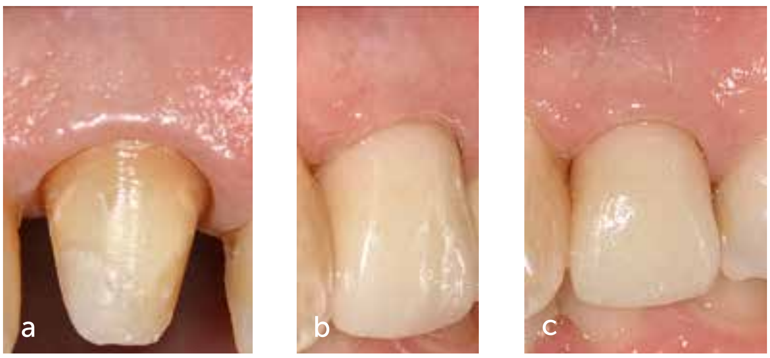

Fig 27 (a) View of the abutment before the adhesive cementation of the final lithium disilicate crown. (b) Testing of the crown with try-in paste simulating the value of the adhesive cement. (c) View of the final crown after cementation.

solution with a liquid chelating agent (eg, 13% EDTA), activated by sonic instruments to optimize its final elimination. Once again, suitable magnifying instruments need to be used (prismatic loupes plus light or an operating microscope) during the inspection phase.

Rotstein et al[26] demonstrated the effectiveness of catalase for inactivating peroxide inside dentinal tubules. In the authors' opinion, however, osteoclastic stimulation by lowering the previously obtained pH value would in any case require neutrality to be restored, and so this enzyme could be used as an aid but not as an alternative to calcium hydroxide.

Conclusions

The need to close the bleaching chamber temporarily with an adhesive composite reconstruction is supported in the literature.[27-29] However, the motivations regarding the usefulness of this approach diverge from those presented in this article. Some authors recommend its clinical execution due to its increased resistance to occlusal loads or its ability to secure the patient against accidental ingestions of peroxide; however, they fail to emphasize the key role of the approach. Hermetically closing the bleaching chamber ensures ideal conditions for the performance of the chemical reaction, both in terms of yield and rapidity.[30] The increase in temperature of the bleaching agent due to the heat from the oral cavity, combined with the increase in internal pressure, allows for the full exploitation of the yield of the reaction in the short term. It also allows for the oxygen radicals to be effectively carried inside the dentinal tubules.[31,32] Moreover, this approach also makes it possible to use mixtures that are increasingly less concentrated. According to the European Directive 2011/84/UE, thanks to the adhesive hermetic sealing, low-concentration substances can be manipulated. On its own, the hermetic sealing is capable of making the difference, independently of the concentration of the bleaching agent used. Its quick results also encourage clinicians to introduce it during complex prosthetic-esthetic treatments, in the knowledge that the therapy will not be complicated by further and sometimes lengthy clinical-operational phases.

The authors conclude by emphasizing that if, in future, the legislation regarding the handling and administration of H_2O_2 mixtures is tightened, it will be useful for clinicians to know how to best exploit very low concentrations of peroxide, which may become an essential aspect of the procedure presented in this article.

References

1. Salvas CJ. Perborate as a bleaching agent. J Am Assoc 1938;25:324.
2. Spasser HF. A simple bleaching technique using sodium perborate. NYS Dent J 1961;27:332–334.
3. Nutting EB, Poe GS. Chemical bleaching of discolored endodontically treated teeth. Dent Clin North Am 1967:655–662.
4. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of literature and clinical procedures. J Endod 2008;34:394–407.
5. Torres CR, Wiegand A, Sener B, Attin T. Influence of chemical activation of a 35% hydrogen peroxide bleaching gel on its penetration and efficacy – in vitro study. J Dent 2010;38:838–846.
6. Cogo E, Sibilla P, Turrini R. Sbiancamento Dentale. Milan, Quintessence 2011:68–69.
7. Rotstein I, Torek Y, Lewinstein I. Effect of bleaching time and temperature on the radicular penetration of hydrogen peroxide. Endod Dent Traumatol 1991;7:196–198.
8. Jiang J, Zuo J, Chen SH, Holliday LS. Calcium hydroxide reduced lipopolysaccharide-stimulated osteoclast formation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:348–354.
9. Khan AA, Sun X, Hargreaves KM. Effect of calcium hydroxide on proinflammatory cytokines and neuropeptides. J Endod 2008;34:1360–1363.
10. Heller D, Skriber J, Lin LM. Effect of intracoronal bleaching on external cervical root resorption. J Endod 1992;18:145–148.
11. Montgomery S. External cervical resorption after bleaching a pulpless tooth. Oral Surg Oral Med Oral Pathol 1984;57:203–206.
12. Kawamoto K, Tsujimoto Y. Effect of the hydroxyl radical and hydrogen peroxide on tooth bleaching. J Endod 2004;30:45–50.
13. Lou EK, Cathro P, Marino V, Damiani F, Heithersay GS. Evaluation of Hydroxyl Radical Diffusion and Acidified Thiourea as a Scavenger during Intracoronal Bleaching. J Endod 2016;42:1126–1130.
14. Attin T, Paqué F, Ajam F, Lennon AM. Review of the current status of tooth whitening with the walking bleach technique. Int Endod J 2003;36:313–329.
15. Costas FL, Wong M. Intracoronal isolating barriers: effect of location on root leakage and effectiveness of bleaching agents. J Endod 1991;17:365–368.
16. Magne P, Belser U. Restauri adesivi in ceramica dei denti anteriori. Un approccio biomimetico, Milan: Quintessenza, 2002: 110–117.
17. Schlichting LH, Stanley K, Magne M, Magne P. The non-vital discolored central incisor dilemma. Int J Esthet Dent 2015;10: 548–562.
18. Rotstein I, Zyskind D, Lewinstein I, Bamberger N. Effect of different protective base materials on hydrogen peroxide leakage during intracoronal bleaching in vitro. J Endod 1992;18:114–117.
19. Friedman S. Internal bleaching: long-term outcomes and complications. J Am Dent Assoc 1997;128(suppl):51S–55S.
20. Da Silva Machado J, Cândido MS, Sundfeld RH, De Alexandre RS, Cardoso JD, Sundefeld ML. The influence of time interval between bleaching and enamel beonding. J Esthet Restor Dent 2007;19:111–118.
21. Forghani M, Mashhoor H, Rouhani A, Jafarzadeh H. Comparison of pH changes induced by calcium enriched mixture and those of calcium hydroxide in simulated root resorption defects. J Endod 2014;40: 2070–2073.
22. Calt S, Serper A. Dentinal tubule penetration of root canal sealers after root canal dressing with calcium hydroxide. J Endod 1999;25:431–433.
23. Lambrianidis T, Kosti E, Boutsioukis C, Mazinis M. Removal efficacy of various calcium hydroxide/chlorhexidine medicaments from the root canal. Int J Endod 2006;39: 55–61.
24. Lambrianidis T, Margelos J, Beltes P. Removal efficiency of calcium hydroxide dressing from the root canal. J Endod 1999;25:85–88.
25. Taşdemir T, Celik D, Er K, Yildirim T, Ceyhanli KT, Yeşilyurt C. Efficacy of several techniques for the removal of calcium hydroxide medicament from root canals. Int Endod J 2011;44:505–509.
26. Rotstein I. Role of catalase in the elimination of residual hydrogen peroxide following tooth bleaching. J Endod 1993;19: 567–569.
27. Waite RM, Carnes DL Jr, Walker WA 3rd. Microleakage of TERM used with sodium perborate/water and sodium perborate/superoxol in the "walking bleach" technique. J Endod 1998;24:648–650.
28. Barthel CR, Strobach A, Briedigkeit H, Göbel UB, Roulet JF. Leakage in roots coronally sealed with different temporary fillings. J Endod 1999;25:731–734.
29. Deveaux E, Hildebert P, Neut C, Romond C. Bacterial microleakage of Cavit, IRM, TERM, and Fermit: a 21-day in vitro study. J Endod 1999;25:653–659.
30. da Silva Marques DN, Silveira JM, Marques JR, Amaral JA, Guilherme NM, da Mata AD. Kinetic release of hydrogen peroxide from different whitening products. Eur J Esthet Dent 2012;7:344–352.
31. Ubaldini AL, Baesso ML, Medina Neto A, Sato F, Bento AC, Pascotto RC. Hydrogen peroxide diffusion dynamics in dental tissues. J Dent Res 2013;92:661–665.
32. Palo RM, Valera MC, Camargo SE, et al. Peroxide penetration from the pulp chamber to the external root surface after internal bleaching. Am J Dent 2010;23:171–174.