Jorge Perdigão
Editor

Tooth Whitening

An Evidence-Based Perspective

Second Edition

Springer

Editor
Jorge Perdigão
University of Minnesota
Minneapolis, MN, USA

ISBN 978-3-031-38243-7 ISBN 978-3-031-38244-4 (eBook)
https://doi.org/10.1007/978-3-031-38244-4

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Dear colleagues,

The first edition of this book was published 7 years ago. Thank you all for the +30,000 visits to download the book chapters and those who purchased the paper edition. All the authors of the second edition hope that you'll enjoy reading this updated edition.

Evidence-based information in Dentistry has become more accessible than ever within the last few years. Unfortunately so has anecdotal evidence with the eruption of social media platforms and the number of users. Opinions posted in social media have quickly become 'evidence' in spite of being at the bottom level of the evidence pyramid. Often students ask me about clinical procedures that they learn on social media.

The bright side is that over the last few years numerous peer-reviewed randomized clinical trials and systematic reviews/meta-analyses have changed some concepts that are still taught in many dental schools. We need to learn and keep adapting our clinical teaching and practice to those evidence-based findings.

Let's keep learning while sharing the 'real' information.

Minneapolis, MN, USA
December 2022

Jorge Perdigão

Acknowledgements

I am forever thankful to all my teachers, mentors, and students. Students have been a great source of inspiration throughout my 37-year academic career.

I also feel blessed to have worked with so many gifted colleagues around the world in clinical and laboratory research. Our readers will also enjoy the outstanding clinical skills of our co-authors that are reflected in this book.

My special appreciation goes to family for their support.

We never quit.

Jorge Perdigão

Contents

Part I

Peroxides for Dental Whitening—History, Mechanism of Action, Side Effects, and Pulp Response

Introduction to Tooth Whitening: Past and Present

1

So Ran Kwon

Abstract

Few dental treatments have been more successful and conservative in nature than tooth whitening. Therefore, it is noteworthy to reflect on the efforts of pioneers in our dental profession that continuously attempted to search for the most effective and safest whitening agent. This quest has extended to determine the best whitening technique to meet our patients' desires and expectations about the esthetic outcome. Here, a short history of tooth whitening agents developed and employed based on the type of discoloration is summarized, as is our current knowledge on the relative efficacy and safety of various types of tooth whitening regimens available. The information on proper diagnosis and treatment planning will guide the clinician in establishing a step-by-step protocol for determining the etiology of the discoloration, selecting the best whitening technique, and monitoring tooth color until the desired outcome has been achieved.

1.1 History of Tooth Whitening

Tooth whitening is a conservative and effective method to lighten discolored teeth and has been practiced in dentistry for many centuries. During the course of development, careful observation and research on various materials and techniques enabled the dental profession to introduce effective, safe, and predictable methods of whitening.

In the middle 1800s, crowns were commonly used for the treatment of discolored teeth (Kirk 1906). However early pioneers were concerned with the aggressive removal of tooth structure using this technique and found tooth whitening to be a

S. R. Kwon (✉)
Division of General Dentistry, Loma Linda University School of Dentistry, Loma Linda, CA, USA
e-mail: sorankwon@llu.edu

J. Perdigão (ed.), *Tooth Whitening*, https://doi.org/10.1007/978-3-031-38244-4_1

Table 1.1 History of tooth whitening

Date	Name	Material used	Discoloration
1799	Macintosh (Dwinelle 1850)	Invented chloride of lime (called bleaching powder)	
1848	Dwinelle (Dwinelle 1850)	Chloride of lime	Non-vital teeth
1860	Truman (Kirk 1889)	Chloride and acetic acid, Labarraque's solution (liquid chloride of soda)	Non-vital teeth
1861	Woodnut (Woodnut 1861)	Advised placing the bleaching medicament and changing it at subsequent appointments	
1868	Latimer (Latimer 1868)	Oxalic acid	Vital teeth
1877	Chapple (Chapple 1877)	Hydrochloric acid, oxalic acid	All discolorations
1878	Taft (Haywood 1992)	Oxalic acid and calcium hypochlorite	
1884	Harlan (Harlan 1884)	Used the first hydrogen peroxide (called hydrogen dioxide)	All discolorations
1893	Atkinson (Atkinson 1862)	3–25% Pyrozone used as a mouthwash, which also lightened teeth	
1895	Garretson (Haywood 1992)	Applied chlorine to the tooth surface	Non-vital teeth
1910	Prins (Haywood 1992)	Applied 30% hydrogen peroxide to teeth	Non-vital and vital
1916	Kaine (Haywood 1992)	18% hydrochloric acid (muriatic acid) and heat lamp	Fluorosed teeth
1911	Fisher (Fisher 1911)	Reported on the use of hydrogen peroxide with a heating instrument or a light source	Vital teeth
1924	Prinz (Prinz 1924)	First recorded use of a solution of perborate in hydrogen peroxide activated by a light source	Vital teeth
1942	Younger (Haywood 1992)	5 parts of 30% hydrogen peroxide heat lamp, anesthetic	
1958	Pearson (Pearson 1958)	Used 35% hydrogen peroxide inside tooth and also suggested 25% hydrogen peroxide and 75% ether, which was activated by a lamp producing light and heat to release solvent qualities of ether	Non-vital teeth
1961	Spasser (Spasser 1961)	Walking bleach technique: Sodium perborate and water are sealed into the pulp chamber	Non-vital teeth
1965	Bouschor (Bouschor 1965)	5 parts 30% hydrogen peroxide, 5 parts 36% hydrochloric acid, 1 part diethyl ether	Orange colored fluorosis stains
1965	Stewart (Stewart 1965)	Thermocatalytic technique; pellet saturated with Superoxol is inserted into the pulp chamber and heated with a hot instrument	Non-vital teeth

Fig. 1.3 Generalized erosion of teeth can contribute to a more chromatic appearance of teeth

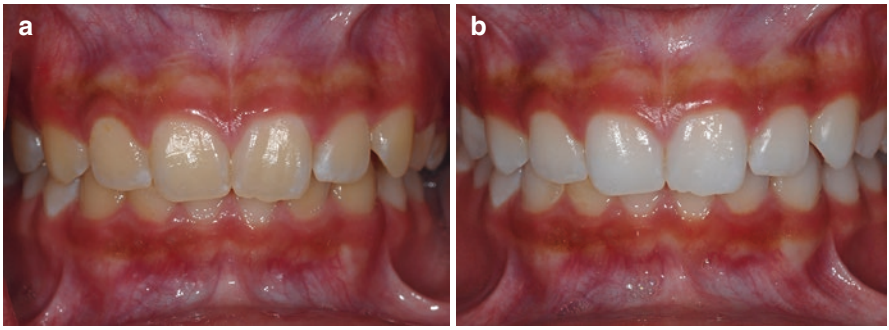

Fig. 1.4 (**a**) The best time for initiating whitening in children should be carefully discussed with the parents. This 12-year-old child complained about his dark teeth as well as the localized white areas on the upper anterior teeth. (**b**) Treatment options include at-home whitening with custom fabricated trays when the child is compliant or in-office whitening where the whole procedure is performed in the clinic

1.3.2.3 Tooth Whitening in Children

Another emerging topic is the age deemed appropriate for tooth whitening (Fig. 1.4a, b). The American Academy on Pediatric Dentistry Council on Clinical Affairs recognized the increased desire for whiter teeth in pediatric and adolescent patients and advised the judicious use of whitening for vital and non-vital teeth, as well as consultation with the dentist to determine the appropriate method and timing for treatment (American Academy on Pediatric Dentistry Council on Clinical Affairs 2015). A single clinical study is currently registered to evaluate the efficacy and tooth sensitivity in an adolescent population (patients ranging from 12 to 20 years) (Pinto et al. 2014).

when between 5.4 and 8.1, and excellent when exceeding 8.1 (Paravina et al. 2019). These proposed cutoffs are helpful but warrant future studies and support on a more comprehensive level.

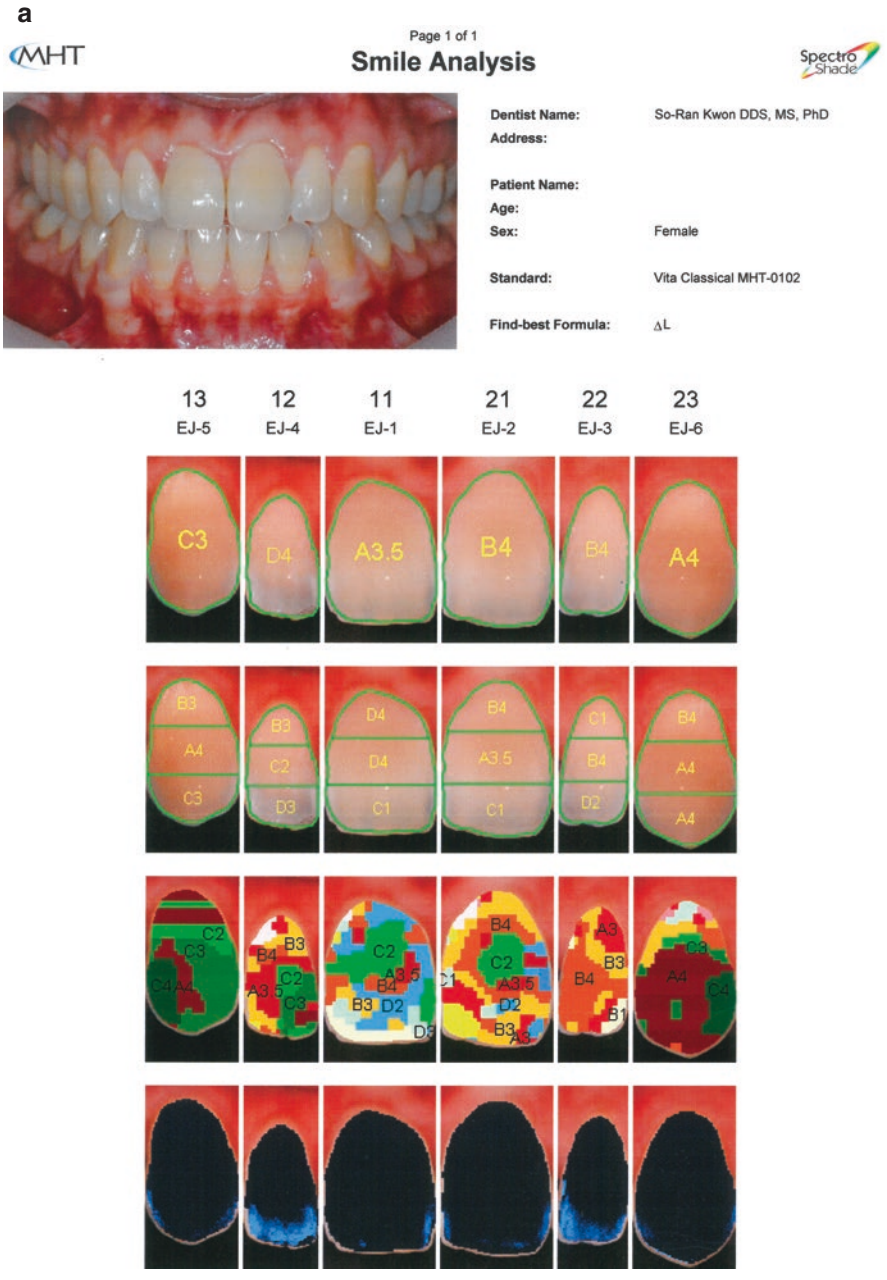

Fig. 1.6 (**a**) Smile analysis before whitening. (**b**) Smile analysis after whitening

Fig. 4.4 (**a**) Lower incisors submitted to in-office bleaching. (**b**) The barrier may have been applied in an excessively humid operative field, or the gel may have kept in the mouth for too long which could have caused alterations in the thixotropic characteristics of the gel and subsequent seepage to the soft tissue, causing extensive damage. (**c**) Application of neutralizing product based on sodium bicarbonate. (**d**) Clinical aspect 45 min after the incident

that etching of the damaged mucosa with a neutralizing agent reduces the extent of damage caused by the bleaching gels, particularly those with H_2O_2 concentrations greater than 15% (Fig. 4.6).

Another factor that may be related to gingival tissue aggression is the site of application of whitening gel. As shown in Fig. 4.2, the isolation of gingival tissue is sometimes ineffective, with areas of exposure to the soft tissues, especially around the dental papillae. This region is the most cervical portion of the crown, which sometimes comes into contact with a large volume of whitening gel. The preponderant dentin component in this region of the tooth means that it is a region very relevant for any changes in tooth color.

A possible strategy to minimize the risk of gingival tissue burns under these clinical conditions is to reduce the area of exposed crown to ensure that the bleaching gel is not applied in areas close to the gingival tissue. Haywood and Heymann (1991) reported that H_2O_2 diffuses very well through the tooth structure and is present not only in the applied area but also in the entire tooth structure. However, the clinical evidence is not abundant (Gomes et al. 2017; Jadad et al. 2011).

To illustrate the bleaching capacity and remote action of the bleaching gel, clinical cases (Figs. 4.7, 4.8, and 4.9) evaluated the chromatic alteration capacity in

Fig. 4.7 (**a**) Treatment performed with application of bleaching gel in the cervical region vs. on the entire buccal surface. The baseline color of incisors and canines was VITA A3. (**b**) Different application protocols for the whitening gel. (**c**) Clinical aspect after the first session. (**d**) Clinical aspect after three sessions. The color changes were homogeneous regardless of the gel application protocol – cervical region or entire surface

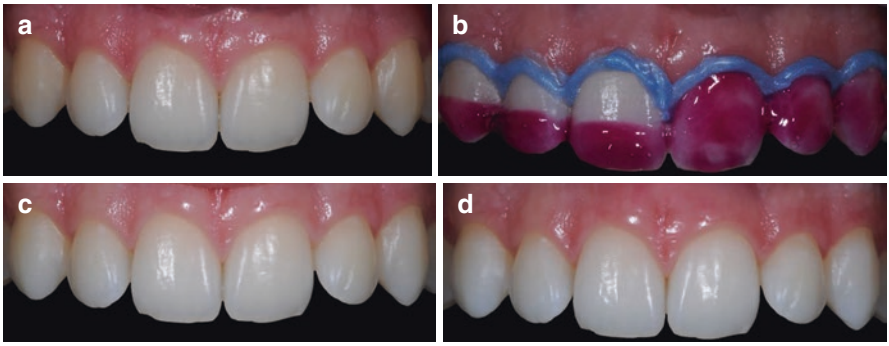

Fig. 4.8 (**a**) Application of bleaching gel on the incisal region vs. on the entire buccal surface. Baseline color was VITA A2. (**b**) Different application protocols for the whitening gel. (**c**) Clinical aspect after the first session. (**d**) Clinical aspect after three sessions. The color changes were homogeneous regardless of the gel application protocol – incisal region or entire surface

Of all the patients submitted to the treatments in the clinical cases depicted above, only the case in Fig. 4.9 (cervical x incisal) presented perceptible but acceptable differences in the cervical region between the hemiarches after the third bleaching session.

In the incisal region, the cases presented in Figs. 4.7 and 4.9 had values above perceptibility in T1 and T2; however, in subsequent evaluations, only the case in Fig. 4.9 retained perceptible but acceptable changes.

Overall, even in the three cases with notable differences in the initial phase of treatment, the response tended to be homogeneous at the end of the three bleaching sessions, with chromatic results favorable to the patient. The evaluation of these data in Fig. 4.10 compares the limits of perceptibility and acceptability with the ΔE

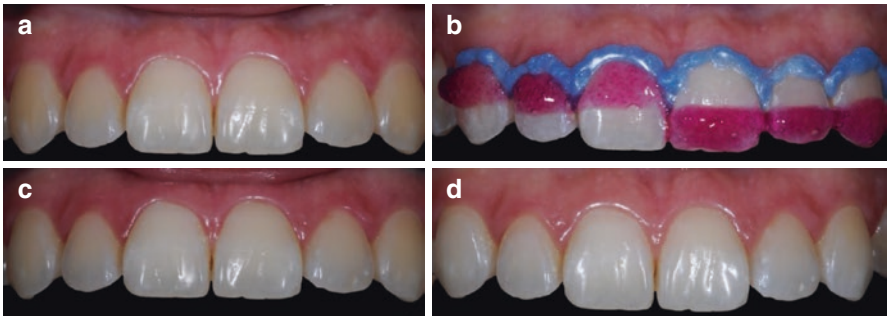

Fig. 4.9 (**a**) Application of bleaching gel on the cervical region vs. on the incisal region. Baseline color was VITA A2. (**b**) Different application protocols for the whitening gel. (**c**) Clinical aspect after the first session. (**d**) Final result. The color changes were homogeneous regardless of the gel application protocol – incisal region or entire surface

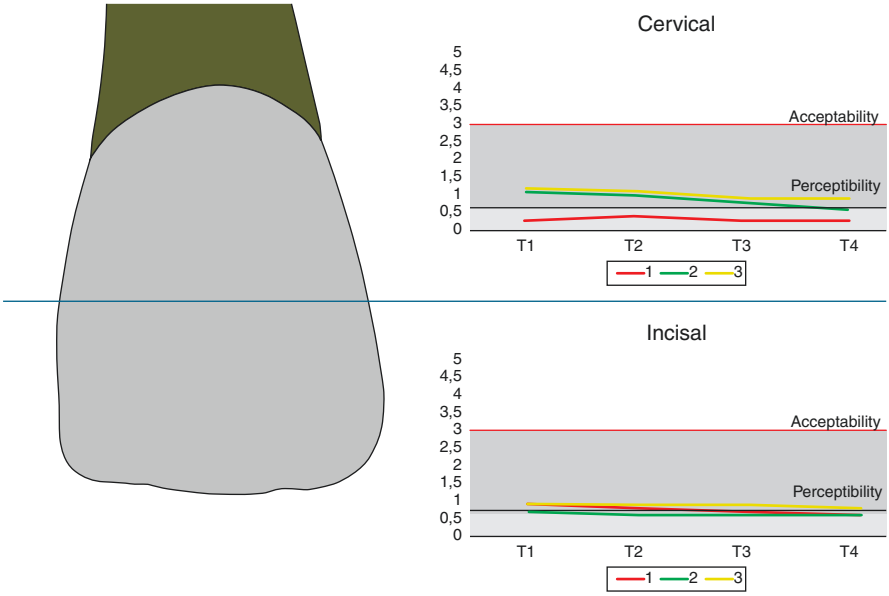

Fig. 4.10 Each line represents the difference in the ΔE values obtained for each hemiarch. Comparison of the perceptibility and acceptability limits with the ΔE values obtained in the cervical and incisal regions between the hemiarches (red line, application on the entire vestibular face vs. on the cervical (Fig. 4.7); green line, application on the incisal application vs. throughout the buccal face (Fig. 4.8); yellow line, cervical application vs. incisal application (Fig. 4.9) in function of time)

values obtained in the cervical and incisal regions between the hemiarches in function of time.

In line with these findings, Esteves et al. (2022a, b) stated that the diffusion of peroxide and other reactive oxygen substances occurs quickly in a multidirectional

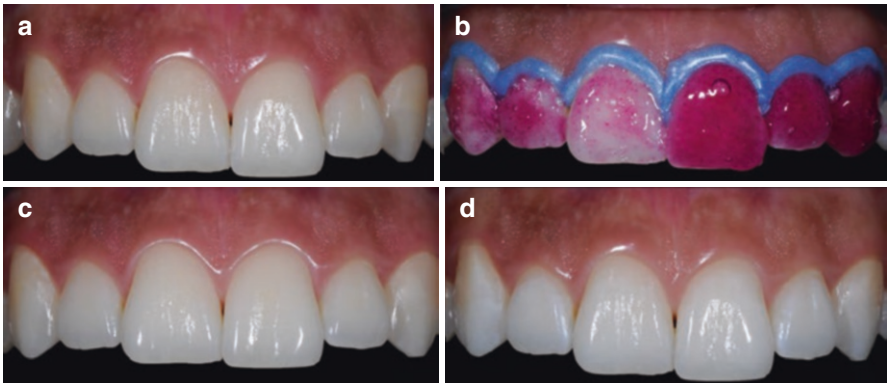

Fig. 4.13 Treatment performed with application of 35% H_2O_2 bleaching gel in a volume of 0.025 mL vs. 0.10 mL. (**a**) Initial appearance of maxillary incisors and canines with shade VITA A3. (**b**) Application of the bleaching gel. (**c**) Clinical aspect after the first session. (**d**) Clinical aspect after the third session. Homogeneous chromatic changes are observed at the end of the bleaching treatment regardless of the volume of gel used

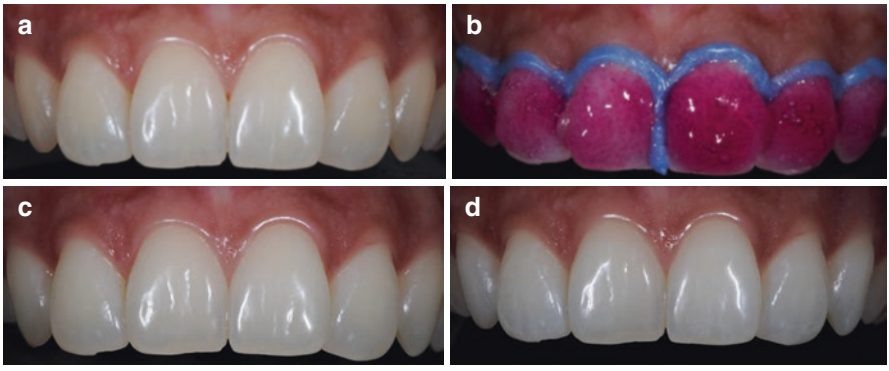

Fig. 4.14 Treatment performed with application of 35% H_2O_2 bleaching gel in a volume of 0.050 mL vs. 0.10 mL. (**a**) Initial appearance of maxillary incisors and canines with shade VITA A2. (**b**) Application of the bleaching gel. (**c**) Clinical aspect after the first session. (**d**) Clinical aspect after the third session. Homogeneous chromatic changes are observed at the end of the bleaching treatment regardless of the volume of gel used

patients remained below the limits of perceptibility. These data can be seen in Fig. 4.15.

These clinical findings mean that there was a correlation between the amount of gel deposited and tooth sensitivity in function of time. Tooth sensitivity resulting from bleaching treatment is not yet fully understood, but the excessive presence of ROS from bleaching products in the pulp tissue seems to stimulate the release of inflammatory chemical mediators, such as substance P, which sensitizes pulp nociceptors, acting in the modulation of pain in reports of spontaneous sensitivity (Briso et al. 2018; Esteves et al. 2022b).

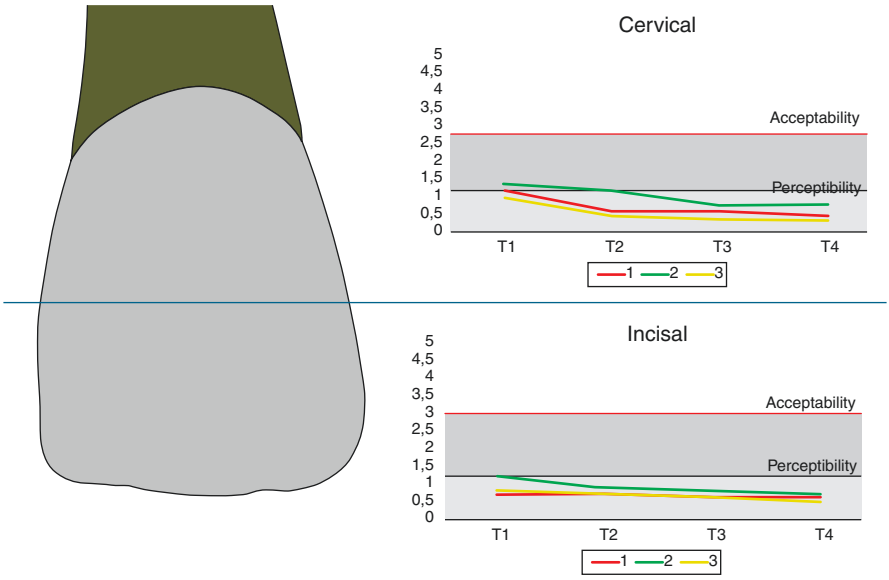

Fig. 4.15 Comparison of the perceptibility and acceptability limits with the ΔE values obtained in the cervical and incisal region between the hemiarches (red line, application of 0.025 mL of gel vs. application of 0.05 mL (Fig. 4.12); green line, application of 0.025 ml vs. application of 0.10 ml (Fig. 4.13); yellow line, application of 0.05 ml vs. application of 0.10 ml (in function of time) (Fig. 4.14))

As the excess gel did not increase the bleaching effect, the unreacted peroxide, known as free H_2O_2, may interact with the pulp cells, resulting in injuries of different magnitude, a topic that will be explored in-depth in Chap. 5.

Although several studies have evaluated the effects of coadjuvant therapies on tooth sensitivity, such as antioxidants and even anti-inflammatory drugs (Vargas et al. 2014; May et al. 2010), it seems that controlling the volume of the bleaching gel can also help prevent tooth sensitivity without interfering with the esthetic results. Thus, the bleaching effect obtained with the in-office bleaching treatment did not show a direct correlation with the volume of bleaching gel applied to the enamel. However, the adverse effects related to the penetration of ROS into the pulp tissue were volume-dependent.

4.5.2 Protection Protocols

The treatment options currently adopted by clinicians may result in undesirable biological effects, particularly when the oral cavity is not evaluated prior to receiving H_2O_2-based products and when the dosage is not adjusted for each patient. In addition to making sure that we evaluate the adequate dosage for each patient, we

Fig. 6.6 (**a**) Frontal view of maxillary incisors in a 26-year-old patient whose chief complaint was a "dark front tooth" (tooth #9, FDI 2.1). Patient had had a traumatic injury to this tooth at the age of 12 years old. No other signs or symptoms were associated with this tooth. Response to percussion was identical in all maxillary anterior teeth. Although the response to cold was negative, the pulp responded to the electric pulp tester. (**b**) Periapical radiograph showing a calcified pulp space. (**c**) Aspect after 2 weeks of at-home whitening with 10% carbamide peroxide gel with potassium nitrate and sodium fluoride (Opalescence 10% PF, Ultradent Products) in a custom-fitted tray. Patient decided to bleach for another period of two weeks but did not return for the recall appointment

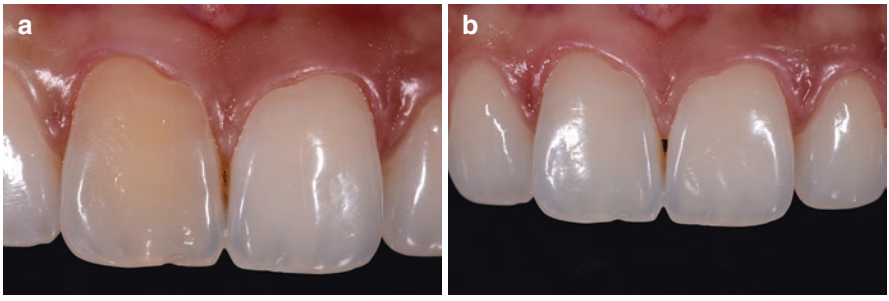

Fig. 6.7 (**a**) A 24-year-old patient had a traumatic injury to tooth #8 (FDI 1.1). After four years the tooth became darker without any symptoms. The patient immediately visited the family dentist who diagnosed pulpal necrosis. Root canal therapy was performed. (**b**) After 5 days of at-home whitening with 22% carbamide peroxide gel (Whiteness Perfect 22%, FGM, Joinville, SC, Brazil) for 2 h twice daily

forming the tray around the stone model in a vacuum or pressure device. The tray is trimmed in a horseshoe shape (Fig. 6.9) after cooling-off. The final tray design includes trimming the tray to follow the free gingival margin (Haywood 1997b). The design has evolved to a scalloped tray slightly short of the free gingival margin (0.5–1.0 mm) to prevent possible irritation caused by the contact of the bleaching gel with the soft tissues (Chap. 4). A recent clinical trial compared the gingival irritation caused by scalloped vs. non-scalloped bleaching trays with 10% hydrogen peroxide gel. Authors reported a similar outcome; however, the contact time was only 30 min (Carneiro et al. 2022).

The scalloped design is contraindicated with low-viscosity bleaching gels, as the gel is more likely to seep to the mouth and irritate the tongue and lips (Haywood 2003). In specific situations, such as in one-tooth bleaching clinical cases, the tray may be slightly extended gingivally.

In case of inadvertent fabrication of shortened trays, successful whitening still occurs beyond the borders of the short tray without demarcation lines on the teeth (Oliver and Haywood 1999) as peroxides diffuse easily through enamel.

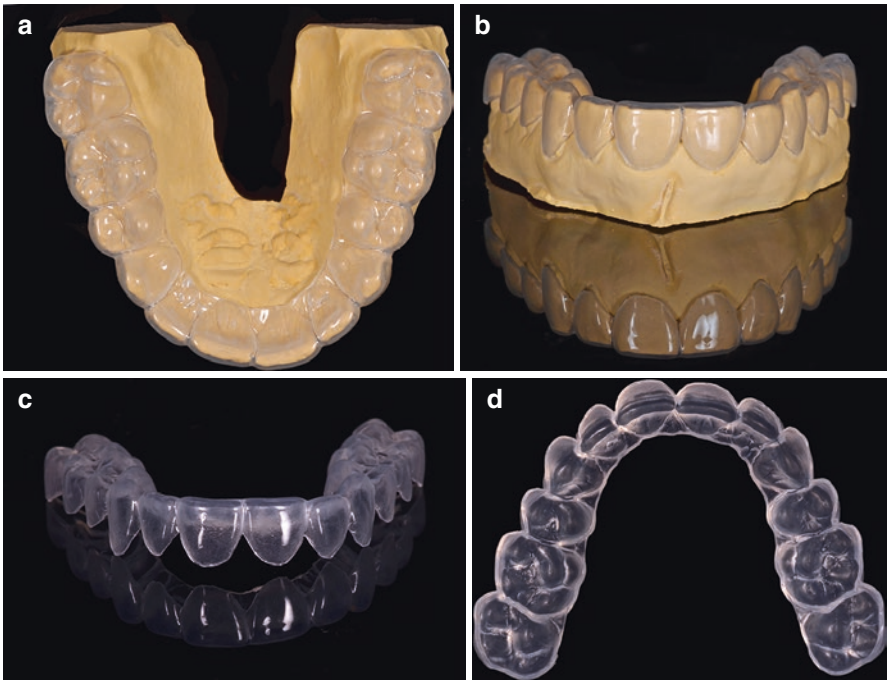

Fig. 6.9 Custom-made bleaching tray for at-home whitening (courtesy of Dr. George Gomes). (**a**) Occlusal view of the tray inserted onto the stone model. The model had been trimmed to remove the palatal aspect and obtain a tighter adaptation of the tray to the teeth. (**b**) Frontal view of the model after the tray was scalloped around the gingival margins. (**c**) Frontal view of the scalloped tray. (**d**) Inside view of the scalloped tray

This is even more important when both dental arches are bleached simultaneously. Shade recording can be performed with a value-oriented or bleach shade guide (Fig. 7.5) and spectrophotometer, or by means of dental photographs.

Some authors encourage whitening one dental arch at a time (Haywood 2005), because it minimizes TS, allows the patient to monitor the opposing arch to compare progress, and also encourages compliance. However, this procedure significantly increases the cost of the bleaching protocol, as it requires more dental visits.

Another advantage of color recording is that baseline dental color can predict the whitening degree obtained after dental bleaching. A recent multivariable regression analysis (Rezende et al. 2016c) identified a significant relationship between baseline color and age in relation to color change estimates. After adjustment for the other variables, every increase of one shade guide unit (in the value-oriented Vita Classical A1–D4 shade guide) in the baseline color resulted in an increase of approximately 0.66 in the final color change in ΔSGU and 2.48 for the ΔE, meaning that the darker the baseline tooth color, the higher the degree of whitening. In an opposite trend, the degree of whitening is negatively affected by the patient's age (Rezende et al. 2016c). It is note worthy that the ΔEab value higher than 2.4 units exceeds the 50:50% perceptibility threshold for ΔEab, although it is still lower than the 50:50% acceptability threshold. Nevertheless, the difference would still be clinically acceptable for 50% of the observers (Paravina et al. 2015).

This allows for the dentist to manage the patient's expectations regarding the bleaching outcomes. Older patients with lighter baseline color may request more than two bleaching sessions to achieve the same whitening degree than younger patients with darker baseline dental color. It is important to perform a dental prophylaxis recording the baseline tooth color. A published paper showed a significant difference (average of two ΔE units of change) on tooth color when measured before and after dental prophylaxis (de Geus et al. 2015). This value is still lower than the 50% acceptability threshold (Paravina et al. 2015). However, this 50:50% acceptability may reach the threshold for clinical detection (ΔEab = 3.0) in some patients (de Geus et al. 2015).

Fig. 7.5 The baseline tooth color being recorded with a value-oriented shade guide after performing a dental prophylaxis

7.4.3 Application of a Desensitizing Agent

As reported earlier, one of the main side effects of in-office dental bleaching is TS. Although this side effect cannot be completely eliminated, the number of patients that experience TS and the intensity of TS can be reduced by previous application of a desensitizing gel composed of 5% potassium nitrate (Tay et al. 2009; Wang et al. 2015; Martini et al. 2021).

This procedure can be performed before or after isolation of the dental arch, as the material is not aggressive to the gingival tissue. However, as the gel is usually agitated with the aid of a rotating brush, it is recommended to apply the desensitizer before the protection of the soft tissues. The buccal surface of all the teeth to be bleached should be covered with a 1 mm-thick layer of the desensitizer and left in place for at least 10 min (Fig. 7.6). At the end of this period, the product should be agitated in each dental surface for 20 s with a rotating brush before removal. The inclusion of this step into the in-office bleaching protocol does not jeopardize the whitening efficacy of the hydrogen peroxide (Tay et al. 2009). After this period, the product should be removed with gauze (Fig. 7.7) or with a saliva ejector before

Fig. 7.6 Application of a desensitizing gel composed of 5% potassium nitrate for 10 min (Desensibilize KF 2%, FGM Dental Group, Fort Lauderdale, FL, USA). After this period the product should be agitated in each dental surface for 20 s with a rotating brush before removal

Fig. 7.7 Removal of the desensitizing gel with dental gauze or high-speed suction. Rinsing with water was performed after removing the excesses

Fig. 7.9 The 35% hydrogen peroxide in-office bleaching gel (Whiteness HP Blue 35%, FGM, Joinville, SC, Brazil) is mixed and applied to all the teeth to be bleached

Fig. 7.10 After 5 min in place, bubbles are visible within the gel, which result from the decomposition of the hydrogen peroxide

lead to either whitening at reduced speed or increased TS rates (Reis et al. 2011b; Kose et al. 2016; Meireles et al. 2021). By increasing the number and/or time of application, one may increase the degree of whitening obtained, but at the same time the risk of TS is also increased. In an opposite trend, reducing the number and/or time of application reduces the probability of TS but also limits the degree of whitening. The increased formation of bubbles on the surface layer of in-office bleaching gel has led some manufacturers and clinicians to believe that agitation of the in-office bleaching gel with a microbrush is needed to bring fresh bleaching gel into contact with the tooth surface (Fig. 7.10). However, this agitation seems to be unnecessary because no improvement in bleaching efficacy was observed (Kiyuna et al. 2021).

Most in-office bleaching gels require replenishing the product during the clinical application period. Some gels require two, three, or four product replenishments during each clinical session. Some products, however, are indicated for a single 40–50-min application without replenishments. These products usually possess a basic pH that allows them to be used for longer application times without increasing

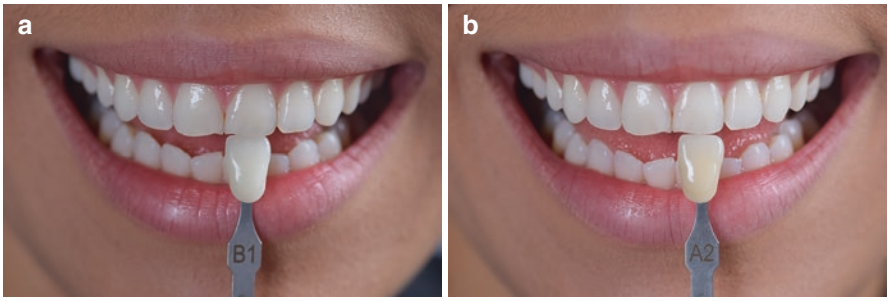

Fig. 7.12 One week after the second in-office bleaching session, the color of the patient's teeth was checked. In (**a**) one can observe that the patient's teeth reached shade B1 (the lightest shade in the value-oriented Vita Classical shade guide), which is five shades lighter than the baseline A2 shade measured at the beginning of the treatment (**b**)

Also, a randomized clinical trial revealed that a two-day interval between two in-office bleaching sessions did not increase the risk and intensity of bleaching-induced TS (de Paula et al. 2015). However, this clinical trial used a calcium-containing alkaline gel applied for a single 40-min application without replenishment (de Paula et al. 2015), which precludes any generalization of this protocol to all in-office bleaching gels currently available.

In the clinical case (Figs. 7.5, 7.6, 7.7, 7.8, 7.9, 7.10, 7.11, and 7.12), two clinical appointments were required to reach patient satisfaction. The color reached after the end of the bleaching procedure should be recorded with the same instrument used to record the baseline color. This measurement, however, should be carried out 4–7 days after the last in-office bleaching session to avoid the effects of dehydration and demineralization on the final outcomes (Fig. 7.12).

7.5 Durability of Color Change and Need for Touch-Up

As explained earlier in this chapter, the very short color reversal that occurs within some days after the in-office bleaching session cannot be interpreted as lack of effectiveness of the in-office bleaching protocol. To avoid any potential patient's frustration with the treatment, we need to instruct patients that a slight darkening is expected to occur within the next few days as a result of tooth rehydration and remineralization, which does not necessarily mean that the bleaching was unsuccessful. An adequate measurement of the baseline tooth shade will allow the dental professional to monitor the degree of color change resulting from the oxidizing nature of the hydrogen peroxide gel.

Although there are many randomized clinical trials reporting the immediate effects of several bleaching techniques, only few of them evaluated the long-term efficacy of in-office bleaching (Giachetti et al. 2010; Mondelli et al. 2012; Tay et al. 2012). These studies reported that in-office bleaching achieves stable results in periods ranging from 9 months to 2 years (Giachetti et al. 2010; Tay et al. 2012).


a
b
c
d
e
f
g

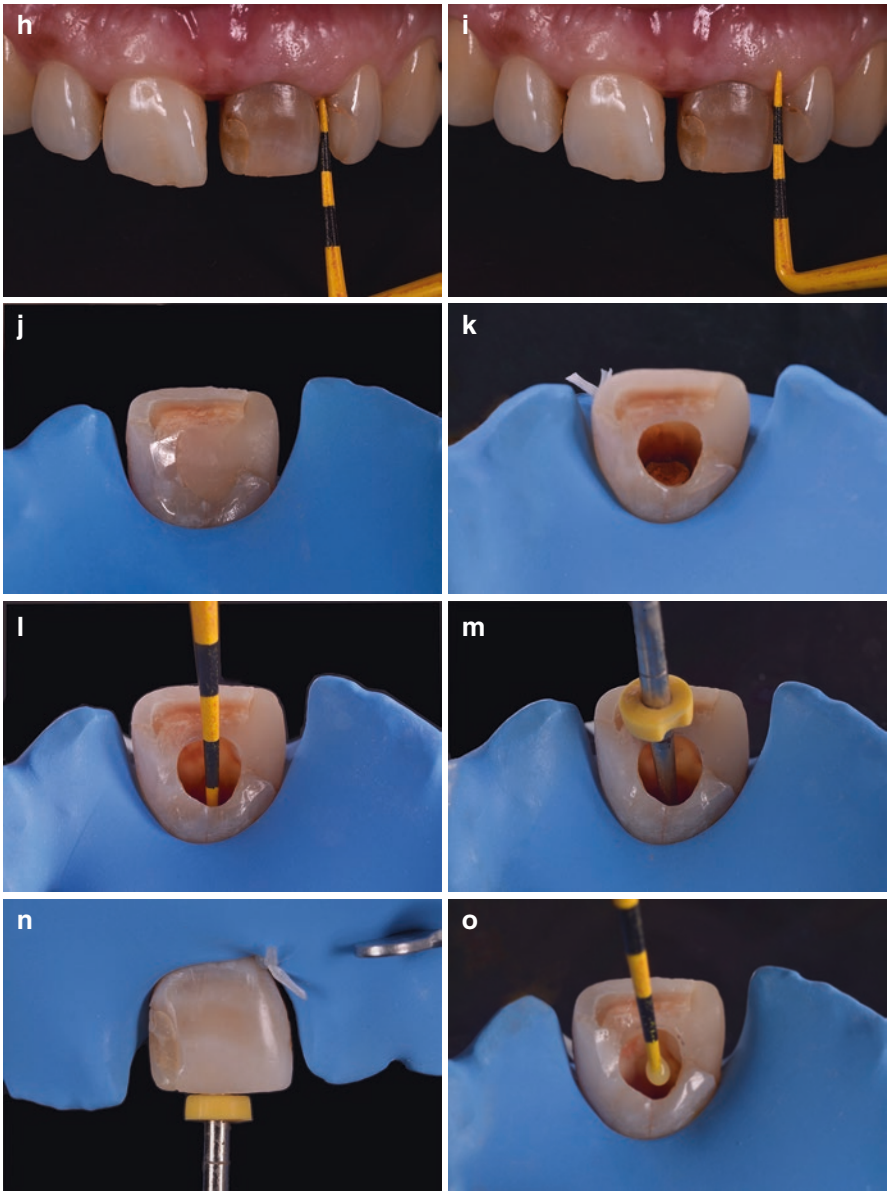

Fig. 8.8 (continued)

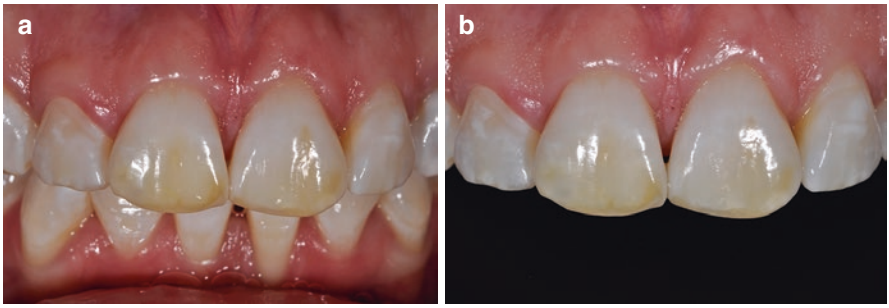

Fig. 10.2 (**a**, **b**) Clinical aspect after 7 weeks of overnight at-home whitening with 10% carbamide peroxide with potassium nitrate and sodium fluoride in a custom-fitted tray

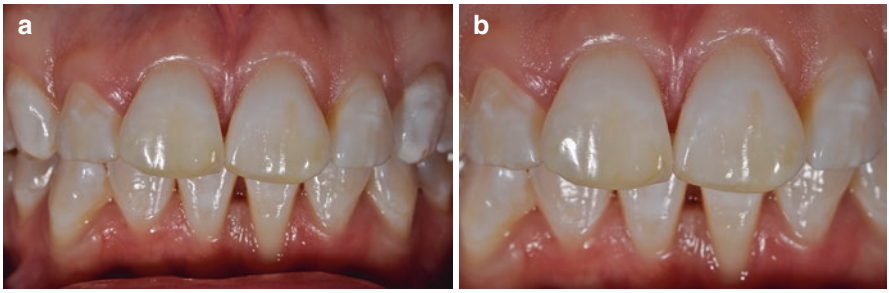

Fig. 10.3 (**a**, **b**) Patient retuned to clinic 4 weeks after the first recall

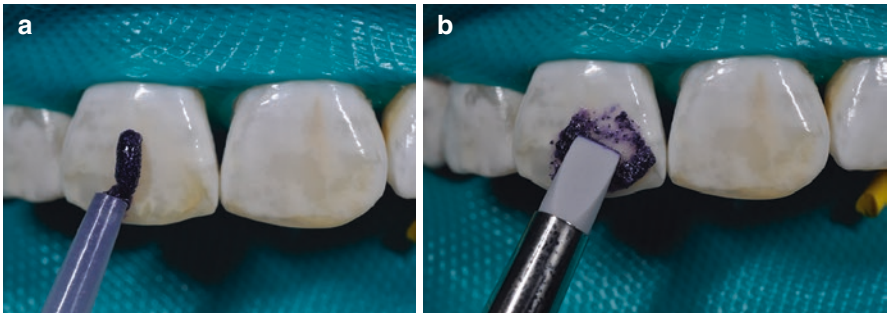

Fig. 10.4 (**a**, **b**) The four maxillary incisors were treated with an enamel microabrasion compound (Opalustre, Ultradent Products, Inc.). Six consecutive applications of 60 s each were carried out with water rinsing between each application

with the patient, we decided to perform the enamel microabrasion technique with Opalustre (Ultradent Products, Inc.) on the four maxillary incisors (Fig. 10.4a, b). Six consecutive applications of 60 seconds each were carried out, with water rinsing between each application. Figure 10.5 depicts the intense dehydration immediately after removing the rubber dam.

Fig. 10.5 Intense dehydration of the teeth immediately after removing the rubber dam

Fig. 10.6 The patient returned to clinic 2.5 months after the enamel microabrasion procedure. The patient was extremely satisfied with the color improvement of her anterior teeth. We suggested a few more weeks of at-home whitening with the same 10% carbamide peroxide gel and the same bleaching tray, following the same regimen that she had been prescribed in the beginning of the treatment

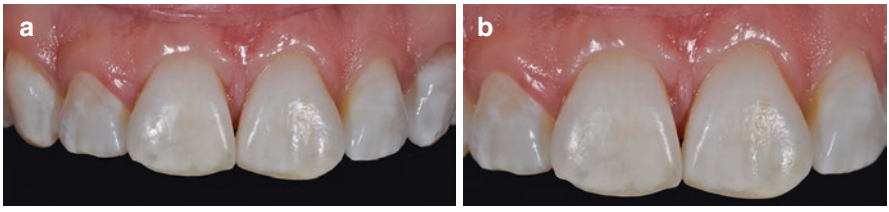

Fig. 10.7 (**a**, **b**) Clinical aspect after 3 extra weeks of at-home whitening with 10% carbamide peroxide with potassium nitrate and sodium fluoride in a custom-fitted tray. At this time the patient decided that she did not want to pursue any further treatment, as she was extremely happy with the esthetic outcome

Patient returned to the clinic 2.5 months later (Fig. 10.6). Although the patient was extremely happy with the color improvement, we suggested a few extra weeks of at-home whitening with 10% carbamide peroxide gel. Figure 10.7a, b represents the final result after 3 weeks of at-home whitening. At this time the patient decided that she did not want to pursue further treatment.

Fig. 12.6 Patient was scheduled for a resin infiltration procedure 2 weeks after finishing the at-home whitening treatment

Fig. 12.7 The teeth were cleaned with a suspension of pumice and water and thoroughly washed with water. Area was isolated with a rubber dam. A 15% HCl gel (Icon-Etch, DMG, Hamburg, Germany) was applied to the white spot areas of tooth #9 (FDI 2.1). The respective manufacturer provides an application tip in the respective kit; however, we prefer a small round brush to ensure application accuracy

Fig. 12.8 The 15% HCl gel was extended to the other white spot areas and left undisturbed for 2 minutes

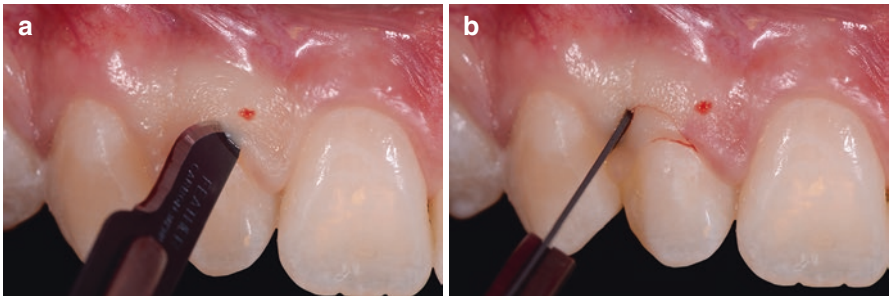

Fig. 13.3 (**a**, **b**) Sequential photographs during the surgical incision to obtain a new gingival contour

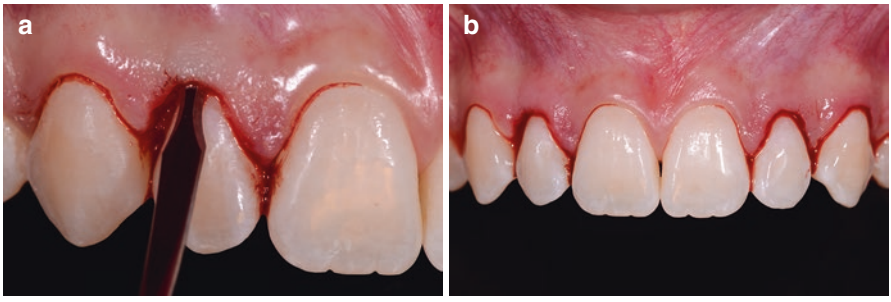

Fig. 13.4 (**a**) Osteotomy with periodontal micro chisel. (**b**) After the periodontal surgery. *Special thanks to Dr. Rodrigo Barbosa Lima who performed the periodontal surgery and respective follow-up*

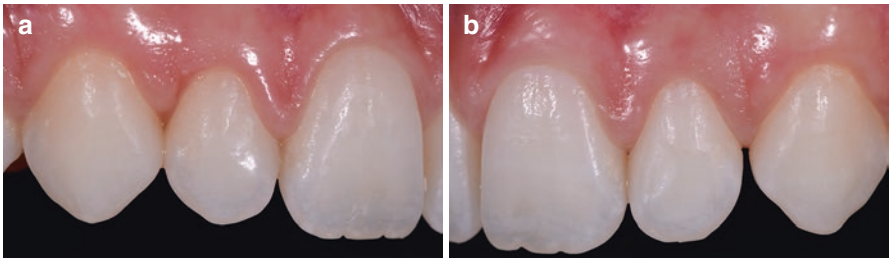

Fig. 13.5 Results shown 6 weeks after the periodontal surgery. (**a**) Close-up view of the right maxillary lateral incisor; (**b**) Close-up view of the left maxillary lateral incisor

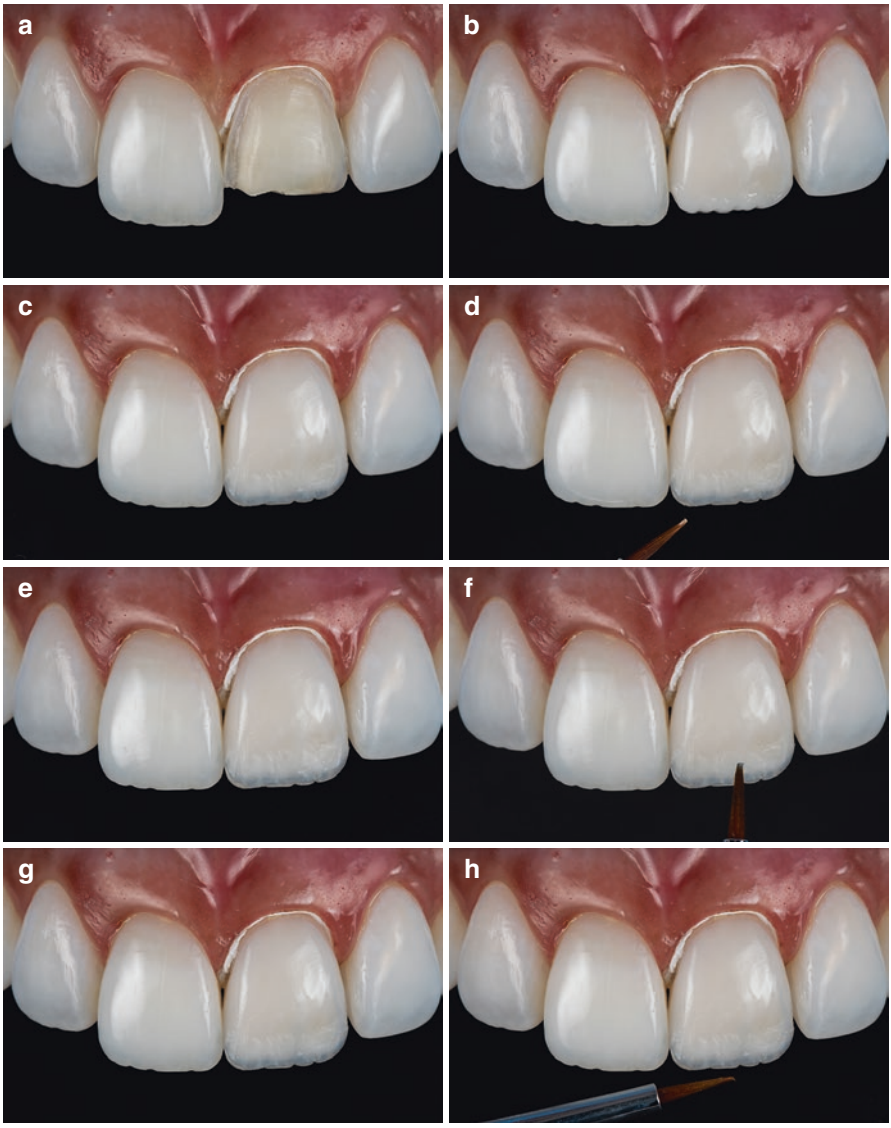

Fig. 14.4 (**a**) A ribbon made of polytetrafluoroethylene tape was inserted in the gingival sulcus of tooth #9 (FDI 2.1) to mimic a retraction cord. (**b**) A dentin-shaded composite resin was used to mask the darkened dentin. (**c**) A translucent composite resin was used to create the appearance of translucency of the incisal edge. (**d** and **e**) A series of pigments was applied to highlight some effects in the restoration. A white-colored pigment was used to emphasize the opaque incisal halo. (**f** and **g**) A blue-colored pigment was applied to create a translucency effect between the mamelons. (**h** and **i**) A pink-colored pigment was applied to mimic the counter-opalescence effect. (**j** and **k**) An olive-colored pigment was used to increase the saturation of the cervical third of the restoration. (**l**) An enamel-shaded composite resin was applied to the buccal surface. (**m**) A #15 blade was used to create a craze line to mimic the anatomy of tooth #8 (FDI 1.1)

Fig. 15.1 Preoperative view denoting a dark composite resin restoration on tooth #8 (FDI 1.1) and an enamel white spot lesion on tooth #9 (FDI 2.1). Patient was not pleased with the overall color of the teeth

Fig. 15.2 After at-home whitening for 5 weeks using 10% carbamide peroxide in a custom-made bleaching tray

Fig. 16.17 Postoperative view of patient's smile

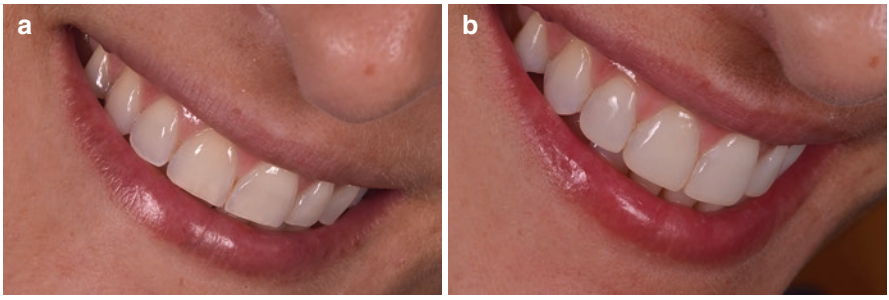

Fig. 16.18 (**a**) Preoperative right-side view of patient's smile. (**b**) Postoperative right-side view of patient's smile

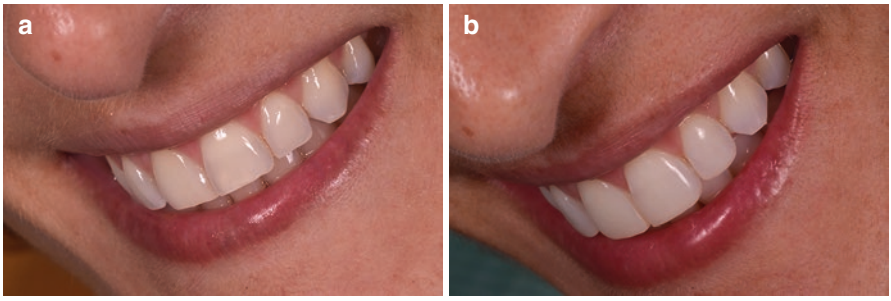

Fig. 16.19 (**a**) Preoperative left-side view of patient's smile. (**b**) Postoperative left-side view of patient's smile

patient also reported that she had undergone two surgical procedures ("gingival surgery", probably connective tissue graft), in an attempt to increase/recover the volume of the gingival contour in the implant region. The esthetic result of the region after the surgeries became even more compromised. As a result the patient decided that she did not want any further surgery in the same region of the mouth (Figs. 17.11, 17.12, 17.13, 17.14, and 17.15).

Figs. 17.11 Pre-treatment view showing the unsatisfactory esthetics from the absence of gingival tissue volume caused by bone loss in the region of the crown over the implant of tooth #7 (FDI 1.2). The color change of tooth #9 (FDI 2.1) also compromised the esthetics. Radiographically this tooth had a process of pulp calcification (calcific metamorphosis) resulting from the trauma

Fig. 17.12 Frontal view after completion of the bleaching treatment with 15% carbamide peroxide (at-home bleaching for 4 weeks). A mockup with bis-acryl resin was tested to define the morphology of the final ceramic restorations

Fig. 18.13 Shade matching to the Vita Classical A1–D4 shade guide

Fig. 18.14 High-opacity lithium disilicate coping try-in (IPS e.max Press HO, Ivoclar Vivadent)

Fig. 18.15 Characterization of the opaque ceramic coping