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Home Dental Bleaching Monitored With Microelectronic Sensors to Record the Wearing Times of an Acetate Tray/Bleaching Product

CC Pavani • D Sundfeld • TC Schott • APM Bertoz • R Bigliazzi • RH Sundfeld

Clinical Relevance

Measuring/quantifying the wearing time of carbamide peroxide in acetate trays will better guide professionals to promptly identify and overcome problems of cooperation resulting from the inappropriate use of bleaching products and provide a more effective bleaching treatment.

SUMMARY

The present case study quantifies the clinical wearing time of an acetate tray/bleaching product during home dental bleaching. The patient was instructed to use a 10% carbamide peroxide gel for 6-8 hours each day for 20 days. The wearing time of the tray was measured by a microsensor from TheraMon microelectronic system (Sales Agency Gschladt, Hargelsberg, Austria) completely embedded in the tray so that the clinician would be informed as to the precise time the tray was placed in the mouth. Evaluation of the daily printout during dental bleaching demonstrated that the patient did not correctly follow the clinician's instructions as to the wearing time of the tray. Recording the wearing time of dental bleaching agents can be beneficial for both dental professional and patient to obtain a more effective treatment according to the patient's needs and expectations.

INTRODUCTION

The carbamide peroxide bleaching product, poured in custom acetate trays during home dental bleach-

Caio Cesar Pavani, MDS student, Department of Restorative Dentistry, Araçatuba Dental School, São Paulo State University–UNESP, Araçatuba, SP, Brazil

Daniel Sundfeld, DDS, MDS, PhD, professor, Department of Restorative Dentistry and Prosthodontics, Ingá University Center–UNINGÁ, Maringá, PR, Brazil

Timm Cornelius Schott, DMD, professor, Department of Orthodontics and Orofacial Orthopedics, Eberhard Karls University, Tübingen, Germany

André Pinheiro de Magalhães Bertoz, DDS, MDS, PhD, professor, Department of Pediatric and Social Dentistry, Araçatuba Dental School, São Paulo State University–UNESP, Araçatuba, SP, Brazil

Renato Bigliazzi, DDS, MDS, PhD, professor, Department of Pediatric and Social Dentistry, Araçatuba Dental School, São Paulo State University–UNESP, Araçatuba, SP, Brazil

*Renato Herman Sundfeld, DDS, MDS, PhD, professor, Department of Restorative Dentistry, Araçatuba Dental School, São Paulo State University–UNESP, Araçatuba, SP, Brazil

*Corresponding author: Araçatuba Dental School, 1193 José Bonifácio St, Araçatuba, SP, Brazil; e-mail: sundfeld@foa.unesp.br

DOI: 10.2341/17-108-S

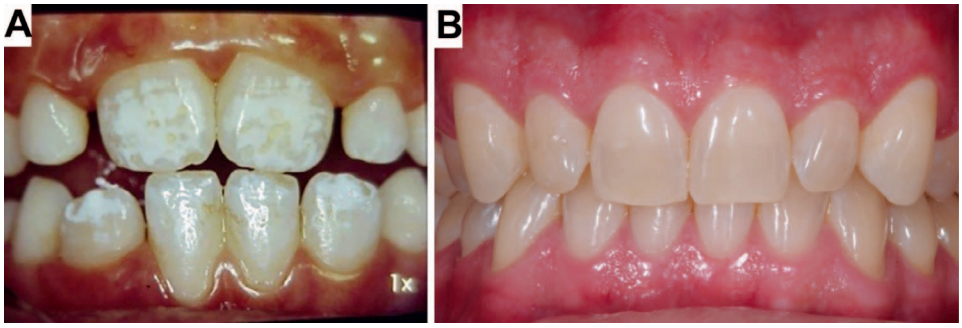

Figure 1. *(A) In 1989, a 9-year-old boy showing white enamel stains of hard texture located on his maxillary and mandibular teeth removed by the enamel microabrasion technique. (B) Clinical condition before starting bleaching treatment.*

ing, provides a significant margin of clinical success and good patient acceptability due to its easy handling; however, this bleaching treatment should be supervised by a dental professional.[1-7] This remarkable technique, introduced by Haywood and Heymann in 1989,[6] requires the patient to use the bleaching product nightly for 6 to 8 hours for 6 weeks.[6] However, patient cooperation, such as wearing time, will certainly influence the success of dental bleaching.

Recently, an electronic microsensor, TheraMon (TheraMon Microelectronic System; Sales Agency Gschladt, Hargelsberg, Austria. http://www.english.thera-mon.com/the-product/index.html),[8-15] was developed to measure the wearing time of removable orthodontic appliances, verifying that patients do not always follow the clinician's instructions, thereby jeopardizing the final quality of the orthodontic treatment. Therefore, to provide a more effective and safe bleaching process, measuring the wearing time of the carbamide peroxide–containing trays will better guide professionals in promptly identifying and addressing concerns of cooperation. Based on the capability of the TheraMon electronic device,[8-15] the aim of the present case study was to assess the level of commitment of a home dental bleaching patient by embedding a microsensor in the custom tray.

CASE REPORT

In 1989, a 9-year-old boy presented to the Clinic of Dentistry of Araçatuba School of Dentistry (São Paulo State University–UNESP) showing white enamel stains of a hard texture on the upper and lower teeth (Figure 1A). The enamel stains located on the maxillary central incisors and mandibular teeth were removed by the enamel microabrasion technique,[1,16] except for the stains located on the lower right central incisor, which presented a deep white stain that needed to be restored with resin composite. In 2016, the patient aimed to bleach his teeth (Figure 1B). During clinical examination, the patient did not reveal any contraindication to the treatment. Also, the patient reported no smoking habits and no history of a dental bleaching treatment. The bleaching was performed using 10% carbamide peroxide gel (Opalescence, Ultradent Products Inc, South Jordan, UT, USA). As this case report is not a clinical investigation, no institutional review board was necessary.

To begin the treatment, maxillary and mandibular alginate impressions were taken, soft vinyl mouth trays were fabricated, and an electronic microsensor, TheraMon (TheraMon), was embedded in the labial region of the acetate tray in order to evaluate the wearing time of the trays (Figure 2). The trays and four bleaching gel tubes were given to the patient, who was instructed to place a small drop of the bleaching gel into each tooth section of the tray, from first molar to first molar, and advised to use the tray at night for 6 to 8 hours per day (h/d), during sleep. All tubes of the bleaching gel were used during the bleaching treatment, which accomplished the patient's expectations. The size and appearance of the embedded TheraMon did not affect patient comfort during bleaching (Figure 3).

The microsensor measures the temperature of the mouth with an accuracy of ±0.1°C, and the temperature is recorded every 15 minutes. The collected data were transferred using a wireless connection between the functional unit and a reading station (Figure 4) coupled to a USB connection. TheraMon software is able to read and interpret data, providing a daily diagram of the wearing time of the tray at each treatment consultation interval. The wearing time of the trays was considered the dental bleaching time, as the patient was instructed to always pour the bleaching gel when the tray was positioned on both dental arches.

Figures 5 and 6 indicate that, during the 22 days of the bleaching period, corresponding from the beginning to the end of the treatment, the mean wearing time of the trays were 6.6 and 6.58 h/d for the upper

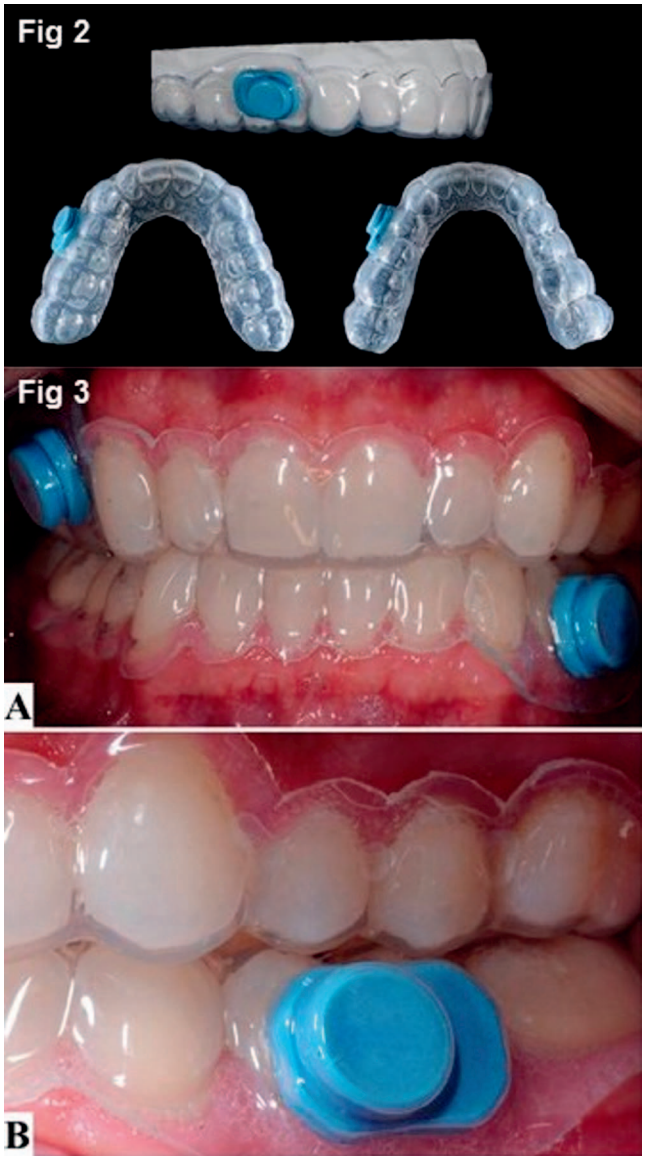

Figure 2. *Microsensor TheraMon embedded in the labial region of the acetate custom tray.*
Figure 3. *Maxillary and mandibular acetate trays containing the microsensor TheraMon placed on teeth (A and B).*

and lower arches, respectively. It was observed that the patient used the trays containing the bleaching gel for a shorter period of time than instructed on the first, second, fifth, and ninth day of treatment. In addition, an additional time of 1 h/d was recorded on the eighth and 21st day of treatment, in both arches. It was also possible to point out that even when guiding the patient about the wearing time per day, there were variations in the wearing time during treatment, ranging from 2.25 to 9.25 h/d. This result demonstrated that the patient did not correctly follow the recommendations for the daily wearing time of the bleaching product on both dental arches. However, during treatment, the patient used the trays containing bleaching product in both arches at the same time he had been instructed.

Figure 4. *Microsensor TheraMon read-out station.*

Dental color assessment was performed before and after the bleaching treament using a digital spectrophotometer (Vita Easyshade Advance, Vita Zahnfabrik, Bad Säckingen, Germany) (Figure 7). The junction of the middle and cervical third of teeth 6 to 11 and 22 to 27 was used for color determination; therefore, an opening on the labial surface, which served as a guide for placing the Easyshade tip before and after bleaching, was made on each tooth position of the tray. According to the data obtained from the Easyshade analysis, the color of the teeth before and after bleaching was determined following the classic Vita shade guide parameter (Tables 1 and 2). Figure 8 depicts the final result of the bleaching treatment. No gingival irritation or sensitivity was observed, and the patient reported satisfaction with the bleaching treatment.

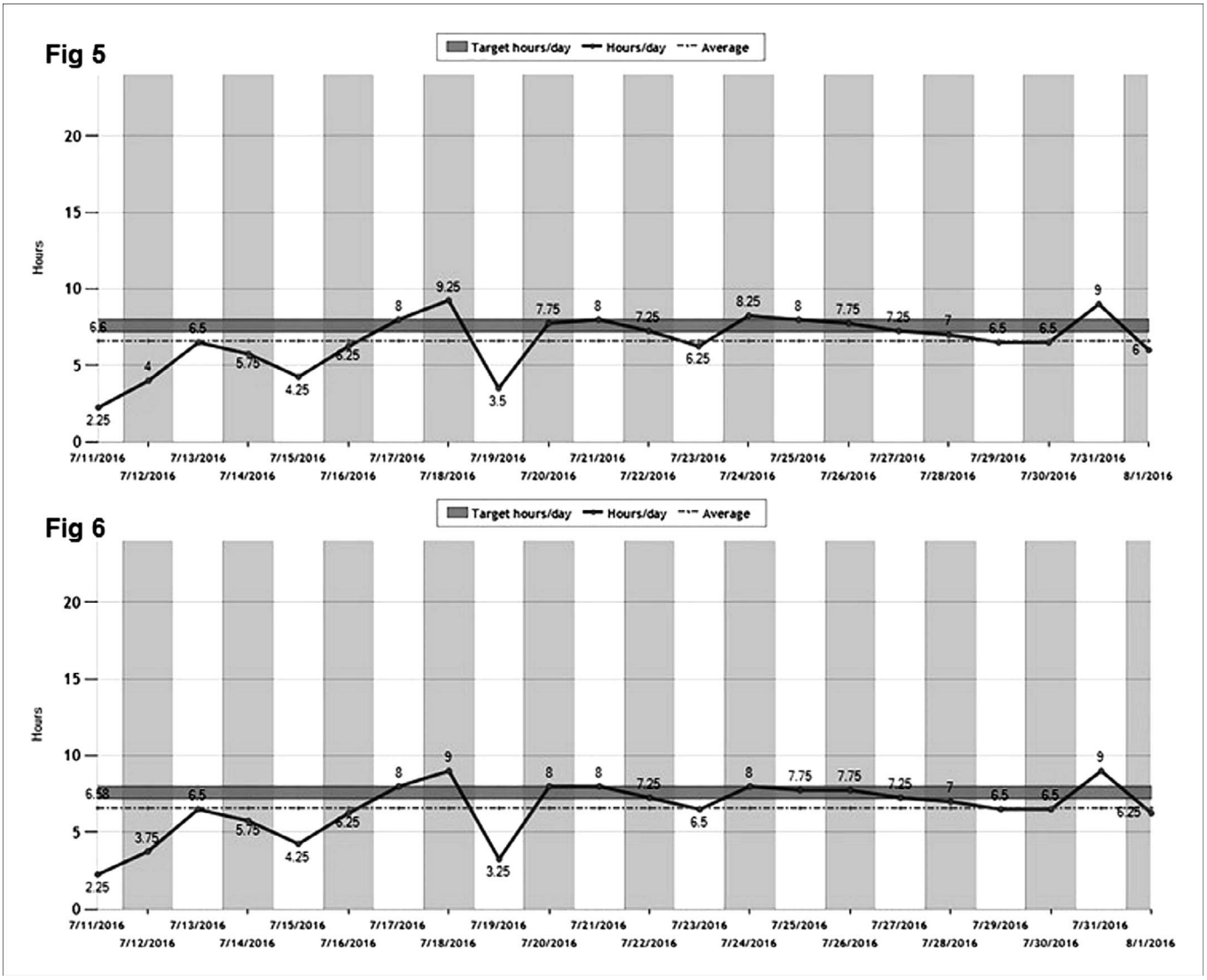

Figure 5. *Diagram evaluating daily tooth bleaching time (time recommended: 6-8 h/d) in the upper arch measured by the TheraMon system microsensor.*
Figure 6. *Diagram evaluating daily tooth bleaching time (time recommended: 6-8 h/d) in the lower arch measured by the TheraMon system microsensor.*

DISCUSSION

The present clinical case report demonstrated the precise wearing times of acetate trays measured by an electronic microsensor device to evaluate the patient's compliance during bleaching treatment.

A significant factor that must be raised for obtaining bleaching effectiveness is related to the degree of patient commitment, especially about the daily wearing time of the trays containing the bleaching product. Several wearing times of dental bleaching products have been reported, from 2 to 8 h/d;[6,7,17] without assuming, however, whether the patient actually used the bleaching product for the time recommended by the professional. Since the bleaching product containing carbamide peroxide is applied to the teeth by the patients themselves, the wearing time of the trays is under their control. Previous orthodontic studies[8-15] have demonstrated the use of the electronic microsensor (TheraMon), which identifies the temperature changes within the oral cavity, making it possible to assess the wearing time of removable orthodontic appliances.[11,12] Based on the described assessments, the aim of the present study was to record the daily wearing time of the carbamide peroxide gel during dental bleaching using the microsensor.

Table 1: *Color Analysis of Teeth Submitted to Dental Bleaching Following the Classical Vita Shade Guide[a] and Its Correlation With the Score Corresponding to Value Arrangement[b]*

Tooth No	Initial Color/Value	Final Color/Value
6	B3/11	A1/2
7	A2/5	A1/2
8	A1/2	B1/1
9	A1/2	B1/1
10	B2/3	B1/1
11	A2/5	A1/2
22	A2/5	B1/1
23	A2/5	A1/2
24	A1/2	B2/3
25	A1/2	B1/1
26	B2/3	B1/1
27	A2/5	A1/2

[a] *Obtained from the Easyshade spectrophotometer assessment (Vita Easyshade Advance, Vita Zahnfabrik, Bad Sackingen, Germany).*
[b] *Vita Classical, Vita Zahnfabrik, Bad Säckingen, Germany.*

The TheraMon is able to monitor the usage time of the trays by recording the temperature of the surrounding area every 15 minutes. Temperatures between 32°C and 36°C count as wear times. The sensitivity of the temperature module makes it extremely difficult to record false data, since the temperature of the trays being used correctly in the oral cavity will move slightly up and down, especially during sleep when body temperature falls at night and increases in the morning. To alert the practice to the "suspect" use time, the software may highlight any abnormal lack of temperature fluctuation or "atypical" temperature change in the oral cavity, with slightly suspect periods of time indicated in yellow and periods strongly suspect in red.[9,10]

It was found that the wearing times of the trays can be recorded during the bleaching treatment (Figures 5 and 6). This technology permits precise measurement and recording of the daily wearing times of the trays by the patients and also provides additional data of mean times by the software at any time. It was found that the patient had not followed the instructions about the daily wearing time (6-8 h/d) of the bleaching product. During the 22 days of treatment, the mean daily wearing time of the trays was 6.6 (from 2.5 to 9.25 h/d) and 6.58 h/d (from 2.5 to 9 h/d) for the upper and lower arches, respectively. Schott and Ludwig in 2014[13] assessed the wearing time of orthodontic appliances and observed that the patients compensated for the fewer hours used in one day by using it for more hours than recommended on succeeding days. It is noteworthy that the patient consented to embedding the microsensor in the trays and knew that monitoring would be accomplished during treatment.

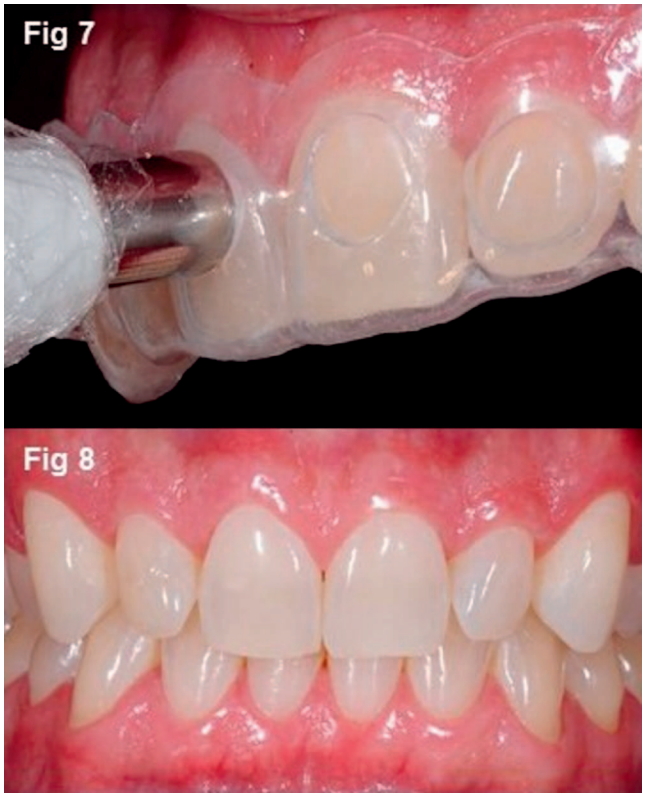

Figure 7. *Dental color evaluation using Easyshade spectrophotometer.*
Figure 8. *Twenty-seven years after removal of white stains on the maxillary and mandibular teeth and 8 months after dental bleaching.*

The mean wearing times found in this study allowed us to suppose that if the patient had used the trays with gel for the recommended time per day, a satisfactory bleaching could have been obtained in a shorter time.[7,17] We noted that the patient appeared to be anxious and usually did not sleep quietly and for a predetermined time, as was reported during anamnesis. This condition may have influenced the adequate wearing time of the trays recommended by the clinician. No tooth sensitivity was reported during or after treatment.

Table 2: *Vita Classical Shade Guide Arranged by Value Scale[a]*

Shade	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3,5	B4	C3	A4	C4
Value	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

[a] *Vita Classical, Vita Zahnfabrik, Bad Säckingen, Germany.*

The present case study agrees with Schäfer and others[14] who quantified the wearing times of a removable appliance during active orthodontic treatment using the TheraMon, confirming that patients contribute to the success of treatment. It is also necessary to modify the usual treatment plan to avoid treatment failures. Therefore, using the microsensor can be beneficial to both clinicians and patients to obtain more effective treatment according to the patient's needs and expectations. Likewise, it has been mentioned that this commercial sensor, besides being inexpensive (about $30 in the United States and €28.5 in Europe), can be inserted into the removable appliance by a dental technician as part of routine practice.[14] Use of the Theramon device will enable researchers to more accurately measure patients' wearing time and may help in identifying optimal times necessary for satisfactory tooth whitening. Further, clinical studies with shorter bleaching times are essential for future research using the TheraMon device to determine the ideal bleaching time.

CONCLUSION

Based on this clinical case report, it can be concluded that the wearing time of the carbamide peroxide bleaching product can be monitored during bleaching treatment by the microsensor TheraMon embedded in the custom acetate tray.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Araçatuba School of Dentistry, São Paulo State University.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, or company presented in this article.

(Accepted 24 August 2017)

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