

In Vivo Measurement of Colour Changes in 1600 Natural Teeth with Pola Office + (SDI, Australia): Spectrophotometric Shade Analysis

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ABSTRACT

The aim of the study was to evaluate the efficacy of professional teeth whitening treatment using the Pola Office+ system (SDI Ltd.): the shade, chroma and value parameters of the anterior teeth were analyzed.

One hundred patients were selected at the Prosthetic Department of Modena and Reggio Emilia University. All patients underwent oral hygiene treatment and spectrophotometric analysis (Spectro Shade) of the 8 front upper and 8 lower teeth: the variables L (value), c (chroma), and h (shade) were measured.

Spectrophotometric analysis was repeated a week after initial bleaching.

The (L) value of the treated teeth increases after bleaching, the chroma parameter (c) showed lower values than those prior to treatment.

The course of the shade parameter is uniform and constant for all patients, with a shift towards yellow chroma values.

Esthetic results obtained using the Pola Office+ (SDI, Australia) in-office teeth whitening procedure were visibly significant; this was confirmed by colorimetric analysis. The harmony between chroma, shade and value remained stable one week after the whitening treatment.

The ideal smile has long been considered to be an asset, reflecting both good health and enhancing appearance.^{1,2} The Roman Civilization consecrated the tradition of the desirability of having white teeth; Patrician women tried to bleach their teeth by rubbing them with a tissue

soaked with natural compounds made up of urea.

According to recent statistics,³ about 50% of the world's population is not satisfied with the colour of their natural teeth and uses all possible methods to make them whiter and more shiny, as

shown by professional models in the media.

Dental discolouration is a relevant esthetic problem; with dental cosmetic procedures being requested more and more by patients in the modern dental practice. Dental staining can be distinguished as being extrinsic and intrinsic: the former concerns the outside of the tooth and is of an exogenous nature, i.e. caused by external agents (food, drinks, plaque, tartar, products with chlorhexidine) and can be easily eliminated using tooth paste and specific techniques of professional abrasion.

Intrinsic staining is caused by the deposition of pigments in the organic or mineral structure of the tooth during the development and/or mineralization of dental caries. To be removed, these stains require the use of specific products and techniques.³ From the chemical point of view, the term bleaching means the destruction of chromophore groups

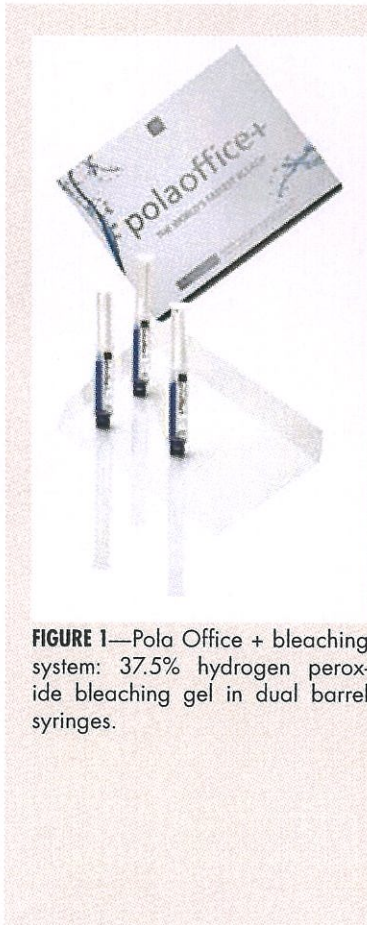


FIGURE 1—Pola Office + bleaching system: 37.5% hydrogen peroxide bleaching gel in dual barrel syringes.

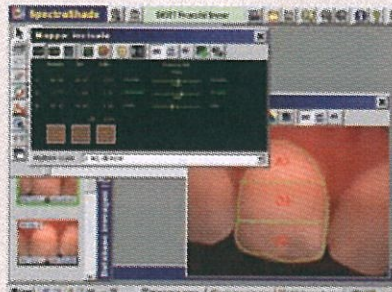


FIGURE 2—Images of tooth no. 11 taken with the SpectroShade colourimeter where one can see the difference in the chromatic measurements when the extensions of the reference areas vary. In the upper left window the program is able to give the value of chroma (c), shade (h), and light (L) of each portion of tooth examined and compare it with the shade guide colour (respectively, left hand column and right hand column). In the examined clinical case, tooth no.11 is closest in chroma, shade and light to colour A2. The right hand column shows discrepancy between the values of light, chroma and shade between A2 and the tooth: the chroma entity is greater than that of A2 while the shade is lower. When compared to the A2 shade, this indicates a more saturated total colour with a tendency towards red.

present in organic and inorganic compounds. Therefore, through chemical reaction, the bleaching agent decolorizes substrates containing double conjugated links and aromatic systems. The compounds used in the bleaching process, whether industrial or home made, can be distinguished, depending on their mechanism of action, as being oxidizing or reducing.

The ancient Egyptians and Phoenicians used oxidation to bleach tissues by combining light alkaline treatment with potassium carbonate and sunlight. In the Eighteenth century, the bleaching of tissues, via alternating treatments with potassium carbonate, acid milk and sun light, was highly developed in the Haarlem area of

Holland, and is still known as “Dutch bleaching”.³

Towards the end of the same century, developments in chemistry made possible the production of hypochlorous acid which, in the form of its sodium, potassium and calcium salts, has been the most important industrial bleaching agent for about 150 years.³ The use of oxygen, as an industrial bleaching agent, started at the end of the 1860’s in the form of the following hydrogen peroxide by-products: peracetates, perborates and persulfates.^{3,4}

The first scientifically documented bleaching attempts on non vital teeth occurred in 1848 and foreshadow the use of calcium chloride.³ Around 1870, recommended chemical agents for

bleaching were oxalic acid and chlorine; the last being in the form of sodium or calcium hypochlorite.³ In 1884, A.W. Harland suggested the use of concentrated hydrogen peroxide for bleaching.³

To make the process easier and so reduce the concentrations of the active constituent, several techniques were developed, for example, the use of an electric current with a mixture of hydrogen peroxide and ether (1:4), the so-called “pirozone” method; the solution, with low superficial current applied, appeared to penetrate the dentinal tubules.³ To avoid the evident disadvantages of this system (flammability and nauseating properties), in 1918 C.H. Abbot suggested using a solution of 30% hydrogen peroxide in distilled water (Superoxol), to be used in conjunction with the heat generated by an electric lamp.³

In 1924 the use of a solution saturated with sodium perborate and hydrogen peroxide was proposed, the teeth were moistened before bleaching with Superoxol accompanied by illumination with a high intensity lamp. In 1961 sodium perborate in water was used to obtain a paste to place on the endodontically treated tooth: this procedure reduced the risk of external absorption by the roots.³

In 1963 Nutting and Poe replaced the water of the paste with Superoxol and thus combined the two techniques that up to that moment had given the best results.³ This new technique, called the “walking” bleach technique, (i.e. ambulatory bleaching technique) did not require the use of light or heat and the bleaching action took place between one session and the next, thanks to the bleaching agent present in the pulp chamber.

Table 1

Tooth	Initial L	Final L	Initial c	Final c	Initial h	Final h	ΔL	Δc	Δh	ΔE
11	74.09	75.69	21.08	20.11	83.49	83.14	2.56	0.9409	0.1225	1.903523
12	70.38	71.67	22.99	21.2	81.10	82.00	1.6641	3.2041	0.81	2.3828974
13	70.47	72.12	27.14	26.34	78.75	78.99	2.7225	0.64	0.0576	1.8493512
14	69.18	71.25	22.06	20.98	79.25	79.56	4.2849	1.1664	0.0961	2.3552919
21	74.03	76.53	21.21	20.49	83.21	82.12	6.25	0.5184	1.1881	2.8207269
22	70.62	71.45	22.91	21.59	81.38	82.45	0.6889	1.7424	1.1449	1.8910843
23	71.35	72.78	26.69	25.45	79.59	79.22	2.0449	1.5376	0.1369	1.9285746
24	69.95	71.23	19.99	18.24	78.15	77.41	1.6384	3.0625	0.5476	2.2909605
41	74.83	75.42	17.09	17.58	83.50	82.61	0.3481	0.2401	0.7921	1.1748617
42	70.20	70.55	20.74	20.43	82.02	81.36	0.1225	0.0961	0.4356	0.8088263
43	71.48	72.44	27.18	26.45	80.38	81.23	0.9216	0.5329	0.7225	1.475466
44	70.20	71.81	23.09	21.1	79.31	80.67	2.5921	3.9601	1.8496	2.8985859
31	74.64	75.56	16.94	16.61	83.60	83.38	0.8464	0.1089	0.0484	1.0018483
32	71.75	73.75	20.41	19.02	81.86	80.84	4	1.9321	1.0404	2.6405492
33	71.62	73.21	26.21	25.98	80.77	79.11	2.5281	0.0529	2.7556	2.3101082
34	70.51	72.36	21.63	20.14	80.37	81.23	3.4225	2.2201	0.7396	2.5263016

In 1966, in order to remove the brownish spots from teeth, Mc-Innes proposed the use of a solution made out of five parts of 30% Superoxol, five parts of 36% hydrochloric acid and one part of ether.³

In 1983, dissociation of the hydrogen peroxide in an alkaline medium in the presence of a catalyst was used to form a strong bleaching substance: the radical peroxide. In 1989, two researchers at North Carolina University developed the Nightguard bleaching method, a home bleaching technique, based on 10% carbamide peroxide, this technique is still in use.⁴

Presently, on the market there are teeth whitening products based on hydrogen peroxide, with different concentrations, with these materials it is possible to perform ambulatory or home bleaching. Higher hydrogen peroxide concentration products are typically used in the dental surgery and involve the dentist applying the mixture on the elements to be treated; with lower

concentrations a resin mask is fabricated to be worn, enclosing the product, at night.

The purpose of this research is to verify the efficacy of teeth whitening treatment with Pola Office+ (SDI Australia, Fig. 1), through spectrophotometric analysis, on a group of one hundred patients, together with an assessment of the performance of the treatment a week after the initial whitening procedure.

MATERIALS AND METHODS

At the Prosthetic Department of Modena and Reggio Emilia University, 100 patients asking for teeth whitening due to cosmetic reasons were selected for the clinical study. The following inclusion criteria were applied:

- aged between 18 and 50 years,
- apparent good health,
- motivation,
- good periodontal condition,
- absence of prosthetic rehabilitations in the upper front sector.

Exclusions:

- heavy smokers,

- psychological unsuitability,
- pregnancy.

Before starting the clinical whitening session, all patients underwent oral hygiene treatment and spectrophotometric analysis (Spectro Shade) of their eight anterior maxillary and mandibular teeth. For each tooth (from 1.4 to 2.4 and from 3.4 to 4.4), the variables L (value), c (chroma), and h (shade) were measured, for a total of 1600 teeth.

In order to prevent irritation of the periodontium, a photocuring gingival barrier was applied. 37.5% hydrogen peroxide Pola Office+ gel was then applied on the vestibular surface of the teeth to be treated. Both upper and lower arches were treated at the same time.

The bleaching agent was left in situ for approximately 10 minutes and then washed away. Fresh bleaching gel was applied to the teeth and the treatment was repeated two times. The gingival barrier was removed after the last application. Patients were ad-

vised to avoid consuming drinks and pigmented substances (carrots, cabbage, tea, coffee) and tobacco for at least two hours after the treatment.

According to the manufacturer's instructions, the whitening speed can be accelerated using a heat emitting curing light for 30 seconds on each tooth. At the end of the treatment, the patients were subjected to an additional spectrophotometric analysis to compare the shade, chroma and light parameters before and after bleaching (Fig. 2).

Further measurements were taken a week after the initial treatment, repeating the readings, to evaluate the stability of the colour obtained.

RESULTS

Example of results obtained from one patient is presented in Table I below. Table I shows the mathematical average parameters of L (value), c (chroma), h (shade) and $\Delta L2$, $\Delta c2$, $\Delta h2$ used to calculate ΔE (Table 1).

DISCUSSION

In order to define a colour, from a psychosensory point of view, three parameters are used:

- a) shade (h), the base colour of the tooth, which is the parameter easiest to identify. Shade derives primarily from the dentine and is defined in four gradients: A (red-brown), B (orange yellow), C (green-gray) and D (pink-gray).
- b) chroma (c), which is a measure of the degree of saturation; the pigmented portion of a shade. The Vita scale contains four degrees of chroma: 1, 2, 3, 4;
- c) value (L), represents the degree of luminosity; it distinguishes value colours from dark ones: black is the minimum value, white is the maximum value.

The determination of colours can be done through direct visual description, photographs or colourimetry. Direct visual description and photography are the traditional methods but there are considerable problems to overcome.

Direct vision is highly subjective and is readily influenced by various factors:⁴⁻⁶

- tendentiously, women see colours better than men;
- young people perceive chromatic differences better than older people;
- tiredness diminishes the capacity to distinguish colours;
- it is necessary to moisten the teeth and models of the colour scale;
- it may be necessary to close the eyes slightly for a better differentiation of the values;
- colour fatigue may occur (this can be prevented by not concentrating on a single colour for more than 8-10 seconds, then relaxing by observing a light blue colour);
- illumination: natural daylight is variable, whereas neutral light is between 6.000°K and 5.000°K.

With photographic images, communication of colour results is improving but other variables may be introduced due to :

- the power of the flash;
- film sensitivity;
- tilting of the frame;
- positioning of the model teeth in the scale of colours;
- variables during film development.

With traditional methods standardization of the film impression is very difficult and researchers are continually experimenting with new measurement methods and colour scales.⁷⁻⁹ Colorimeters are instruments which are speci-



FIGURE 3—Patient needing bleaching treatment.



FIGURE 4—Patient's teeth were cleaned using a paste made of pumice and water.



FIGURE 5—Light curing resin dam (Gingival Barrier) was placed.



FIGURE 6—Pola Office+ gel was directly applied on the vestibular surface of the teeth and left on according to the manufacturer's instructions.



FIGURE 7—Post treatment result.

cally designed for colour measurement and quantitation, and have been used for many years in the industrial and scientific sectors. Application of colorimeter technology to the dental field has proven to be of considerable assistance in quantifying colour.¹⁰⁻¹⁵

In fact, in the in vivo study of Paul et al,¹⁶ where 30 upper central incisors were treated and on which three measurements with the Spectrometer and three shade evaluations by three different clinicians were made, instrumental analysis showed agreement in 83.3% of the cases, however clinical assessments only coincided in 46.6% of cases. With the SpectroShade colorimeter, the value, shade and chroma of the 1600 teeth were measured. The instrument gives the value of the colour scale closest to the tooth being examined, through the comparison between the delta E (ΔE) values of the different analyzed samples.

The ΔE of the given colour is the square root of the sum of the squares of the colorimeter data obtained from the points taken.

ΔE defines the shortest distance between point A (the tooth being examined) and point B (the sample of the colour scale). One ΔE , equal or below 2.75, is a satisfactory value; above 2.75 it is outside the limits of that particular colour. Analyzing the 100 clinical cases, the value (L) of the 1600 treated teeth increases after bleaching. Optimum results were obtained for the chroma parameter (c) which showed lower values than those prior to treatment; this means a shift towards a lower degree of saturation.

The course of the shade parameter is uniform and constant for all patients, with a shift towards yellow chroma values. Esthetic

results obtained using the Pola Office+ (SDI, Australia) whitening procedure were visibly significant; this result was confirmed by colorimeter analysis.

CONCLUSIONS

Colorimetry is an important adjunct to modern dentistry and is able to quantify with great clarity the otherwise subjective sensation of colour perception.¹⁰⁻²³

On the basis of this study it is possible to state that the Pola Office+ (SDI) represents a valid teeth whitening system for professional use, enabling satisfactory esthetic results to be obtained in a single session. In order to reduce the incidence of gingival irritation, the dentist must ensure that the teeth are perfectly isolated with the light cured dam before applying the whitening product and that it adheres perfectly to the periodontum without the presence of gaps.

Spectrophotometric analysis shows that the esthetic result is obtained over all the 1600 teeth treated (100 patients). **OH**

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