Saudi Dental Journal (2021) 33, 650–655

King Saud University

Saudi Dental Journal

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ORIGINAL ARTICLE

Spectrophotometric analysis of dental bleaching after bonding and debonding of orthodontic brackets

Dikson Claudino [a,*], Weber Adad Ricci [b], Heitor Marquez Honório [c], Renan Vaz Machry [d], Luiz Felipe Valandro [d], Ricardo Abreu da Rosa [e], Jefferson Ricardo Pereira [f]

[a] *Postgraduate Program in Health Sciences, University of Southern Santa Catarina, José Acácio Moreira, 787, Zip Code 88704-900 Tubarão, Santa Catarina, Brazil*
[b] *Department of Social Dentistry, School of Dentistry, São Paulo State University, Humaitá, 1680, Zip Code 14801-903 Araraquara, São Paulo, Brazil*
[c] *Department of Orthodontics and Public Health, School of Dentistry, University of São Paulo, Alameda Doutor Octávio Pinheiro Brisolla, 975, Zip Code 17012-901 Bauru, São Paulo, Brazil*
[d] *Postgraduate Program in Oral Science, School of Dentistry, Santa Maria Federal University, Roraima Av., 1000, Zip Code 97105-900 Santa Maria, Rio Grande do Sul, Brazil*
[e] *Department of Conservative Dentistry, School of Dentistry, Federal University of Rio Grande do Sul, Paulo Gama Av., 110, Zip Code 90040-060 Porto Alegre, Rio Grande do Sul, Brazil*
[f] *Postgraduate Program in Health Sciences, University of Southern Santa Catarina, José Acácio Moreira Tubarão, 787, ZIP Code 88704-900 Santa Catarina, Brazil*

Received 5 January 2020; revised 9 May 2020; accepted 12 May 2020
Available online 29 May 2020

KEYWORDS

Dental enamel;
Orthodontics;
Orthodontic brackets;
Spectrophotometry;
Teeth bleaching

Abstract *Introduction:* The aim of this study was to evaluate the bleaching effect after aging simulation in teeth submitted to bonding and debonding of orthodontic brackets.

Materials and methods: For this study, 90 human premolars were selected, and randomly divided into 6 groups: control, bleaching, and other 4 groups submitted to bleaching after bonding and debonding brackets using different methods. Color measurement of sample through the CIE L*a*b* system was performed in three moments: T1 – after brackets debonding, T2 – after staining cycling, and T3 – after bleaching. For evaluation of results among the components L*, a* and b*, the two criteria analysis of variance and the multiple comparison Tukey test ($p < 0.05$) were used.

* Corresponding author.
E-mail addresses: diksonc@hotmail.com, dikson.claudino@unisul.br (D. Claudino), wricci@foar.unesp.br (W.A. Ricci).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2020.05.003

Results: Statistically significant difference was observed among the groups submitted to brackets bonding and debonding through self-conditioning adhesive system and tungsten drill, also the control and bleaching groups between the moments T1 e T2.

Conclusion: Bonding and debonding brackets methods tested in this study showed influence on the sample color change, and after the tooth bleaching process, only the group without brackets previous bonding achieved the color value presented before the staining and aging of samples in the brackets absence.

1. Introduction

Currently, a high demand is observed in the search for a harmonic smile that expresses a health appearance and eliminates natural signs of human aging. The search for a youthful appearance of mouth is associated to development and improvement of techniques and materials for the purpose of odontology esthetics (Claudino and Traebert, 2013), and the orthodontics treatment and tooth bleaching may be highlighted.

Tooth bleaching uses hydrogen peroxide as common whitening agent, which presents as basic function permeating enamel, also the dentin by diffusion, what cleaves large pigment molecules into smaller particles. Through an oxidation and reduction reaction, a cleavage of complex molecules of organic pigments occurs, converting them into simple molecules (Hintz et al., 2001).

In orthodontic therapy, current adhesive systems used for brackets fixation during the treatment can promote irregularities on enamel surface until 100 μm depth due to the necessary previous acid etch, and penetrating on enamel by resin tags in more than 50 μm (Ramesh Kumar et al., 2011).

At the end of the orthodontic treatment, brackets and remaining adhesive removal from enamel surface is carried out, as well as the surface polishing. However, due to the variety of the adhesive permeating in enamel, different amount of this material might continue incorporated in its structure (Claudino et al., 2018).

However, remaining adhesive might contribute for teeth color changes over time. Besides, resin tags can interfere on the bleaching agents' permeation and action on the enamel structure, as well as in their diffusion in dentin, what interferes on the tooth bleaching process effectivity (Joo et al., 2011).

Thus, teeth submitted to brackets bonding and prior debonding might present different behavior after teeth bleaching procedures, when compared to those with no previous bonding of these accessories (Hintz et al., 2001). Then, this study has as aim at evaluating the efficacy of tooth bleaching after aging simulation in teeth submitted to orthodontic brackets bonding and debonding. The hypotheses in this work are there is statistically significant difference when compared the effectiveness between tooth bleaching with and without use of brackets, and there is difference on bleaching effect with different polishing techniques.

2. Materials and methods

This research was carried out through an experimental analytical study performed in laboratory, according to the outline presented in Fig. 1. 90 premolars were used: freshly extracted, less than 6 months, obtained from the human teeth bank of the dentistry school, storing the sample in 0.9% saline solution. Upper and lower first and second premolars were included in the sample. Through naked-eye inspection, specimens with caries, restorations, fractures or cracks on the crown vestibular surface, changes on enamel shape and staining due to fluorosis, hypoplasia or tetracycline were discarded. Estimate between means was used to calculate the sample size and divided into 6 groups with 15 specimens each one (Table 1); the group C was the control one, and group CL was submitted only to bleaching. Other groups (PC + TAR, PC + ZBR, AC + TAR and AC + ZBR) also were submitted to tooth bleaching after brackets standard slot 0.022″ (Morelli Ortodontia, Sorocaba, SP, Brazil) bonding and debonding.

Enamel surface preparation on groups PC + TAR and PC + ZBR was performed through 35% phosphoric acid (Dentsply, Petrópolis, RJ, Brazil) for 30 s and Transbond XT Light Cure Adhesive Primer® (3 M/Unitek, Monrovia, CA, USA). Transbond Plus Self Etching Primer® (3 M/Unitek, Monrovia, CA, USA) was used for AC + TAR and AC + ZBR groups after acid etching.

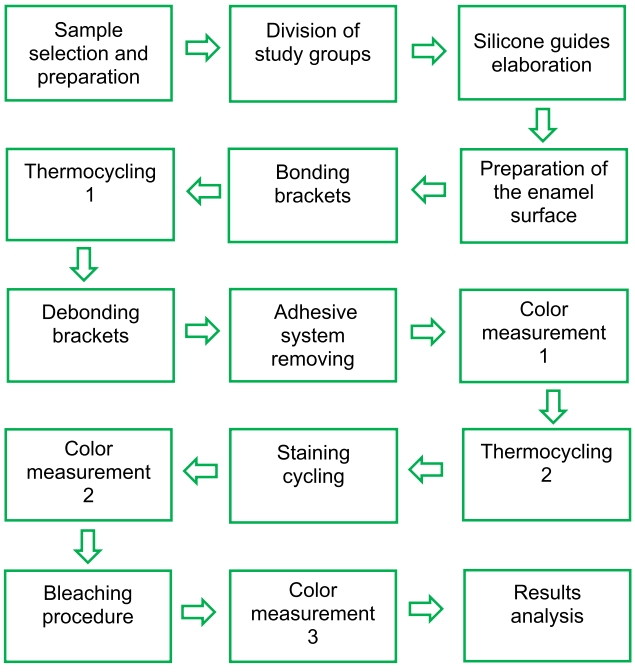

Fig. 1 Study design.

Table 1 Study groups.

Group	n	Procedure
C	15	Control
CL	15	Bleaching
PC + TAR	15	(PC + TAR) + Bleaching
PC + ZBR	15	(PC + ZBR) + Bleaching
AC + TAR	15	(AC + TAR) + Bleaching
AC + ZBR	15	(AC + ZBR) + Bleaching

C (Control); CL (Bleaching); PC (pre-etched adhesive system); AC (self-etching adhesive); TAR (High speed multi-laminated tungsten carbide drill); ZBR (Low speed multi-laminated zirconia drill).

Transbond XT® (3 M/Unitek, Monrovia, CA, USA) was the resin used for photopolymerization with device (Gnatus, Ribeirão Preto, SP, Brasil) measured power at 600 mW/cm^2, during 30 s for adhesive systems, and 40 s for bond resin.

The brackets were removed 3 weeks after bonding with 364R pliers (Quinelato, Rio Claro, SP, Brazil). Bond resin and residual adhesive removal was carried out with 24-blade multi-laminated tungsten carbide drill (Orthometric, Marília, SP, Brazil) in high rotation for the groups PC + TAR and AC + TAR, and 18-blade multi-laminated zirconia drill (Morelli Ortodontia, Sorocaba, SP, Brazil) in low rotation for groups PC + ZBR and AC + ZBR. All the groups were submitted to bonding and debonding brackets, the drills were used during 30 s with no irrigation in each specimen, followed by vestibular surface polishing with fine and extra fine granulation discs (Sof-Lex®, 3 M/ESPE) during 20 s each one. Multi-laminate drills and polishing discs were changed each 5 specimens, and the inspection was direct look using dental light focus.

Specimens were prepared initially by removal of periodontal remaining from radicular surface with Gracey curettes and polishing the crown vestibular surface with rubber cup and pumice paste before inclusion in the study. To standardize the place of brackets bonding, bleaching agent application and color measuring, individualized condensation silicone guides - Zetalabor® (Zermack, Badia Polesine, RO, Italy) were confectioned, presenting a central fenestration on vestibular surface (Fig. 2), performed with punch circular scalpel 5 mm diameter.

All the groups were submitted to a tooth aging simulation through two moments of thermocycling, corresponding to 3 years each one, after bonding/debonding brackets, multi-laminated drills and polishing discs application, performing 3.600 continuous thermocycling cycles each moment. The temperature varied from 5 to 55 °C, and permanence time of 30 s each bath and transference time of 2 s, corresponding to the equipment mechanical time (Leibrock et al., 1999, Andreatta Filho et al., 2005). After the second thermocycling stage, the staining process was performed in order to achieve the pigmentation standardization of specimens, immersing the sample during 72 h in coffee, maintained in a biological kiln at 37 °C (Berber et al., 2013), with manual shaking each 8 h.

Color measurement was carried out inside a metamerism box (Mako, Rio Negro, PR, Brazil) by spectrophotometer Vita Easyshade® (Vita, Brea, CA, USA). The appliance was calibrated each two readings, using the color system CIE L*a*b*, established by the *commission Internationale de I'Eclairage*. Component L* evaluates luminosity through changes on black and white shades (bright/dark perceptions) ranging from 0 to 100, and the components a* and b* evaluate saturation and hue in red-green and blue-yellow axes respectively, ranging form −120 to +120 (Martin-Biedma et al., 2010). Color measurement was performed in three moments: T1 – after brackets debonding, residual adhesive removal and coronal vestibular polishing; T2 – after sample staining process; T3 – after bleaching process.

Fig. 2 Individualized silicone guide.

After the second color record, all the groups except the control one (C group) were submitted to the tooth bleaching procedure with 38% hydrogen peroxide - Opalescence Boost® (Ultradent, South Jordan, UT, USA), 3 sessions with 30 min each one with 24 h interval among them, and the bleaching agent was replaced after 15 min in each session.

Intra-examiner calibration was performed before data collection with a double examination of fifteen specimens at five-day interval. Kappa statistic was used as a measure of reliability with minimum allowed kappa equal to 0.7 for color measurement.

The analysis of results was carried out through the software SigmaPlot 12.0, with factorial design using two study factors: the factor group was the first one, and the factor moment was the second. Factor group was divided into six levels, regarding the six study groups. Factor moment was divided into three moments, regarding the three-color measuring moments. Factor moment was considered a repeated analysis, because the measurements were paired, where the same sample unit was evaluated in different moments. To verify the statistically significant difference on the average values of variable of each component (L*, a*, b*), the two way analysis of variance was used (ANOVA 2), and the multi comparison Tukey test when the first one indicated statistically significant difference among the mean values of the variables analyzed to identify which groups were different among themselves. The statistical significance level was 0.05 for both evaluations.

Table 2 Average and standard deviation of component L* in T1, T2 and T3.

Group	L*(T1) Average (S.D.)	L*(T2) Average (S.D.)	L*(T3) Average (S.D.)
C	85.52 (±8.48)^{1a}	78.51 (±8.89)^{2a}	80.80 (±9.14)^{2ab}
CL	86.17 (±5.51)^{1b}	78.94 (±4.07)^{2a}	85.14 (±4.55)^{1ab}
PC + TAR	85.88 (±5.30)^{1c}	77.19 (±6.16)^{2a}	82.26 (±6.77)^{3a}
PC + ZBR	84.47 (±8.00)^{1d}	75.33 (±7.38)^{2a}	80.94 (±7.24)^{3ab}
AC + TAR	87.93 (±9.02)^{1b}	75.35 (±5.97)^{2a}	80.48 (±6.47)^{3b}
AC + ZBR	85.73 (±6.72)^{1e}	76.52 (±5.45)^{2a}	82.24 (±5.43)^{3ab}

^{123} Presence of one or more equal number(s) in the lines means no statistically significant differences among moments, considering p = 0.000 value for Tukey test.
^{abcd} Presence of one or more letter(s) in columns means no statistically significant difference among the groups, considering p = 0.000 value for Tukey test.

Table 3 Average and standard deviation of component a* in T1, T2 and T3.

Group	a*(T1) Average (S.D.)	a*(T2) Average (S.D.)	a*(T3) Average (S.D.)
C	0.64 (±1.86)^{1a}	1.27 (±1.25)^{2a}	−2.06 (±1.15)^{3a}
CL	0.60 (±1.17)^{1a}	0.81 (±0.99)^{2a}	−2.79 (±0.91)^{3a}
PC + TAR	1.78 (±2.41)^{1a}	2.54 (±1.86)^{2a}	−1.43 (±2.23)^{3a}
PC + ZBR	0.33 (±1.75)^{1a}	0.79 (±1.16)^{2a}	−2.94 (±1.14)^{3a}
AC + TAR	0.94 (±2.13)^{1a}	1.91 (±1.76)^{2a}	−2.06 (±1.65)^{3a}
AC + ZBR	0.53 (±2.32)^{1a}	1.29 (±2.06)^{2a}	−2.10 (±1.95)^{3a}

^{123} Presence of one or more equal number(s) in the lines means no statistically significant difference among moments, considering p = 0.00 value for Tukey test.
^{a} Presence of one or more letter(s) in columns means no statistically significant difference among the groups, considering p = 0.800 value for Tukey test.

Table 4 Average and standard deviation of component b* in T1, T2 and T3.

Group	b*(T1) Average (S.D.)	b*(T2) Average (S.D.)	b*(T3) Average (S.D.)
C	24.73 (±8.40)^{1a}	22.01 (±6.90)^{2ab}	23.99 (±7.42)^{12a}
CL	25.64 (±4.61)^{1b}	22.79 (±3.33)^{2ab}	20.95 (±3.58)^{2a}
PC + TAR	28.07 (±5.95)^{1c}	27.91 (±4.89)^{1a}	24.45 (±5.08)^{2a}
PC + ZBR	23.22 (±5.74)^{1c}	21.95 (±4.20)^{1a}	18.87(±4.06)^{2a}
AC + TAR	26.18 (±7.59)^{1c}	24.45 (±6.28)^{1a}	20.36 (±6.39)^{2a}
AC + ZBR	26.09 (±5.23)^{1d}	25.54 (±5.28)^{1b}	20.77 (±5.68)^{2a}

^{123} Presence of one or more equal number(s) in the lines means no statistically significant difference among moments, considering p = 0.000 value using the Tukey test.
^{abcd} Presence of one or more letter(s) in columns means no statistically significant difference among the groups, considering p = 0.000 value for Tukey test.

3. Results

After the analysis of results, statistically significant difference was verified at the moment (p = 0.000) and the moment/group (p = 0.000) for the components L* and b*; and only at the moment (p = 0.000) for the component a* (Tables 2–4).

In Table 2, when observed the component L*, all the groups presented statistically significant difference between the moments T1 and T2. Only the group C presented no statistically significant difference between the moments T2 and T3, and the group CL between the moments T1 and T3.

Still regarding the component L*, groups CL and AC + TAR presented no statistically significant difference in T1, all the groups presented no statistically significant difference in T2, and just the groups PC + TAR and AC + TAR presented statistically significant difference in T3 (Table 2).

Table 3 shows, when observing the component a*, all the groups presented statistically significant difference among the moments T1, T2 and T3, and all the groups presented no statistically significant difference in every moment.

Table 4 shows, when observed the component b*, groups C and CL presented statistically significant difference between the moments T1 and T2. The groups C and CL presented no statistically significant difference between the moments T2 and T3. Group C also presented no statistically significant difference between the moments T1 and T3.

Still regarding the component b* evaluation, the groups PC + TAR, PC + ZBR and AC + TAR presented no statistically significant difference in T1, group AC + ZBR presented statistically significant difference regarding the groups PC + TAR, PC + ZBR and AC + TAR in T2, and all the groups presented no statistically significant difference in T3 (Table 4).

4. Discussion

After statistical analysis, the hypotheses of this search can be accepted, when comparing both the bleaching effect on teeth and the material used for polishing.

All the groups evaluated presented lowered average values of component L* between the moments T1 and T2 and increased these values between the moments T2 and T3. These values presented no statistically significant difference only for the group CL between the moments pre-thermocycling and post bleaching, respectively T1 and T3. It is justified because the group CL was not submitted to previous brackets bonding. Eliades et al. (2001) and Ye et al. (2013) affirmed that bonding and debonding brackets procedures promote irreversible changes on enamel, and both the remaining adhesive system from the bonding process and the removal method for this system migth promote changes on the enamel color.

Remaining resin interferes on the light reflection capacity on the enamel surface, influencing the component L* values (Chung, 1994, Leibrock et al., 1997). These data present great importance, because the axis L* represents the value or luminosity of an object, and quantifies in a gray scale, from pure white (L* equals one hundred) to pure black - L* equals zero. The reference between the dark and the light is attributed to this component (Dozic et al., 2003). The value is the most important factor to the color determination in dental substrate spectrophotometric readings (White et al., 2000).

Object images formation occurs on the retina where photoreceptors cells called cones and rods are responsible to transmit, through chemical and electrical means, the light and color stimulation to the visual center of the human brain. Cones can recognize the hue presenting three different types with sensitivity to the wave lengths of red, blue, and green. Rods can recognize the value (luminosity), differentiating how much the color is light or dark, and detecting only the gray shades (Guyton and Hall, 2017). The human eye presents around 6 million cones and 120 million rods. This disproportion provides a much better capacity to differentiate values variations than hue and chroma, and this the reason why the value is the most important dimension in color evaluation for dental esthetics (Marcucci, 2003, Vichi et al., 2011).

Regarding the component b*, all the groups presented average values compatible with yellow hue in all the moments of color measurement (T1, T2 and T3). There was no negative record (blue hue), and all the groups, except for C (no bleaching and brackets bonding/debonding) demonstrated decreased values for this component between the moments T1 and T2, and between T2 and T3, keeping the hue and lowering saturation. These results are justified due to the chroma decrease on yellow hue towards the neutral colors, both for darkening and whitening the sample.

Regarding the component a*, all the groups evaluated presented an average increase for their values between T1 and T2, with positive values both for T1 and T2 (red hue), and decreasing their average values between T2 and T3, with negative values for T3 (green hue). It is justified by the hue behavior which compound the axis a*, presenting a small amplitude near the neutral shades on dental elements. Authors like White et al. (2000) indicate that the component a* contribution is small on the CIE L*a*b* system, when dental bleaching is evaluated.

The major limitation on this research is its laboratorial nature because *in vivo* conditions may present not contemplated variations on the methodology described. The origin of sample from a human tooth bank also could be considered as limitation, because enables the inclusion of specimens which were submitted to previous orthodontic brackets bonding in the sample.

5. Conclusions

The brackets bonding and debonding methods tested in this study influenced on color changes of the sample, and after the tooth bleaching process, only the group with no previous brackets bonding reached the color value presented before the sample staining and aging in brackets absence. The color value (luminosity) is the most relevant component for color perception in dental samples. The importance of this association is highlighted by pointing to the need for complementary studies for more clarifications.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical statement

This research (spectrophotometric analysis of dental bleaching after bonding and debonding of orthodontic brackets) was approved by the research ethics committee of the University of Southern Santa Catarina under registration number 1.937.320.

CRediT authorship contribution statement

Dikson Claudino: Conceptualization, Writing - original draft, Methodology, Resources, Investigation. **Weber Adad Ricci:** Methodology, Resources, Investigation. **Heitor Marquez Honório:** Formal analysis. **Renan Vaz Machry:** Resources. **Luiz Felipe Valandro:** Resources. **Ricardo Abreu da Rosa:** Resources. **Jefferson Ricardo Pereira:** Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Claudino, D., Traebert, J., 2013. Maloccusion, dental aesthetic self-perception and quality of life in a 18 to 21 year-old population: a cross section study. BMC Oral Health 13, 1–6.

Hintz, J.K., Bradley, T.G., Eliades, T., 2001. Enamel color changes following whitening with 10 per cent carbamide peroxide: a

comparison of orthodontically-bonded/debonded and untreated. Eur. J. Orthod. 23, 411–415.
Ramesh Kumar, K.R., Shanta Sundari, K.K., Venkatesan, A., Chandrasekar, S., 2011. Depth of resin penetration into enamel with 3 types of enamel conditioning methods: a confocal microscopic study. Am. J. Orthod. Dentofacial. Orthop. 140, 479–485.
Claudino, D., Kuga, M.C., Belizário, L., Pereira, J.R., 2018. Enamel evaluation by scanning electron microscopy after debonding brackets and removal of adhesive remnants. J. Clin. Exp. Dente. 10, e248–e251.
Joo, H.J., Lee, Y.K., Lee, D.Y., Kim, Y.J., Lim, Y.K., 2011. Influence of orthodontic adhesives and clean-up procedures on the stain susceptibility after debonding. Angle Orthod. 81, 334–340.
Leibrock, A., Degenhart, M., Behr, M., Handel, G., 1999. In vitro study of the effect of termo – and load – cycling on the bond strength of porcelain repair systems. J. Oral Rehabil. 26, 130–137.
Andreatta Filho, O.D., Araújo, M.A.J., Bottino, M.A., Nishioka, R. S., Menezes, M.M., 2005. Study of thermocycling effect on the bond strength between an aluminous ceramic and a resin cement. J. Appl. Oral Sci. 13, 53–57.
Berber, A., Cakir, F.Y., Baseren, M., Gurgan, S., 2013. Effect of different polishing systems and drinks on the color stability of resin composite. J. Contemp. Dent. Pract. 14, 662–667.
Martin-Biedma, B., Gonzalez-Gonzalez, T., Lopes, L., Vilar, R., Babillo, J., Varela-Patiño, P., 2010. Colorimeter and scanning eléctron microscopy analysis of teeth submited to internal bleaching. J. Endod. 36, 334–337.
Eliades, T., Kakaboura, A., Eliades, G., Bradley, T.G., 2001. Comparison of enamel colour changes associated with orthodontic bonding using two differents adhesives. Eur. J. Orthod. 23, 85–90.
Ye, C., Zhao, Z., Zhao, Q., Du, X., Ye, J., Wei, X., 2013. Comparison of enamel discoloration associated with bonding with three different orthodontic adhesives and cleaning-up with four different procedures. J. Dent. 41, 35–40.
Chung, K.H., 1994. Effects of finishing and polishing procedures on the surface texture of resin composites. Dent mater. 10, 325–330.
Leibrock, A., Rosentritt, M., Lang, R., Behr, M., Handel, G., 1997. Colour stability of visible light-curing hybrid composites. Eur. J. Prosthodont. Restor. Dente. 5, 125–130.
Dozic, A., Kleverlaana, C.J., Aartmanb, I.H.A., Feilzer, A.J., 2003. The influence of porcelain layer thickness on the final shade of ceramic restorations. J. Prosthet. Dente. 90, 563–570.
White, D.J., Kozak, K.M., Zoladz, J.R., Duschner, H.J., Götz, H., 2000. Effects of tooth-whitening gels on enamel and dentin ultra structure – A confocal laser scanning microscopy pilot study. Compend. Contin. Educ. Dente. 29, 29–34.
Guyton, A.C., Hall, J.E., 2017. Medical physiology. Elsevier, Philadelphia.
Marcucci, B., 2003. A shade selection technique. J. Prosthet. Dente. 89, 518–521.
Vichi, A., Louca, C., Corciolani, G., Ferrari, M., 2011. Color related to ceramic and zirconia restorations: A review. Dent mater. 27, 97–108.