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Original Article

Laboratory Study of Color Stability of Different Types of Materials for Temporary Constructions

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Abstract

Introduction: A temporary construction serves as a preliminary representation of the type and appearance of a future permanent one that is tailored to the patient's requirements. Like any prosthetic construction, it should meet the functional requirements, preserve or improve chewing and speech function. No matter how well maintained a prophylactic and functional prosthetic structure is, it will not be evaluated by the patient unless it retains and restores the existing shape, size and color of the natural teeth.

Aim: To determine instrumentally to what extent different colorants change the color of temporary constructions.

Materials and methods: Two materials for temporary restoration were tested – Protemp II and Protemp IV, of which a total of 100 test specimens, were fabricated. Under the equal storage conditions of room temperature and no direct access to sunlight, they were exposed to five 100-ml staining solutions: Coca-Cola, coffee (espresso), berry tea, orange juice and red wine in five separate containers. Measurements of color changes in the three areas of the tooth were performed using two spectrophotometric devices – Vita EasyShade and SpectroShade, at different time intervals – immediately before placement in the staining solution, at 1, 4, 7, and 14 days.

Results: The results were analysed using the SPSS Statistical Processing Program (SPSS Inc., IBM SPSS Statistics) version 21.0. They were converted to a text file with the converter of the same program. In hypothesis testing, a standard value of $p \leq 0.05$ was chosen for the level of significance that rejects the null hypothesis.

Conclusion: Based on this study, the strong colouring effect of coffee and red wine on these restorations was demonstrated. We can conclude that Protemp IV material showed better color stability compared to Protemp II.

Keywords

color stability, color-matching devices, temporary crown

INTRODUCTION

Temporary constructions serve as preliminary representations of the type and appearance of future permanent ones that are tailored to the patient's requirements.[1,2] Like any prosthetic construction, it should meet the functional requirements, preserve or improve chewing and speech function. No matter how well maintained a prophylactic and functional prosthetic structure is, it will not be evaluated by the patient unless it retains and restores the existing shape, size and color of the natural teeth.[3]

The color and appearance of teeth are a phenomenon created by a lot of factors such as lighting conditions, translucency, opacity, light scattering, gloss, and human perception.[4]

Recent advances in color determination are driven by the desire to achieve high-quality aesthetic restorations. Improved colouring and the availability of colour-matching devices increase the clinician's ability to achieve satisfactory accuracy in their reproduction.[5,6]

The knowledge of human tooth color and its distribution are very important in aesthetic dentistry.[7] The basic shade of the tooth is represented in the middle third, and the color range changes from the incisal to the gingival region.[8]

Determination of tooth color can be done by two basic methods: visual in a clinical environment and instrumental with the help of different devices – colorimeter, spectro-photometer and digital imaging.[9-14]

Instrumental methods of color matching are increasingly used.[15] In the visual determination of color, a high variability of the selected color is observed with different determinations of the same colour. In such cases, the instrumental matching is strongly recommended as an additional method in everyday dental practice.[16]

Modern devices provide a fast, reproducible and environment-friendly way of registering colour. They reduce the subjective influence of the operator and the need for special lighting conditions.[15]

AIM

To determine instrumentally to what extent different colorants change the color of temporary constructions.

MATERIALS AND METHODS

Two materials for temporary restoration were tested – Protemp II and Protemp IV **(Fig. 1)**, of which 100 test specimens were fabricated in total.

Protemp II Protemp IV

Figure 1. Materials for temporary restorations.

For this purpose, we used a matrix with an individual design, which is as close as possible to the anatomical configuration of the natural teeth **(Fig. 2)**. The test specimens obtained were 1.2 mm thick in the cervical region, 1.5 mm in the tooth body, and 2 mm in the area of the cutting edge (at the front teeth) and the chewing surface (at the lateral ones).

Figure 2. Matrices with individual parameters and design.

Figure 3. Test specimens of Protemp II.

Figure 4. Test specimens of Protemp IV.

Fifty pieces were made from each of the two materials. The test specimens were obtained from the cavity formed between the assembled matrix and the die **(Figs 3, 4)**. They were distributed equally from all dental groups (central and lateral incisors, canines, premolars and molars).

Under the same storage conditions – room temperature and without direct access to sunlight, they were exposed to five 100 ml staining solutions: Coca-Cola, coffee (espresso),

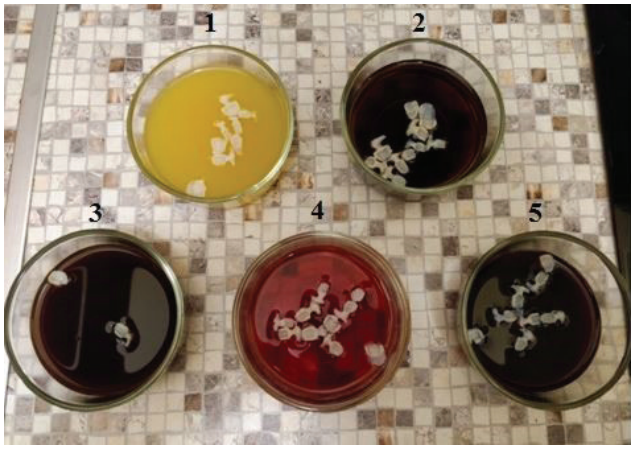

Figure 5. Staining solutions – 1: orange juice; 2: Coca-Cola; 3: coffee; 4: berry tea; 5: red wine

berry tea, orange juice and red wine in five separate containers **(Fig. 5)**. Each material was examined individually, placing ten copies from it in each of the five vessels.

Measurements of color changes in the three areas of the tooth were performed using two spectrophotometric devices – Vita EasyShade and Spectro Shade **(Fig. 6)**, at different time intervals – immediately before placement in the staining solution, and at 1, 4, 7, and 14 days.

Figure 6. Color-matching devices – Vita EasyShade and SpectroShade.

To harmonize the conditions of color determination, we used an LED apparatus consisting of 85500 K intensity LEDs that reproduce naturally neutral daylight **(Fig. 7)**.

Figure 7. LED apparatus reproducing neutral daylight.

Statistical analysis of the data from all measurements was performed using the SPSS Statistical Processing Program (SPSS Inc., IBM SPSS Statistics) version 21.0. The results obtained from the processing were converted to a text file with the converter of the same program. In hypothesis testing, a standard value of $p \leq 0.05$ was chosen for the level of significance that rejects the null hypothesis.

Microsoft Office Excel 2010 was used to interpret and present the obtained results.

The following methods were used:

- Graphic analysis – to visualize the results obtained;
- Descriptive statistics – point estimates of parameters – finding averages, standard deviations, standard errors of averages;
- Fisher's exact test – to determine the statistical significance of the influence between parameters (Fisher's exact test) for tables 2×2;
- Chi-squared Tests – for statistical testing of hypotheses at nominal measurement scales.

RESULTS

The results below show how the most common initial colors D2, B3, and B4 change over the given period from different colorants. Thus, by looking specifically at the change from one color to another, we can determine with certainty the color stability of the individual materials. We looked at the data obtained separately for the three areas of the tooth – cervix, body, cutting edge.

Cervix

Color D2

The Protemp II specimens of the initial D2 color, measured with SpectroShade, were 32 in the cervix. On the first day the color was mostly retained, but in 12 of them it changed to C4 after staining with coffee and red wine. On day 4, specimens that had retained their color were now stained to D4, B4, and C3, and stained to C4 retained their number. On day 7, the stains from coffee and red wine remained unchanged; the tea stains to C4 and to a lesser extent to C3, and the coke and natural juice to B4. On day 14, some of the Coca-Cola and natural juice specimens darkened to C3.

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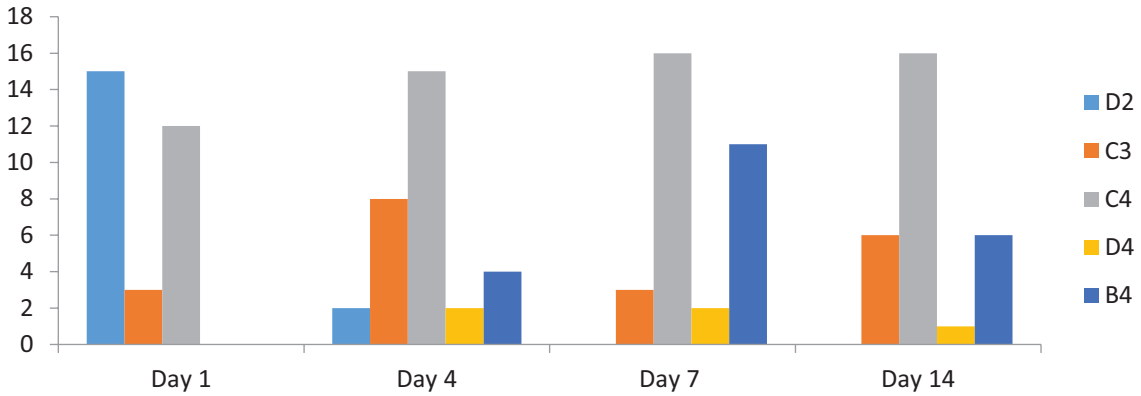

Figure 8. Protemp II with initial color D2 measured with SpectroShade.

In the case of coffee, red wine and tea, data were retained **(Fig. 8)**.

The D2 color in the cervical area was also measured in the Protemp IV test specimens. On day 1, those immersed in Coca-Cola retained their original color and those in red wine darkened to C4. On day 4, the specimens in Coca-Cola changed to B4. On day 7, the results were retained, and on day 14, the predominant color was already C4, followed by B4 and C2 **(Fig. 9)**.

Color B3

Color B3 in the cervix area of Protemp II material measured with the Vita EasyShade apparatus was found in 40 specimens. After 1 day it changed to C4 from coffee and red wine and to A3.5 from Coca-Cola and tea. One part of the samples (4 pieces) stained with Coca-Cola retained their original colour. On day 4, five of those immersed in tea darkened from A3.5 to A4, and the coffee and red wine colorants retained the coloration to C4. On day 7 the results were maintained – Coca-Cola stained to A3.5, coffee and red wine – to C4, and tea – to A4. On day 14, the results were again retained, with only natural juice causing a partial darkening of A3.5 to B4 **(Fig. 10)**.

Color B4

For Protemp IV specimens of B4 initial color, measured with a Vita EasyShade apparatus, in the cervical area, the changes tended to be C4 when colored with coffee and red wine, but 6 of them on day 1 retained their B4 colour. On day 7, a change in the samples immersed in Coca-Cola was observed, staining to A4, the others remaining unchanged for 24 hours. At the end of the study period (14 days), changes were observed only in orange juice specimens which darkened to A4 **(Fig. 11)**.

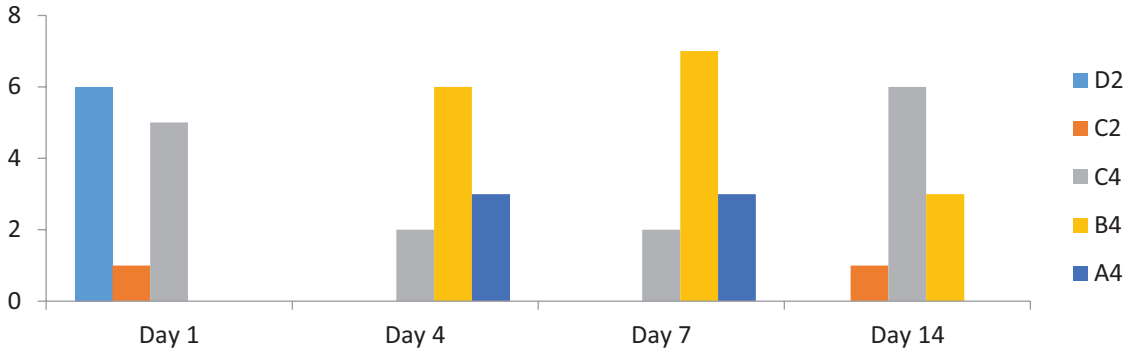

Figure 9. Protemp IV with initial color D2 measured with SpectroShade.

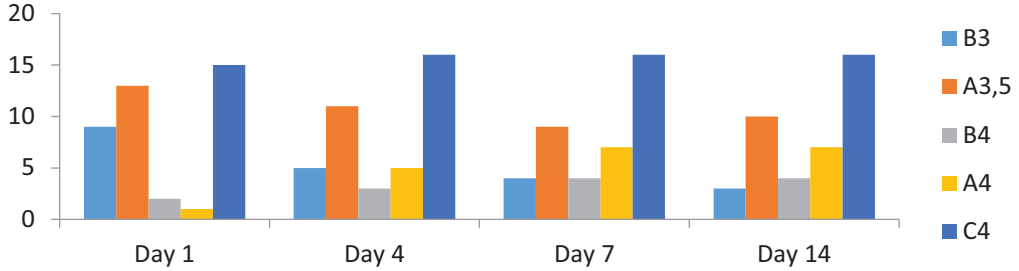

Figure 10. Protemp II with initial color B3 measured with Vita EasyShade.

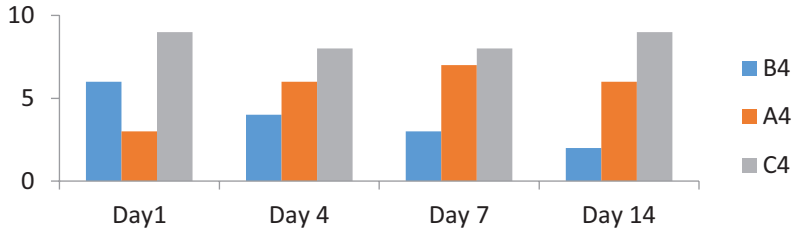

Figure 11. Protemp IV with initial color B4 measured with Vita EasyShade.

The color C4 in the cervix was also indicated by the SpectroShade apparatus. At day 1, the samples dipped in coffee darkened to C4, and those from tea – to C3. On day 4, color B4 of those immersed in tea and natural juice and color A4 of those in coffee were observed. The results were unchanged on day 7. On day 14, all specimens immersed in coffee darkened to C4, those from natural juice – to B4, and those from tea – to C3 and C4 **(Fig. 12)**.

Body

Color D2

Protemp II specimens measured with SpectroShade with initial color D2 retained their color for 1 day on Coca-Cola, tea and natural juice. For coffee and red wine they changed to C4.

Data on coffee and red wine were retained on day 4. The specimens from Coca-Cola darkened to C3 and from tea – to B4. On day 7, the juice also darkened to B4. On day 14, the tea darkened to C3 and C4 and the results for coffee and red wine were maintained **(Fig. 13)**.

For Protemp IV material, the initial D2 color was also measured in the body area with a SpectroShade apparatus. Here, too, red wine stains more than Coca-Cola and natural juice.

Color B3

Protemp II specimens measured with Vita EasyShade with initial color B3 in the body area for 1 day stayed unchanged in Coca-Cola, tea and natural juice solutions, most of

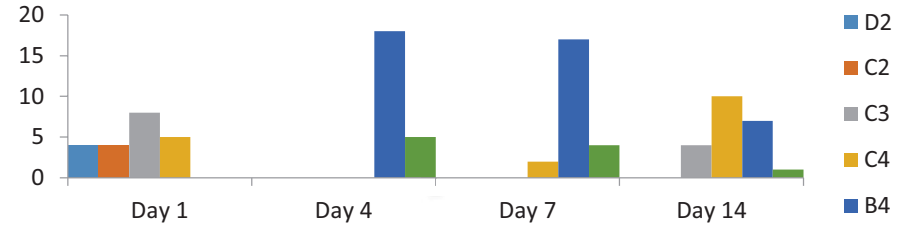

Figure 12. Protemp IV with initial color B4 measured with SpectroShade

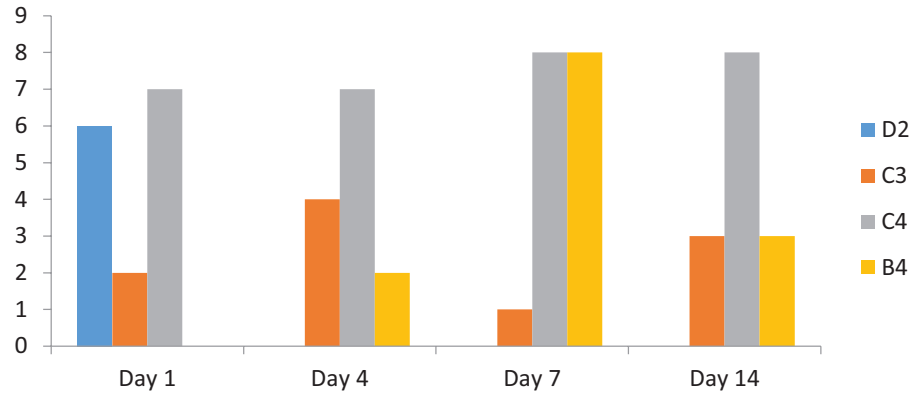

Figure 13. Protemp II with initial color D2 measured with SpectroShade.

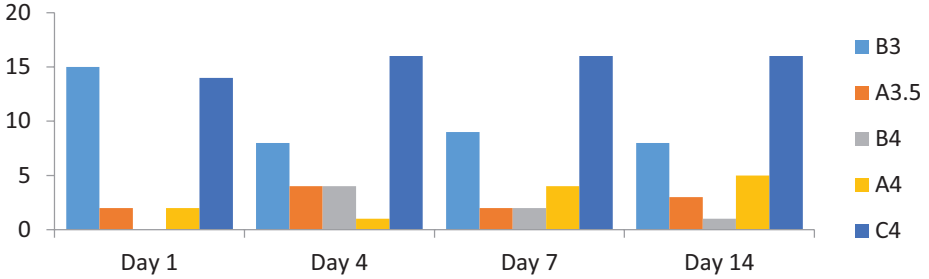

Figure 14. Protemp II with initial color B3 measured with Vita EasyShade.

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those immersed in coffee and all in red wine changed to C4. On day 4, the red wine data was retained, but they all were coloured to C4. Three of the samples immersed in the Coca-Cola solution changed to B4. On day 7, there was a change only in the samples immersed in tea, which darkened to A4. Data were retained on day 14 **(Fig. 14)**.

Color B4

Protemp IV samples measured with Vita EasyShade with initial color B4 in the body area at day 1 changed to C4 in coffee and red wine solutions. With natural juice, the original color was mostly retained, and there was no discernible difference in Coca-Cola and tea. Data was saved on day 4. On day 7, there was a change in the Coca-Cola specimens colouring up to A4, and tea – darkened to C4 and A4. At 14 days there was already a darkening in the natural juice, which was colored to B4 and A4 **(Fig. 15)**.

Protemp IV specimens of B4 initial color were also measured with a SpectroShade apparatus. On day 1, all the samples dipped in coffee change to C4, all from tea – to C3, and those from natural juice to C2 and C3. At the end of the study period, data on coffee and Coca-Cola remained unchanged, with changes in tea mainly up to C4 **(Fig. 16)**.

Cutting edge

Color D2

In the area of the cutting edge, the samples of Protemp II material with D2 initial color, measured by a SpectroShade

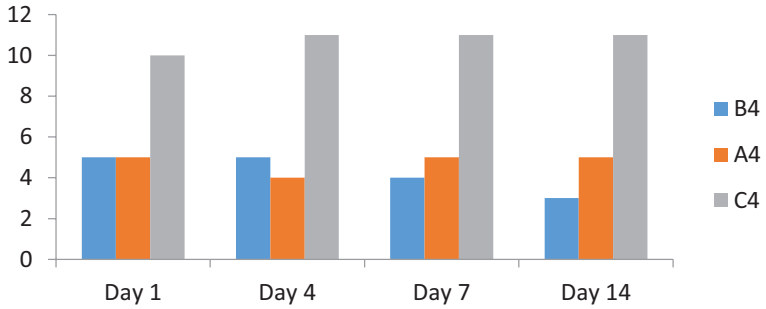

Figure 15. Protemp IV with initial color B4 measured with Vita EasyShade.

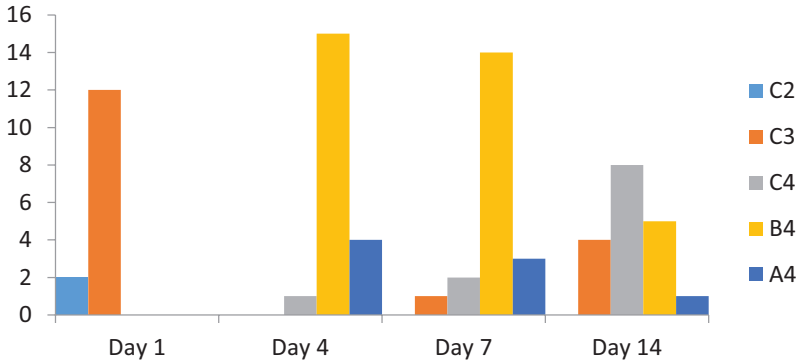

Figure 16. Protemp IV, with initial color B4, measured with SpectroShade.

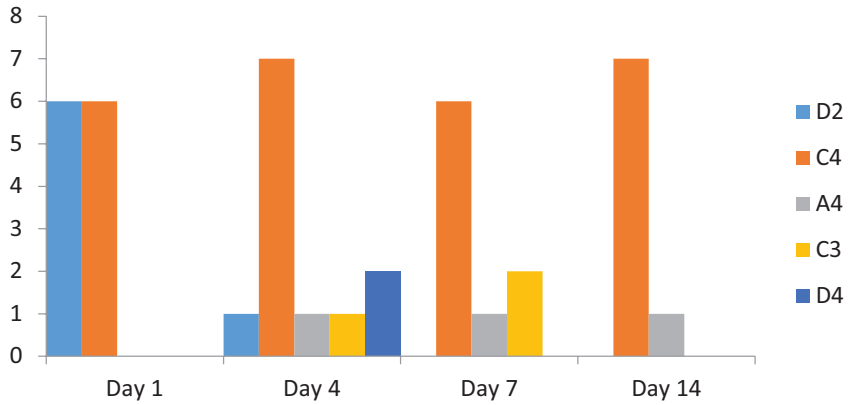

Figure 17. Protemp II with initial color **D2,** measured with SpectroShade.

apparatus on day 1 showed the following results: all specimens immersed in Coca-Cola, tea and natural juice retained their original color, while those in coffee and red wine stained to C4. On day 4, the natural juice stained to D4, and the tea – to A4. On day 7, Coca-Cola and natural juice darkened the specimens to B4. On day 14, a change was observed only in tea, which had already stained the samples not only up to A4 but also up to C4 **(Fig. 17)**.

Protemp IV material also displays specimens of initial D2 color in the cutting edge area measured with a SpectroShade apparatus. At the end of the study period, the red wine solution was found to colour to C4 and natural juice and Coca-Cola – to B4.

Color B3

In the area of the cutting edge, samples of Protemp II material of initial B3 color measured with a Vita EasyShade apparatus on day 1 showed the following results: the original color was retained with the specimens in the Coca-Cola, tea and natural juice solutions, and in the coffee and red wine solutions it changed to C4. On day 4, changes were observed only in the tea staining samples up to A3.5 and A4 and in natural juice staining up to A3.5 and B4. On day 7, two of the specimens in the Coca-Cola solution darkened to B4 and A4, and in the tea those with A4 color already prevailed over A3.5. At day 14, data were retained with changes in natural juice only up to B4 **(Fig 18)**.

Color B4

Protemp IV specimens of B4 initial color in the cutting edge area measured with Vita EasyShade gave the following results on day 1: For Coca-Cola and natural juice colorants, we have a primary preservation of the original colour. For coffee, all were colored to C4, and for red wine – to C4 and A4. On day 4, the red wine specimens were almost entirely C4, and the tea was colored up to A4. On day 7, the specimens immersed in the Coca-Cola were fully A4. In the case of coffee, red wine and natural juice, there was no change from the previous measurement. On day 14, only one of those stained with tea darkened to C4, and no changes were observed in the others **(Fig. 19)**.

The SpectroShade apparatus also found an initial B4 color in some of the Protemp IV specimens. On day 1, the results showed that all samples immersed in wine were colored to C4 and those dipped in coffee – to C4 and A4.

Almost all specimens immersed in Coca-Cola and natural juice retained their original color, the tea staining to C3. On day 14 of the study, all samples immersed in coffee, wine and most of those in tea were already C4. Coca-Cola and natural juice specimens retained their initial color **(Fig. 20)**.

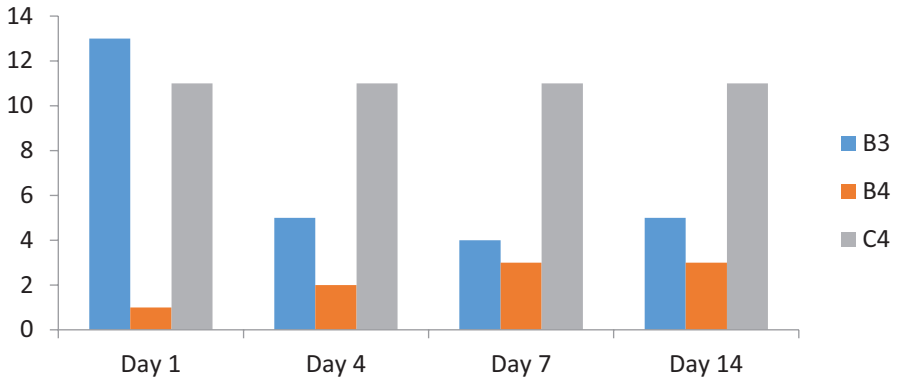

Figure 18. Protemp II with initial color B3, measured with Vita EasyShade.

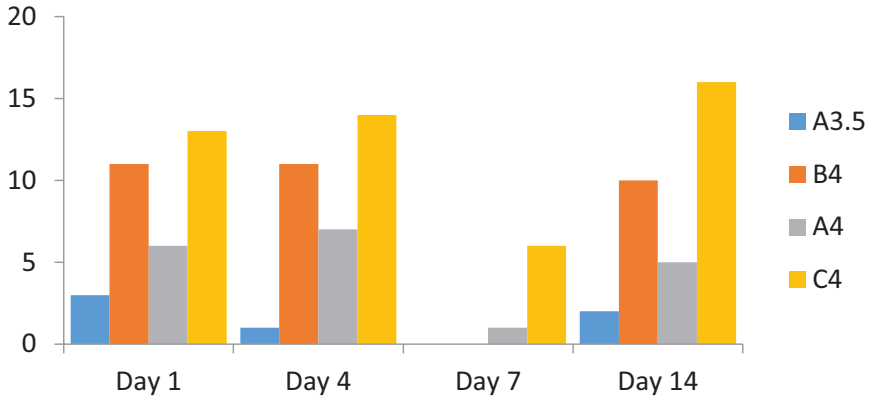

Figure 19. Protemp IV with initial color B4, measured with Vita EasyShade

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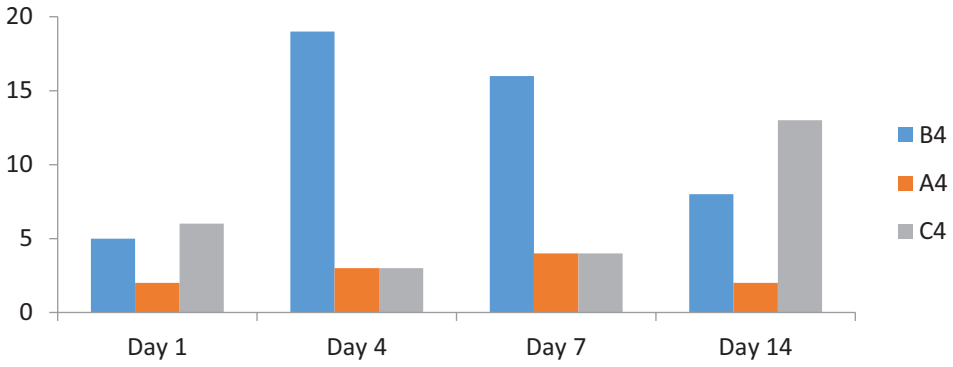

Figure 20. Protemp IV with initial color B4 measured with SpectroShade

DISCUSSION

The initial measurement of all test specimens prior to their treatment with colorants from all zones and apparatus summarized that the most common colors were D2, B3 and B4, although the manufacturer noted A3 on the package. There is a difference in the colours in the three zones of the tooth, which is explained by the fact that the material in them is of different thickness and the light passes through them differently. It was important for us to prove the zonal distribution of colors through individually created matrices in order to trace and color the temporary crowns in zones independently of one another.

Comparing data from the two Protemp materials, it was found that fewer Protemp IV test specimens reached C4 and A4 color on day 7. It follows that it shows greater color stability than Protemp II during this period. On day 14, the results of the two materials are very similar, which means that with the long stay and the influence of the strong colouring solutions, the stability of the material is significantly reduced. As the days of stay increase, the color change becomes more noticeable and the stability less significant.

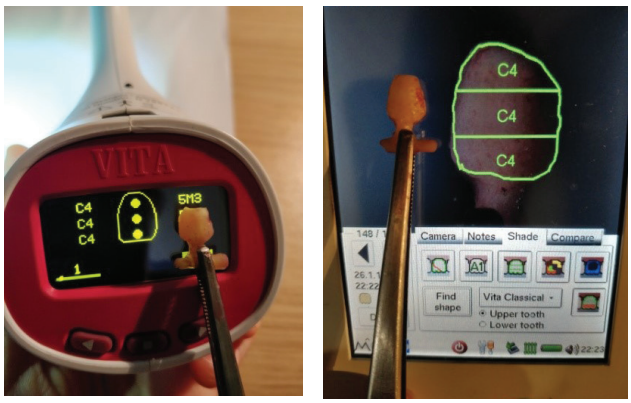

Figure 21. Data from the two devices at day 14 from Protemp II stained with red wine.

Comparing the results of 7 days of staining in the three zones, we came to the conclusion that approximately the same number of specimens in the cervix, body and cutting edge darken to C4. There was a slight predominance in the body area (42%) followed by the cervix (39%) and the cutting edge (36%). This can be explained by the thicker layer of material in this zone, which imbibes the colorant more.

The aforementioned results from both devices (Vita EasyShade and SpectroShade) summarized for all tooth areas prove that coffee and red wine have the most pronounced colouring effect on both materials for temporary restorations **(Fig. 21)**.

Unlike the others, these colouring solutions mainly achieve color C4, which is visible on the first day of the study. They are followed by tea, which also achieves color C4, but after a longer stay in the solution. From Coca-Cola and orange juice, the color change is smaller – it reaches color B4.

CONCLUSION

By examining the temporary crowns by area, we can more accurately compare the changes in colour, guided by the anatomical shape of the teeth. Based on this study, the strong colouring effect of coffee and red wine on these restorations was demonstrated. Frequent use of these leads to permanent color changes that violate the aesthetics, which should be taken into account in a prosthetic treatment. Also important is the selection of material for temporary crowns, which, in addition to being robust and with good marginal adaptation, should also be stable in colour until it is replaced by permanent construction. As a result of our research, we can conclude that Protemp IV material is more in line with these criteria.

Acknowledgements

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REFERENCES

1. Gratton DG, Aquilino SA. Interim restorations. Dent Clin North Am 2004; 48(2):vii, 487–97.
2. Lodding DW. Long-term esthetic provisional restorations in dentistry. Curr Opin Cosmet Dent 1997;4:16–21.
3. Perry RD, Magnuson B. Provisional materials: key components of interim fixed restorations. Compend Contin Educ Dent 2012; 33(1): 59–60, 62.
4. Pustina-Krasniqi T, Shala K, Staka G, et al. Lightness, chroma, and hue distributions in natural teeth measured by a spectrophotometer. Eur J Dent 2017; 11(1):36–40.
5. Brewer JD, Wee A, Seghi R. Advances in color matching. Dent Clin North Am 2004; 48(2): 341–58.
6. Liberato WF, Barreto IC, Costa PP, et al. A comparison between visual, intraoral scanner, and spectrophotometer shade matching: A clinical study. J Prosthet Dent 2019; 121(2): 271–5.
7. Pustina-Krasniqi T, Xhajanka E, Ajeti N, et al. The relationship between tooth color, skin and eye color. Eur Oral Res 2018;52(1):45–9.
8. Joiner A. Tooth colour: a review of the literature. J Dent 2004;32(1): 3–12.
9. Brook AH, Smith RN, Lath DJ. The clinical measurement of tooth colour and stain. Int Dent J 2007;57(5):324–30.
10. Chiche G. Color planing. SDK and NUS. 2011;1:7–9.
11. Vadher R, Parmar G, Kanodia S, et al. Basics of color in dentistry: a review. journal of dental and medical sciences. 2014; 13(9)I: 78–85.
12. Chang JY, Chen WC, Huang TK, et al. Evaluating the accuracy of tooth color measurement by combining the Munsell color system and dental colorimeter. Kaohsiung J Med Sci 2012; 28(9):490–4.
13. Parameswaran V, Anilkumar S, Lylajam S, et al. Comparison of accuracies of an intraoral spectrophotometer and conventional visual method for shade matching using two shade guide systems. J Indian Prosthodont Soc 2016;16(4):352–8.
14. Jarad FD, Russell MD, Moss BW. The use of digital imaging for colour matching and communication in restorative dentistry. Br Dent J 2005; 199(1):43–9.
15. Manchorova N, Tsanova M, Mateva N. A comparative study of digital and conventional methods for color measurement. Dental Magazine 2015; 3: 28–32.
16. Igiel C, Lehmann KM, Ghinea R, et al. Reliability of visual and instrumental color matching. J Esthet Restor Dent 2017; 29(5):303–8.

Лабораторное исследование цветостойкости различных типов материалов для временных реставраций

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Резюме

Введение: Временная реставрационная конструкция служит для предварительного представления типа и внешнего вида будущей постоянной реконструкции, которая изготавливается в соответствии с требованиями пациента. Как и любая протезная конструкция, она должна отвечать функциональным требованиям, сохранять или улучшать жевательную и речевую функцию. Независимо от того, насколько хорошо поддерживается данная профилактическая и функциональная протетичская структура, она не будет оценена пациентом в том случае если не восстановит существующую форму, размер и цвет естественных зубов.

Цель: Определить инструментально, в какой степени разные красители меняют цвет временных конструкций.

Материалы и методы: Были испытаны два типа временного восстановительного материала – Protemp II и Protemp IV, из которых было изготовлено общее количество из 100 пробных образцов. Хранящиеся в одинаковых условиях при комнатной температуре и без прямого доступа солнечного света, они подвергались воздействию пяти красящих растворов по 100 мл – кока-колы, кофе (эспрессо), ягодного чая, апельсинового сока и красного вина в пяти отдельных контейнерах. Изменения цвета измеряли в трёх областях зуба с использованием двух спектрофотометрических приборов – Vita EasyShade и SpectroShade через разные промежутки времени – непосредственно перед помещением в окрашивающий раствор, в дни 1, 4, 7 и 14.

Результаты: Результаты были проанализированы с использованием SPSS (SPSS Inc., IBM SPSS Statistics) версии 21.0. Они были преобразованы в текстовый файл с конвертером из той же программы. В гипотетическом исследовании стандартное значение $p \leq 0.05$ было выбрано для уровня значимости, что опровергает нулевую гипотезу.

Заключение: На основании этого исследования было показано окрашивающее воздействие кофе и красного вина на эти реставрации. Можно прийти к заключению, что материал Protemp IV показал лучшую цветостойкость по сравнению с Protemp II.

Ключевые слова

цветостойкость, устройства подбора цвета, временная коронка