COMPARATIVE ANALYSIS OF COLOUR CHARTS AND SPECTROPHOTOMETRICAL STUDIES IN DENTAL PRACTICE

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Abstract: Introduction: Difficulty in matching the hue of prosthetic restorations with that of the patient's natural teeth and failure to achieve the desired esthetic effect particulary regarding fixed partial dentures result from clinical, technical and environmental conditions.
Objectives: The objective of this study was (1) to determine whether the use of colour charts might cause the wrong colour match of fixed dentures and (2) to suggest the use of spectrophotometrical method that would eliminate or reduce obstacles to achieving proper esthetics.
Results: Differences in perception of chart colours and dental materials were determined according to the Weber-Fechner principle (according to the mean values of sensitivity of human`s eye). The threshold of sensitivity of human`s eye is constant for all the points of colour space and equels 1.7 of L*a*b* units.
Conclusions: Prosthetic materials used for temporary crowns have tendency to discolour much greater then the sensitivity of human`s eye. The results of measurement showed the usefulness of this apparatus.and method to precise shade matching of dental materials to the natural teeth of the patients. This method is an objective method and independent on the visual perception of dentist and dental technician. It allows also for achieve better results than the method based on the visual shade matching of the tooth according to dental charts.

Introduction

Difficulty in matching the hue of prosthetic restorations with that of the patient's natural teeth and failure to achieve the desired esthetic effect particularly regarding fixed partial dentures result from clinical, technical and environmental conditions.

Dental materials show various tendency to discoloration and often cause the patient`s serious esthetic discomfort. Esthetics of any restoration depends on outline form, translucency and colour. One of the most challenging aspects of esthetic dentistry is colour matching and its durability.

The perception of light or elements subjected to light is connected with the subjective reception of visual sensations. The perception of colour, that is light of varying spectral composition, may cause the same visual sensation.

It is commonly known that light can be absorbed, reflected, transmitted and dispersed by the object.

The colour is described in 3-dimensional coordinate system of value (lightness, brightness), dominant hue and chroma (saturation). Hue refers to the dimension of colour that distinguishes one family of colour from another (red, blue yellow and so on). Value describe the dimension of colour that denotes relative blackness or whiteness/brightness. Chroma is the dimension that describes the saturation, intensity or strenght of hue.

At present there are two methods of colour description in the CIE system of the International Commission on Illumination (Commission Internationale de l`Eclairage – C.I.E.)

The first method CIE (X, Y) involves three-dimensional colour triangle. The second most common method – CIE (Lab) involves the use of geometrical solid (ball of colour). The CIE system incorporates a standard observer and light source. The international CIE (Lab) system is usually used for describing parameters of colour.

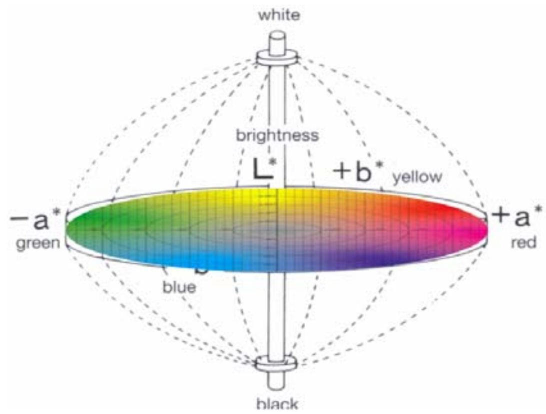

Figure 1: The international C.I.E. (L*a*b*) system

The L axis represents the darkness and lightness coordinate, with values ranging from 0, for perfect black to 100, for perfect white. The values of a* and b* are the chromaticity coordinates in red-green axis and yellow-blue axis, respectively.

Positive a* values (+100) indicate the red colour range and negative values (-100) the green colour range. Similarly, positive b* values (+100) indicate the yellow colour range, whereas negative values (-100) indicate blue colour range.

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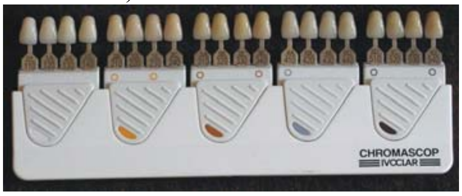
The horisontal colour planes describe hue and chroma of CIE Lab system. Colours are purest at the periphery of the wheel and become progressively grayer as they approach the central achromatic L axis. The nearer the L axis the smaller chromaticity.

Objectives: The objective of this study was to determine whether the use of colour charts might cause the wrong colour match of fixed dentures and objective estimation of the colour durability of prothetic materials used for temporary crowns subjected to various environmental conditions resulting from the patient's diet.

Materials and Methods

Common colour charts of two companies producing dental materials for fixed dentures (three charts from each manufacturer) were studied.



A

B

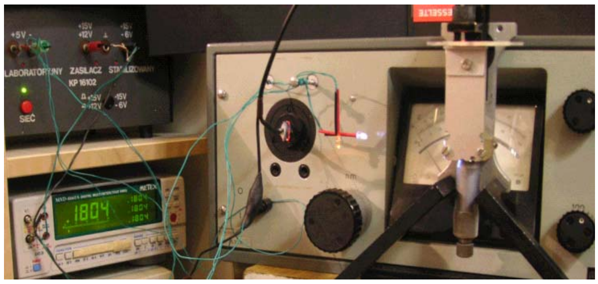
Figure 1: Colour charts (shade guides): a) Chromascop, b) Vita.

This study investigated also the following materials used for temporary fixed dentures: Luxatemp (DMG), Structur 2 SC (VOCO), Protemp II (ESPE), Zhermacryl STC (Zhermapol), Dentalon plus (Heraeus Kulzer). The samples of 1mm thickness and 5mm diameter were based on the earier prepared model.

The previously prepared samples of materials were exposed to the experimental (standardised) liquids such as: tea, coffee and juice of dark fruits over different periods of time and at various pH. Fig. 2. shows laboratory instruments which consist of microcomputer pH meter and vessels collection used for preparing the proper solutions and to control pH of this solutions.

Figure 2: Laboratory pH-meter and vessels collection

The colour characteristics were estimated using a light spectrophotometer (Fig. 3a) (model Specol, Carl Zeiss) with a special fibre optic device designed for photometric measurements As you see at the figure 3b the samples were placed on the special table provided with micrometric screw.



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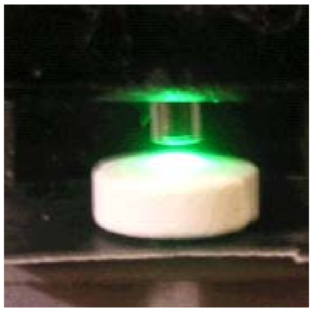

B

Figure 3a, b. Spectrophotometer with optic device.

It allowed to achieve the same distance beetwen the sample and fibre optic device.

Monochromatic coefficients of light ρ (λ) reflecting from the samples were directly measured and the spectrum of them was obtained. The data of: the spectral sensitivity of human eye- V(λ) to two kinds of illuminations: day-light (D65) and artificial light (A) for a standard CIE 31 observer allowed calculating the colour coordinates in the CIE L*a*b* colour space.

Artificial light emits more red light, whereas spectrum of day-light is more uniform.

The samples placed in didestilate water were designated as the trial group.

All the results of mesurements were compared to the international standard.

Results

Differences in perception of chart colours and dental materials were determined according to the Weber-Fechner principle (according to the mean values of sensitivity of human`s eye). The threshold of sensitivity of human`s eye is constant for all the points of colour space and equels 1.7 of L*a*b* units. The analysis of measured parameters on figures show the positions of those chart colours that were the most similar in natural and artificial light. It was also proved that selecting a tooth colour using colour charts may involve

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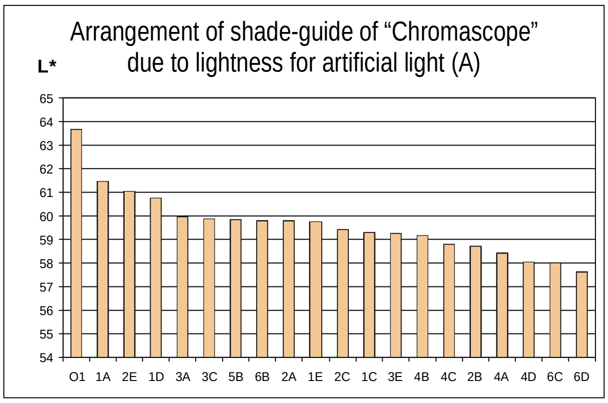
uncertainly regarding two or even three different chart teeth (colour samples).



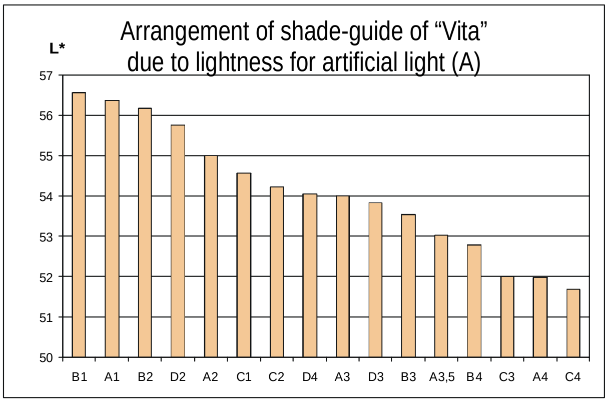
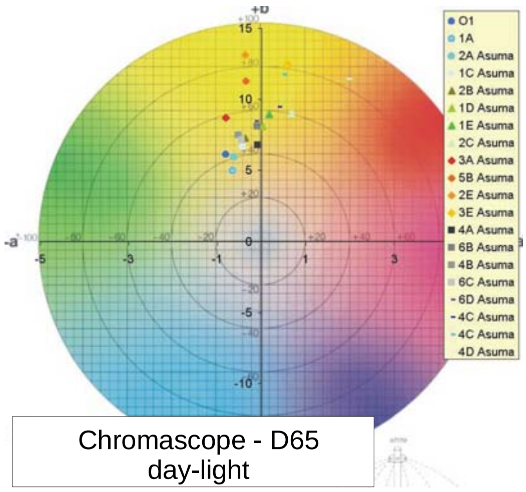


Figure 4. Arrangement of shade-guides due to lightness for artificial light.



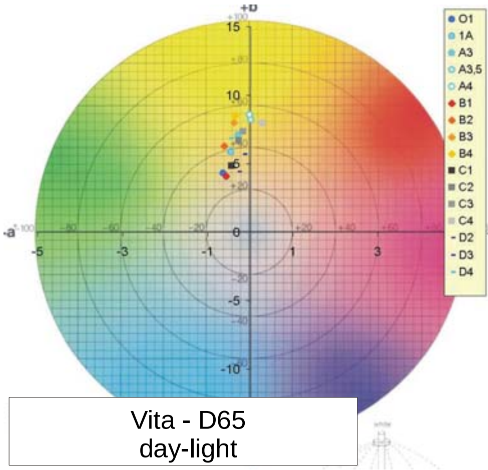


Figure 5. a* and b* parameters diagram for examinated shade-guides.

Shade-guides Chromascope uses wider range of hue and chroma in compare to Vita shade-guide. Vita shade-guide show better arrangement of colour a* and b* parameters than Chromascope.

Examination of dental materials

The Fig. 6 show the example parameters a* and b*changed when the material Protemp placed in juice after 60 h for various pH and for two kinds of illuminations: a) day-light (D65) and b) artificial light (A).

Red point represents start of process, whereas other points show the final discoloration of Protemp.

After 60 hours time the greatest colour change was observed for the samples placed in juice for pH equels 4.

Moreover, the samples of Protemp tend to become more red in artificial light, whereas they become more yellow in day-light.

The greater changes of a* and b* parameters were observed for artificial light than for day-light.

Discoloration process of dental materials is characterised by logarytmic functions of time, and was pH dependent.

Both figures show decreasing the value (brightness) process of Protemp material as a function of time for various pH of juice.

The greatest changes of brightness are observed for pH = 4 solution.

For pH=8 there were registered only small changes of L* parameter.

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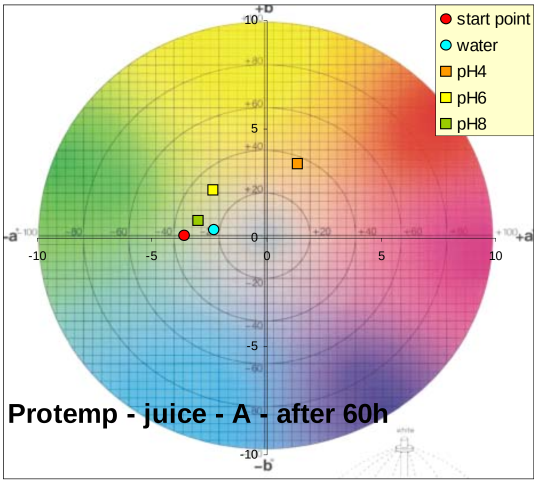


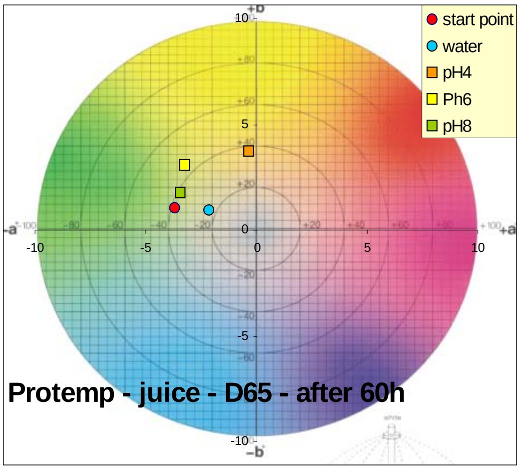


Fig. 6. Parameters a* and b* changed when the material – Protemp was placed in juice after 60h, for various pH and for two kinds of illuminations: a) artificial light (A), b) day-light (D65).

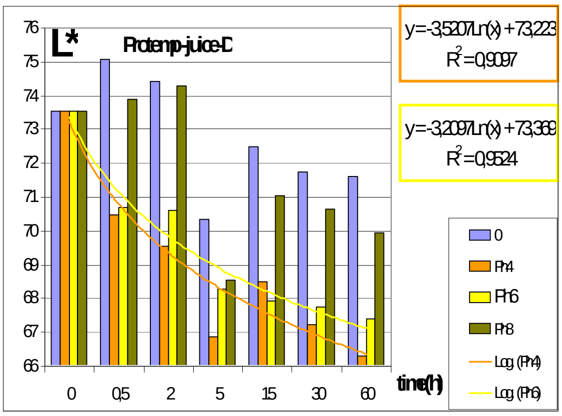
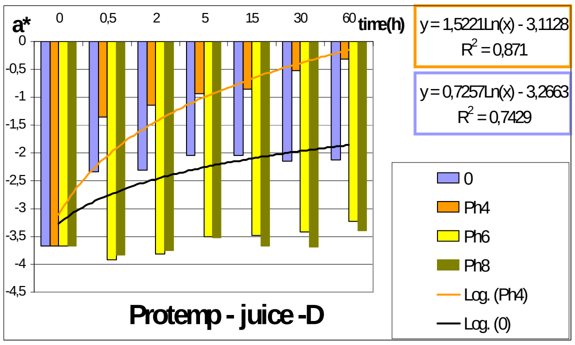


Fig. 7. Discoloration process is characterised by logarythmic functions of time, and was pH dependent (L* - brightness)

Hue and chroma are described by a* and b* parameters (Fig. 8).

Increasing of parameter a* shows redness, whereas increasing b* parameter yellowness of the materials.

For pH=8 there were no registered changes of discoloration for parameters a* and b*.



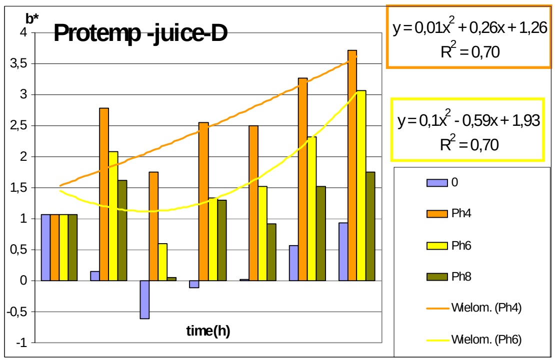


Fig. 8.

The greatest discoloration is observed for solution pH =4.

The following factors were found to affect the colour of the tested dental materials:

– tea
– coffee
– juice of dark fruits

Table shows the changes of L* parameter (lightness) for materials placed in juice of dark fruits, coffee and tea for day-light and artificial light after 60 hours at the range of 4,6,8 pH and for didestilate water.

Table 1. Discoloration for all the material (lightness).

JUICE	Protemp	Zhermacr	Dentalon	Luxatemp	Structur	JUICE	Protemp	Zhermacr	Dentalon	Luxatemp	Structur
D65-60h	ΔL*	ΔL*	ΔL*	ΔL*	ΔL*	A-60 h	ΔL*	ΔL*	ΔL*	ΔL*	ΔL*
H2O	-0,57	-3,73	-0,53	-2,94	-2,36	H2O	-0,45	-3,59	-0,41	-2,83	-2,52
pH4	-7,24	-10,22	-8,37	-5,96	-10,71	pH4	-6,76	-9,86	-8,19	-5,74	-10,23
pH6	–6,14	-6,21	-7,84	-7,39	-9,86	pH6	-5,97	-6,09	-7,73	-7,14	-9,62
pH8	-3,62	-5,17	-5,30	-4,87	-5,32	pH8	-3,55	-5,04	-5,26	-4,67	-5,06
COFFEE						COFFEE					
H2O	-0,55	-3,72	-0,61	-2,78	-2,63	H2O	-0,44	-3,69	-0,47	-2,65	-2,49
pH4	-3,69	-3,85	-2,34	-6,72	-15,19	pH4	-3,25	-3,49	-2,09	-6,35	-14,52
pH6	-1,51	-1,72	-5,43	-4,76	-11,54	pH6	-1,22	-1,41	-5,21	-4,53	-10,94
pH8	-1,38	-1,69	-2,91	-6,97	-10,36	pH8	-1,03	-1,54	-2,79	-6,65	-9,80
TEA						TEA					
H2O	-0,59	-3,90	-0,57	-2,85	-2,56	H2O	-0,58	-3,79	-0,43	-2,75	-2,40
pH4	-9,46	-5,11	-6,61	-3,92	-6,09	pH4	-8,82	-4,49	-6,32	-3,54	-5,40
pH6	-7,58	-6,51	-4,99	-5,61	-2,40	pH6	-7,16	-5,96	-4,76	-5,10	-1,96
pH8	-6,02	-6,11	-5,06	-4,59	-5,02	pH8	-5,74	-5,75	-4,89	-4,28	-4,64

 ISSN: 1727-1983

The darker area denotes the greater discoloration of material toward decreasing of their lightness.

The samples placed in juice revealed the greatest discolorations among the tested factors.

Luxatemp and Structur darken more when placed in coffee, whereas Protemp, Zhermacryl and Dentalon are more susceptibility to tea.

Hue and chroma differences after 60 hours are represented by both Δa* and Δb*.

Table 2. Changes of a* and b* parameters for all materials.

JUICE	Protemp	Zhermacr	Dentalon	Luxatem	Structur	Protemp	Zhermacr	Dentalon	Luxatem	Structur
A-60 h	Δa*	Δa*	Δa*	Δa*	Δa*	Δb*	Δb*	Δb*	Δb*	Δb*
H2O	0,66	0,85	1,07	1,17	0,81	1,32	1,72	1,37	3,29	2,45
pH4	4,91	2,93	1,75	1,73	3,81	3,33	3,32	1,25	2,38	4,98
pH6	1,25	0,87	1,47	1,61	2,29	2,10	1,48	0,39	3,74	3,37
pH8	0,60	0,80	0,21	0,97	1,55	0,72	1,73	0,95	3,31	3,75
COFFEE										
H2O	0,69	0,94	1,08	1,13	0,73	1,41	1,62	1,43	3,40	2,15
pH4	2,43	2,12	1,39	1,87	3,27	6,50	5,00	3,79	6,00	11,49
pH6	1,57	1,60	1,05	1,20	2,95	4,31	3,63	4,01	3,81	10,07
pH8	2,53	0,87	0,61	1,52	3,10	4,37	2,22	2,06	5,39	8,48
TEA										
H2O	0,64	0,58	1,01	1,10	0,83	1,25	1,58	1,40	3,33	2,23
pH4	3,93	3,91	1,95	2,02	3,97	8,48	8,16	3,80	5,81	10,45
pH6	2,64	3,67	1,76	2,83	2,66	5,86	6,94	2,40	7,88	6,20
pH8	1,78	3,89	1,19	1,68	2,05	3,71	0,73	2,24	5,11	5,85

Table 2 shows the changes of a* and b* parameters for all measured materials illuminated by day-light.

The darker area denotes the greater discoloration of material.

Discoloration process of all the materials tends mainly to yellowness indicated by Δb*. Redness indicated by Δa* parameter is only slightly significant.

The less discoloration is observed for Dentalon placed in all the tested liquids for all pH.

The greater discoloration show all the other materials especially placed in coffee and tea.

One can say that coffee and tea are the most discoloration factors but only for hue and chroma, just like juice is the most discoloration factors for brightness.

The changes of parameters a* and b*for artificial light (A) are similar to the changes observed in day-light, however they are slightly greater .

Conclusions

Prosthetic materials used for temporary crowns have tendency to discolour much greater then the sensitivity of human`s eye. The results of measurement showed the usefulness of this apparatus and method to precise shade matching of dental materials to the natural teeth of the patients.

Time dependent changes of colour investigated in our study allow forecasting a proper colour match in dental practice.

This method is an objective method and independent on the visual perception of dentist and dental technician. It allows also for achieve better results than the method based on the visual shade matching of the tooth according to dental charts.

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