Effect of Dehydration Time on Tooth Colour Measurement *in vitro*

Ruo Xi DU[1], Yi Ming LI[2], Jian Feng MA[1]

Objective: *To investigate the effect of dehydration time on tooth colour measurement in vitro using colourimetry.*

Methods: *Ten extracted human maxillary central incisors were used. L*a*b* values at the centre of the labial surface of each tooth were measured using a colourimeter. The first measurement was performed after removal of excess water. The second and third measurements were performed after the teeth had dried at room temperature for 2 h and 4 h, respectively. The colour differences (ΔE) between dehydration time points were calculated. Repeated one-way ANOVA was performed for colour values at different dehydration time points. Pairwise comparison of group means (Student t test) was used to examine the differences between ΔE and 1.5ΔE (α = 0.05).*

Results: *There were statistically significant changes in the L* values after 2 h and 4 h dehydration as well as between each ΔE and 1.5ΔE. Neither 2 h nor 4h dehydration resulted in change of a* value or b* value.*

Conclusion: *Dehydration time affected colour measurement using a colourimeter; the teeth become lighter after dehydration for 2 h or longer.*

Key words: *colour measurement, dehydration, tooth, colour difference, colourimeter*

Tooth colour is an important element in aesthetic dentistry. Uncoordinated tooth colour can have a greater negative impact on overall perception of dental aesthetics than other factors. Patients demand a natural appearance for dental restorations; consequently many efforts have been made to investigate the colour matching ability of modern aesthetic restorative materials. According to dentists and technicians, colour matching and selection is always the most important challenge in such a process.

Human perception of colour relies on light, a reflective surface and the observer's eyes and brain. The colour of an object is the perception of light reflected or scattered from its surface. There are three primary colours of light: red, blue and green. Colour can also be described according to the Munsell colour space in terms of hue, value and chroma[1]. Hue is the name of a colour, such as red, yellow, green, blue and purple. Value is the lightness or darkness of the hue, ranging from pure black to pure white. Chroma is also described as the saturation or intensity of the colour.

Although shade guides are still the most popular aid to colour evaluation in the dental clinic, they are gradually being replaced by instrumental measurement, which is objective and more accurate and reliable[2,3]. However, the disadvantages and limits of instrumental measurement also should be recognised. General variables such as the inherent properties of teeth and the conditions under which the shade assessments are conducted can also affect instrumental colour measurement. In a study on the effects of dehydration on brittleness and toughness of human dentine, dehydration resulted in decreased strain at fracture and brittle behaviour[4].

1 School and Hospital of Stomatology, Wenzhou Medical College, Wenzhou, Zhejiang Province, P.R. China.

2 Center for Dental Research, School of Dentistry, Loma Linda University, Loma Linda, California, USA.

Corresponding author: Dr Jian Feng MA, School and Hospital of Stomatology, Wenzhou Medical College, #113 Xueyuan Xi Road, Wenzhou, 325027 Zhejiang Province, P.R. China. Tel: 86-577-88063033; Fax: 86-577-88855488; E-mail: Dentistmacn@yahoo.com.cn

Fig 1 Position guidance setup.

The aim of this *in vitro* study was to use colourimetric analysis to investigate the effect of dehydration and drying time on tooth colour.

Materials and methods

Ten extracted human maxillary central incisors were selected. These teeth were extracted because of periodontitis (approved by the Ethics Committee of Wenzhou Medical College). The criteria for tooth selection were: normal anatomical shape and no apparent defects, restorations, staining, excessive abrasion or caries on the labial surfaces. The Minolta Chroma Meter CR-321 (Konica Minolta, Tokyo, Japan) was used in this study. It provides a measuring area of 3 mm in diameter, with 45 degrees/0 degree optical geometry.

The study was conducted in a dark room. The distance between the palatal surface of the teeth and the unglazed paper plate background was 1 cm. The teeth were kept moist in a container with saline. Before the experiment, the Minolta Chroma Meter CR-321 was calibrated using a normal white plate. Recalibration was performed during colour measurements as needed. During colour measurements, the detecting head was kept in contact with the observation site using a position guidance setup (Fig 1)[5]. L*a*b* values at the centre of the labial surface of each tooth were measured.

The first measurement was performed just after excess water was removed with filter paper. The teeth were then allowed to dry at room temperature. The second and third measurements were performed after the teeth had dried for 2 h and 4 h, respectively. A total of three measurements were made at each location; the detecting head was turned 90 degrees clockwise after each measurement. The teeth were fixed in a plane, in such way that the contiguous relationship was similar to the alignment of teeth in the oral cavity. Care was taken to preserve the integrity of the enamel of the teeth.

The CIELAB system was used to record the colour data. CIELAB defines a colour space (L*a*b*), in which L* represents lightness, a* represents the chromaticity coordinate for red–green (+a* = red direction; –a* = green direction), and b* represents the chromaticity coordinate for yellow–blue (+b* = yellow direction; –b* = blue direction)[6]. The colour difference (ΔE) between two dehydration times was calculated using the following equation[7]:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}.$$

where $\Delta L^* = L_1^* - L_2^*$, $\Delta a^* = a_1^* - a_2^*$, $\Delta b^* = b_1^* - b_2^*$; subscripts 1 and 2 indicate different dehydration times.

Data were analysed using SPSS version 13.0 (Statistical Package for Social Science, SPSS Inc, Chicago, IL, USA). Repeated one-way analysis of variance (ANOVA) was carried out using the mean colour values at different dehydration times. The colour difference 1.5ΔE was considered the perceptibility threshold[8]. Pairwise comparison of group means (Student t test) was used to examine the differences between mean values of ΔE and 1.5ΔE. For all analyses, $P < 0.05$ was considered statistically significant.

Results

The changes in CIELAB parameters following dehydration are presented in Table 1. L* values were significantly higher ($P = 0.000$) after drying 2 h and 4 h compared with the baseline. However, L* value between 2 h and 4 h groups was not different ($P > 0.05$); a* and b* values were not affected by dehydration time ($P > 0.05$).

The ΔE values between different dehydration time points were shown in Table 2. Compared with 1.5ΔE, each ΔE was significantly different from 1.5ΔE after any dehydration time ($P < 0.05$).

Discussion

Dehydration affects brittleness and toughness of human dentine[4]. This study has demonstrated that dehydration can also affect the CIELAB results.
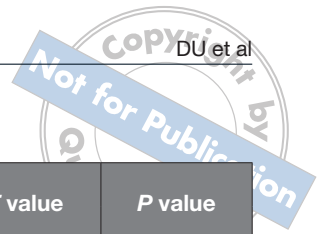
Table 1 The effect of dehydration time on CIELAB values for maxillary central incisors

	Dehydration time (mean ± SD)			Sum of squares	Mean square	*F* value	*P* value
	0 hour	2 hours	4 hours				
L*	53.00 ± 2.26	57.39 ± 2.85	57.34 ± 2.85	127.443	127.443	45.943	0.000
a*	−2.04 ± 0.21	−2.16 ± 0.44	−2.26 ± 0.55	0.245	0.245	2.455	0.143
b*	2.28 ± 1.49	2.31 ± 1.80	2.24 ± 1.89	0.029	0.029	0.024	0.880

Table 2 The colour difference (ΔE) between two dehydration time points and the results compared to 1.5ΔE

	ΔE (mean ± SD)	Degrees of freedom	*P* value
Between 0 and 2 hours	4.56 ± 2.12	9	0.008
Between 0 and 4 hours	4.53 ± 2.05	9	0.007
Between 2 and 4 hours	0.35 ± 0.20	9	0.024

L* represents lightness as to value in the Munsell system. The results indicated that after 2 h and 4 h dehydration, the value of L* had increased. However, L* did not increase further after 2 h. The a* and b* represent the chroma in the Munsell system. There was no significant difference in chroma regardless of how long the teeth were dried. The increase in the L* values or lightness may be accounted for by increased reflectance of light. With the loss of moisture, transparency decreases and thus the lightness increases. After 2 h dehydration, the surface of dental enamel contained hardly any water. Therefore, little change of CIELAB was detected between 2 h and 4 h dehydration.

The minimum colour difference that can be perceived by the naked eye is 1.5ΔE[8]. In the results of the study, each ΔE was significantly different from 1.5ΔE, after both the 2 h and 4 h dehydration periods. Consequently the colour change after dehydration could be detected by a naked eye. Attention has to be paid to ensure that colour measurements are taken as quickly as possible or the data could be affected by further dehydration.

In a future study, the research will be repeated using dehydration time points less than 2 h, to see if the CIELAB result is affected in a shorter time.

Conclusions

Dehydration time can affect colour measurement using a colourimeter. Teeth are brighter after dehydration, and the colour difference can be noticed by the naked eye. Colour measurements should be taken as quickly as possible, otherwise the accuracy of the colour can be affected by continued enamel dehydration.

References

1. Munsell AH. A Color Notation, ed 11. Baltimore: Munsell Color Company Inc., 1961:15.
2. Fani G, Vichi A, Davidson CL. Spectrophotometric and visual shade measurements of human teeth using three shade guides. Am J Dent 2007;20:142–146.
3. Li Y. Tooth color measurement using Chroma Meter: Techniques, advantages, and disadvantages. J Esthet Restor Dent 2003;15(suppl 1):33–41.
4. Jameson MW, Hood JA, Tidmarsh BG. The effects of dehydration and rehydration on some mechanical properties of human dentine. J Biomech 1993;26:1055–1065.
5. Ma J, Du R, Wang S et al. Effects of background, direction and intensity of ambient light, measuring position, and adjacent teeth, on anterior tooth colour measurement in vitro. Chin J Dent Res 2010;13:147–152.
6. Wee AG, Lindsey DT, Kuo S et al. Color accuracy of commercial digital cameras for use in dentistry. Dent Mater 2006;22:553–559.
7. Jarad FD, Russell MD, Moss BW. The use of digital imaging for color matching and communication in restorative dentistry. Br Dent J 2005;199:43–49.
8. Terada Y, Himeno T, Hirayasu R. Chromatic studies of porcelain veneered crown. (Part 1). Application of wire explosion spraying technique. Dent Mater J 1987;6:90–95.