Increased Predictability in Tooth Shade-Matching

Kelvin I. Afrashtehfar, DDS, MSc(C)

FOUNDATION OF ESTHETIC DENTISTRY

Cosmetic and esthetic dental outcomes are essential to meet patients' high expectations and positively influence their self-esteem.[1,2] Shape and color determine the aesthetics of both natural and restored teeth.[3-6] Attractive restorative and prosthodontic outcomes begin with a consistent buccal shape and silhouette that reflect light.[7] The perceived color of natural teeth depends on the illuminating light source, critical to translucency, opalescence and fluorescence.[8,9]

Selecting the appropriate shade-matching color has many clinical applications: porcelain and composite restorations, removable prosthetic teeth and gingival components. Determining a precise shade is dependent on clinical skill, shade guide system and lighting conditions. This paper reviews some of the significant factors in the process of tooth shade matching and benefits of modern light correcting techniques.

ESSENTIALS OF COLOR CONCEPTS

According to the Glossary of Prosthodontic terms[10], color can be defined as 'the quality of an object or substance with respect to light reflected or transmitted by it. Color is usually determined visually by measurement of hue, saturation, and luminous reflectance of the reflected light.'

The three components of color are: light source (illuminates the object), object (reflects, absorbs or transmits the incident light to the observer) and the observer (perceives the reflected light).[11–13]

For indirect cases, the clinician must convey the primary tooth shade characteristics of hue, chroma, and value to the technician who, in turn, produces restorations that match to the remaining dental structure.[14,15] *Hue* refers to the varying wavelengths of observed radiant energy (red, yellow, green, blue, purple, etc).[10] Approximately 80 percent of natural teeth fall into the A hue range.[16,17] *Chroma* describes the strength or saturation of the hue.[10] *Value*, lightness or brightness, distinguishes a color's relative darkness,[10] Value is often the most important dimension of shade.[18-20]

Natural teeth exhibit translucency, fluorescence and opalescence, all of which information is necessary for successful shade matching. *Translucency* is the gradient between transparent and opaque.[8] *Fluorescence* is the absorption of short wavelength light with the spontaneous emission of longer wavelength light.[21] *Opalescence* makes a material appear one color with reflected light and another color with transmitted light.[22]

TOOLS FOR TRANSMISSION OF TOOTH SHADE COLOR

The traditional technique for shade matching is the visual alignment of natural teeth with a shade guide tab. The commonly available shade guides are the standard dental shade-matching instruments.[23,24] Computerized spectrophotometer and colorimeter devices use color quantification that generally provides a more accurate color-matching outcome. However, due to their high cost, these instruments are used more in research in practice.[15,25,26]

OPERATOR LIMITATIONS AFFECTING SHADE MATCHING

Shade matching ability varies with experience, age and individual degree of color perception (functional ganglion cell density and rod and cone photoreceptor morphology).[27,28]

Age. Images are perceived as more yellowish and brownish as eyes age.

Gender. It is commonly believed that women see color more accurately than men. However, there are many studies that show no gender difference.[29-35]

Experience. The issue of whether the accuracy of shade matching is innate or an acquired (learned) skill is unresolved. Many studies, interest-

FIGURE 1—Rite Lite 2 (Addent) A Tri-Spectra LED technology powerd by 12 LEDs activated accordingly for the desired light condition.

FIGURE 2—Initial daylight mode.

FIGURE 3—Shade matching conducted with a neutral pink background.

ingly, contradict the notion that experience is influential in shade matching.[30,31,33,36-39]

Eye color. Brown eyes, with more melanin, absorb wavelengths better,[40] possibly influencing sight but not color perception.

Astigmatism, hypermetropia and myopia. When these refractive errors are corrected with eyeglasses or contact lenses, their ability to influence shade-matching is insignificant.[41]

LIGHT SOURCE EVOLUTION
The most important factor in shade matching is the light source. Since natural light conditions vary, the recommended standard for dental shade matching is a color temperature of 5500°K and a color-rendering index (CRI) greater than 93.[42,43] The CRI measures the balance of all the visible wavelengths. Viewing teeth under diffuse illumination minimizes reflected light distortion.[21] A lowered light intensity makes fine details hard to see and complicates the perception of hue. The value guide is the first to be used[18-20,44] preferably with lower light levels (operator may squint) since this the best environment for determining value.[7,19] There is reliable evidence supporting the utilization of a corrected lighting source during tooth shade matching.[29-33,35,43,45]

In the United Kingdom, a study combining color-correcting devices with a digital recording device improved the success of matching dental shades when compared to the digital device alone under normal light condition.[29] It has been demonstrated that a standardizing daylight lamp significantly improves the ability to match colors when compared to natural daylight.[45] Shade matching performance under corrected light sources was significant better than natural or clinical light.[32] Even a low color-temperature illuminant notably improves color matching in vision deficient individuals.[46,47] Another study indicated that, overall, a light-correcting source creates the most beneficial environment for shade taking.[43] Ideally, both the clinician *and* the technician should operate under similar balanced, full-spectrum lighting conditions, creating closely adapted spectral reflectance curves (optical properties) of original and restoration. This offers a successful color match, with minimal metamerism.[48,49]

RITE LITE 2 TRI-SPECTRA SHADE MATCHING INSTRUMENT
This portable and wireless light-correcting device (Addent, Danbury CT) has been designed to assist chairside shade matching. The aluminum-clad device consists of a ring with a 3cm win-dow-hole (for viewing the patient's teeth) attached to an ergonomic handle. The ring contains 12 LEDs that illuminate the dentition equally from all directions to avoid glare, distortion, and direct reflections (Fig. 1). The brightness of the Rite Lite 2 eliminates the color distortion caused by the color of the dental chair, the operatory, and even brightly colored clothing. However, a color neutral grey or blue bib is still recommended. Six of the diodes are set at 5500°K, while the others produce 3200°K. Battery operated (2 AA cells) and lightweight (185g), the Rite Lite 2 can be used by any member of the dental team. If the battery level falls below the critical power required for full illumination, the device notifies the user.

The two sets of diodes offer three separate color temperature settings at the touch of a button:

• 5500°K (CRI of 92.2) is closest to natural daylight, and is considered the standard shade-matching environment. The six 5500°K LEDs are activated by pushing the button once.

• 3200°K simulates incandescent light. It is produced by the other 6 LEDs by pushing the button a second time.

• 3900°K represents a combined

FIGURE 4—Shade matching through photography is a great communication tool and is enhanced with the use of proper shade tabs and ideal lighting.
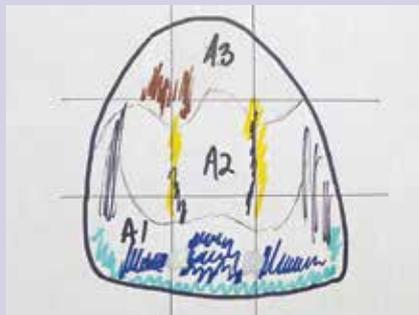

FIGURE 5—The facial surface of the tooth is divided into 9-16 distinct zones.

FIGURE 6—Shade tabs should be left in the guide while performing the shade matching to significantly increase shade accuracy.

incandescent-fluorescent indoor lighting. This light is produced when all 12 LEDs are activated by pushing the activation button a third time.

The 5500°K color temperature is a bright, sunny "outdoors" illumination. The other light settings mimic the indoor ambient illumination to which patients are exposed indoors. By color matching at all three "temperatures", the dentist can avoid restorative metamerism, whereby the restoration looks good indoors but not outside, or vice versa.

BENEFITS OF TRI-SPECTRA LED TECHNOLOGY

For the clinician: Initial daylight mode shade determination is supplemented by room and ambient light modes to avoid metamerism[50] without the patient leaving the dental chair (Fig. 2). The Rite Lite 2 is portable and wireless, and is far less costly than digital spectrophotometers and colorimeters.

For the ceramist: The shade of the fired ceramic can be verified during build-up without leaving the workstation. The shade of the finished restoration can be verified on the model (quality control) prior to returning the case to the clinician.

THE SHADE-TAKING ENVIRONMENT

It is recommended that the shade-matching be conducted with a specified neutral background gray[50-53] that has no complimentary color, and is restful to the eyes' retinal cones.[52] A neutral pink may also be used (Fig. 3).

Bright colors adjacent to the teeth to be shade-matched can cause perceptual problems: red lipstick, for example, fatigues the red receptors in the clinician's eyes while the blue and green receptors remain fresh and fully capable of stimulation. This leads to a color-evaluation that leans more to the blue-green than it should. Brightly colored clothing or jewelry can have a similar distorting effect.[54] Thus, lipstick and jewelry should be removed, and clothing covered by a neutral grayish bib, prior to shade taking. While contrast assists visual perception, an excess of it causes glare. A very bright object on a dark background can affect the shade-taker's perception.[9,55]

Ideal time of the day for shade matching?

"Ideal time-of-day" recommendations are unreliable since daylight varies by location, season, solar position and inclination, windows size and direction, weather conditions, and geography.[24,51]

Shade matching within the appointment

Shade selection is best accomplished before treatment. As the teeth dry out during treatment, their value (whiteness) increases while their chroma and translucency decrease.[56] Shade selection is contraindicated after using a curing light.

Eye fatigue awareness

The high intensity (brightness) and glare of the operatory light cause eye fatigue. Shade selection is best performed prior to turning on the operatory light.[57] Eye fatigue may be reduced by utilizing a daylight corrective lamp during shade match selection.[32,58] Staring at the teeth for more than five seconds during shade selection causes hue accommodation, and should be avoided.[19] First impressions are always better. Eyes can rest by looking at a blue background.[51] In a dedicated shade-taking room, the walls should be gray and illuminated by daylight-correcting lamps.[58]

Surface moisture

Teeth should be dry when evaluating value, translucency, surface texture, and luster. Teeth should be wet for evaluating hue and chroma to limit the influence of surface morphology.

PHOTOGRAPHY

To assist in shade communication with the laboratory technician, the following photographs should be included in the pre-

FIGURE 7—By holding the shade tab's incisal edge to the incisal edge of the natural tooth reduces afterimages.

scription: full face, natural smile, retracted lips and cheeks, and the selected shade tabs against the adjacent natural teeth. At the very least, the last photo must be sent.[59] Photographic shade matching is a great communication tool, but shade tabs must be selected under specific lighting as well (Fig. 4).

DENTAL LABORATORY PRESCRIPTION

The ideal prescription is a 3-D representation of the shade-map, preferably from several perspective points (vectoring). The facial surface is divided into 9-16 distinct zones (Fig. 5). The surface texture and luster have an impact on the optical properties of the tooth and should be described.[60]

ADDITIONAL RECOMMENDATIONS

1. Always use a standardized full-spectrum light source under appropriate conditions when taking shades.

2. Use the shade tabs in the shade guide rather than on their own to significantly increase accuracy.[37] (Fig. 6)

3. Hold the incisal edge of the shade tab to the incisal edge of the tooth; the reflectance reduces afterimages.[49] (Fig. 7)

4. Use the mid-buccal of the tooth to select the hue.[61,62]

5. Evaluate shade by looking at the tooth from different angles (vectoring) to accommodate for curved translucent surfaces, the anisotropic properties of enamel, and the complex layering of the tooth structure.[50,52,57]

6. Delay shade matching for at least one month after bleaching to allow the enamel to rehydrate and achieve color stability.[63,64]

CONCLUSION

Regardless of the operator's gender, training and experience, shade-matching ability in the clinical practice and the dental laboratory improves significantly when conventional lighting is modified by light-correction. Accurate shade selection that allows restorations to match the natural dentition positively influences the patient's appearance and esthetic self-esteem. **OH**

Dr. Afrashtehfar is a post-graduate research trainee in the field of Oral and Craniofacial Sciences. His training is focused on multidisciplinary research including Health Technology Assessment and Evidence-based Dentistry. He is a Fellow of the Academy of Dentistry International and a reviewer for the European Journal of Oral Implantology. His first textbook entitled 'Computerized Dental Occlusal Analysis for Temporomandibular Disorders' will be released this year. Since his arrival in Montreal, Canada, Dr. Kelvin Ian has collaborated with the Jewish General Hospital, Children's General Hospital, Université de Montréal and McGill University. He can be reached at kelvin.afrashtehfar@mail.mcgill.ca
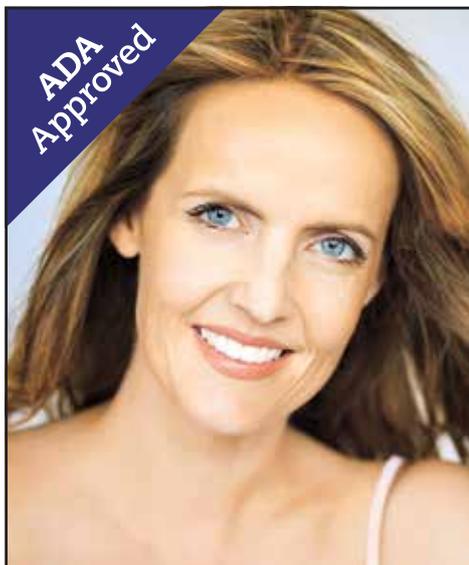
Oral Health welcomes this original article.

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