The contrast-zone color system:

Shade analysis and Porcelain layering to achieve the illusion of a natural tooth

Edward A. McLaren D.D.S. MDC

Yi-Yuan Chang MDC

Fig.2 The Easy Shade- Computerized Spectrophotometer shade taking device

Fig. 1 The 3-D Master shade guide

The process of creating an indirect restoration that mimics nature requires exquisite artistic ability. Transfer of information related to tooth color and form is of paramount importance if we are to achieve this lofty goal. Understanding zones of color that exist in natural teeth and the ability to see these patterns of color and translucency and then communicate them effectively is critical to the process of creating a ceramic restoration that creates the illusion of a tooth. The authors have spent considerable time studying the color and translucency patterns of natural teeth. Concomitantly, extrapolating these observed patterns to a porcelain building technique to simplify the technique of fabricating a porcelain restoration that eludes detection in the oral environment was the goal of this study. There is a general pattern of color that exists in teeth; this pattern can be used in layering of ceramics to manufacture ceramic restorations that can be indistinguishable from their natural counterparts. This system of evaluating tooth color and subsequently layering porcelains to mimic nature the authors have called "The contrast-zone color porcelain layering system". This paper will detail the process of evaluating tooth shade/color, the use a spectrophotometer to analyze base tooth color, the authors ideal use of digital photography for communicating tooth shade, and porcelain layering techniques using the contrast-zone color system.

Analyzing Tooth Shade

Traditional shade selection and communication in dentistry has been mere guesswork due in large part to inadequate shade matching systems available until relatively recently.[1-3] Evaluation of natural tooth color compared to existing shade guides clearly demonstrates that the shade guides don't adequately cover natural tooth shades. More recently new shade guide systems have been introduced that better cover the shades of natural teeth (fig. 1). The authors use primarily the 3-D master shade

system (Vident/Vita) for tooth shade analysis. Even with newer shade systems it is still important to understand that the shade guide is essentially an average or blending of all of the nuances of shade of a tooth. It is intended to "GUIDE" the observer into a shade or color range as a base or starting place. It was never intended to be the complete source of information for shade to create the illusion of natural teeth especially when dealing with individual anterior teeth. It is extremely important to get the base shade correct, if the starting place is wrong e.g. the base should have been a 1m1 (3-D Master shade guide/ Vident) or A1 and the observer choose 3m1 or C3 the final ceramic will never be the correct shade regardless of the nuances or contrasts that are placed in the porcelain. There is several computerized shade taking devices available. We believe from experience that a device should be simple and give an accurate base shade. The EasyShade (figs 2 & 3) (Vident/ Brea California) in our tests have shown to provide as or more accurate base shade than the average visual shade taken by a group of dentists. Photography and the understanding of how to layer porcelain to create correct intra-tooth contrast are the other tools necessary to create a lifelike restoration. Using the base shade only to create a restoration usually creates another problem with the final shade match. We see a particular shade, we have a restoration manufactured that matches the shade guide as close as possible, yet when we place the restoration in situ we can clearly see that it is a crown and doesn't blend appropriately with the natural dentition. Or, we do multiple teeth and they appear like shade guides. The fundamental problem is the "guide" is an average of what is perceived in the mouth (fig. 4). The shade guide has basically the same shade gingivally-incisally with one shade of dentin and one shade of enamel. The tooth on the other hand is polychromatic i.e. different colors and translucencies incisal-gingivally. Those zones of color if placed in a blender (or averaged) would give the correctly chosen shade. The eye sees contrasts very well; if the intra-tooth contrasts are duplicated within the porcelain build-up once the restoration is placed it will fool the eye. But if intra-tooth contrasts are not respected then this will be perceived as a shade guide or denture tooth and look fake.

The Contrast-Zone Color System

Within a tooth there are color contrasts mostly in value, translucency and chroma. Upon significant study it became apparent there was a relatively consistent pattern with these color contrasts. More importantly it was found that following this pattern while building porcelain in most circumstances created the illusion of a natural tooth and would blend in or be inconspicuous assuming the chosen base shade was correct. There are a minimum of three- (3) color zones gingivally-incisally that can be discerned in evaluating natural teeth. There are also two interproximal zones but they are less important than the 3 facial zones Obviously there are infinite variations and gradations of color in a tooth. Our goal is not to recreate these many variations. Our goal is to create the illusion of a tooth and fool the observer as simply and efficiently as possible. This can be effectively done with this technique in most instances. As a general pattern there is a "Base Shade" in a tooth that our eye is drawn to that we relate to the shade guide. This is in the center or middle 1/3 of the tooth. This area of the tooth in most situations is the brightest area of the tooth. The second zone "the gingival zone" is usually higher in chroma and lower in value. The third zone "the incisal zone" is generally lower in value, higher in translucency, and overall lower in chroma (figs 5a & 5b). There are many times higher opacity and high chroma effects we would call mamilon effects that exist in the incisal 1/3, but the overall dentin and enamel color effect is lower in value and chroma. The mamillon effects need to be mimicked to create the illusion of nature and it is only possible to communicate these effects with high quality

Fig. 3 Using the easy shade to take an electronic shade

Fig. 4 Image of the closest match shade guide next to a natural tooth. This clearly demonstrates that the shade guide is an average of the color zones that exist in a natural tooth.

Fig. 5 a and b Image of natural tooth that shows the 3 basic zones of color. Fig. 6 Close-up of the incisal half of central incisors showing multiple streaks of color called mamilons.

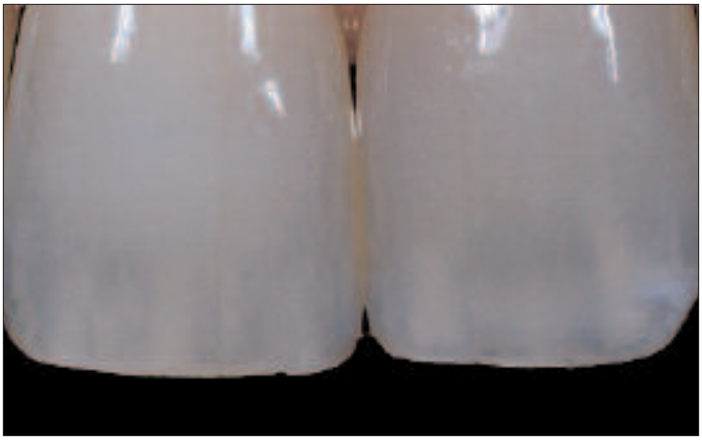

Fig. 6 Close-up of the incisal half of central incisors showing multiple streaks of color called mamilons.

Fig. 7 Canon 20D camera with the Novoflex bracket and the Canon MT 24EX flash.

Fig. 8a Image of a single Spinell restoration on tooth #9 that appears monochromatic similar to the adjacent natural tooth.

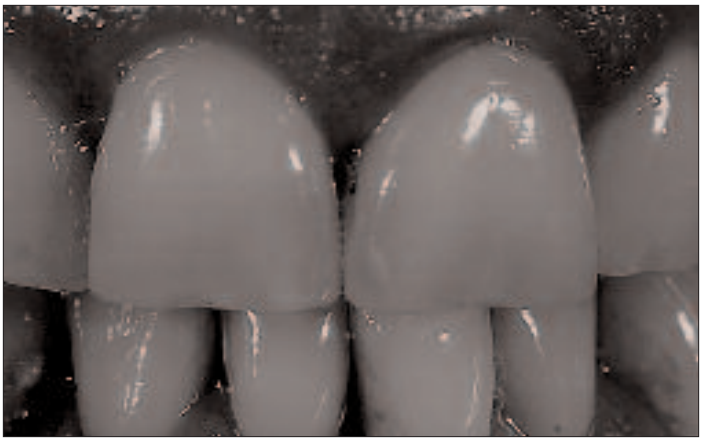

Fig. 8b is the image turned to black and white and darkened, which clearly shows the different value zones gingival incisal.

Fig. 9 Image of 3-D Master shade guide with just the "M" hues in it.

photography (fig. 6). Today digital photography has advanced to the point to get an almost film quality effect. The authors use and recommend the Canon 20D digital camera with the dual point flash MT-24 EX Canon flash (fig. 7). These are the three basic contrast-zones of color that need to be created in the porcelain, or composite restoration for that matter. To review, the base zone of color in the middle 1/3, which is the brightest, the gingival zone, which is higher in chroma and lower in value, and the incisal zone which is lower in value and lower in chorma. The amount of contrast created in a tooth is specific to the patient. Generally speaking if doing multiple teeth there should be only mild contrasts but they should be there. Even in single tooth restorations that initially appear monochromatic when they are darkened they clearly show the different value zones. (figs 8a & 8b)

Taking the Shade

Evaluating the base shade of a tooth begins first with choosing the value. Using the 3-D master shade guide the authors have found it best to first remove from the shade guide all of the "L" and "R" hues. This leaves only the "M" hues, the high value "0" value or bleaching guide is added to the main guide if this patients teeth appear to be high in value (fig. 9). Leaving only the "M" hues in the guide greatly simplifies the process of choosing both value and chroma. It is important to note the value is by far the most important color parameter to get correct as even slight mis-matches in value may cause the case to be rejected by the patient while small mis-matches in hue and chroma usually go undetected. The reason for this is in the human eye there are significantly more receptor rods vs. receptor cones. The rods are sensitive to value or brightness differences, while the cones are sensitive to hue and chroma differences. It is best to work by a process of elimination i.e. first choose the value groups it isn't. Generally there will be no exact value match; there will be one group that appears closest. At this point using a digital camera take an image with the two closet value groups adjacent to the tooth being matched. While taking the image it is important to put the shade guides in the same vertical plane as the natural tooth (fig. 10). Also, the shade guide and the tooth should be wetted with a medium viscosity glaze liquid. Saliva is not adequate for this as it dries to fast and the tooth can dehydrate and appear brighter rendering an incorrect shade evaluation. The glaze liquid will keep both wet long enough for the shade taking process. This image should clearly show the shade guides and the tooth and be easy to see the contrast

Fig. 10 Image with the two closest value matches.

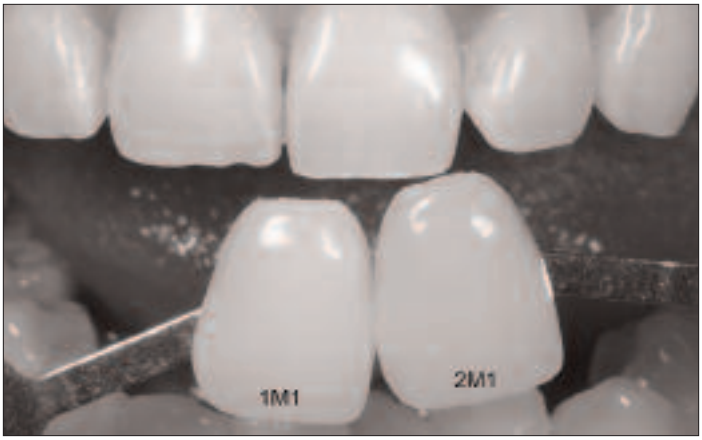

Fig. 11 Black and white image with the two closest value matches

Fig. 12 Image with the two closest chroma's

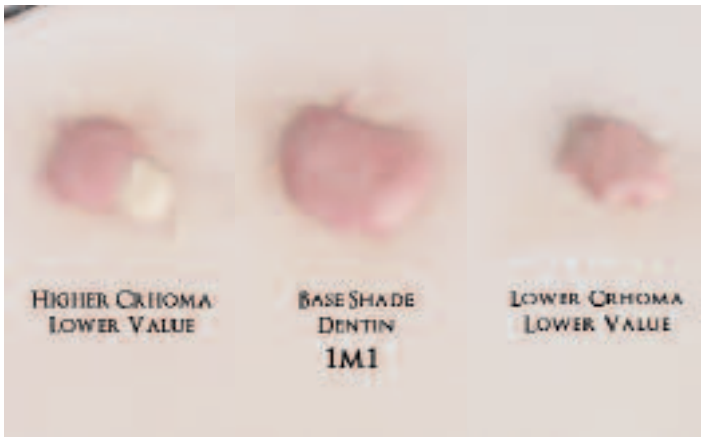

Fig. 13 Image of porcelain tray with 3 piles of base dentin porcelain that have different chroma's and values to duplicate the pattern seen in natural teeth.

differences between the shade guide and areas of the tooth. The image can then be turned into black and white (grayscale) in Photoshop (fig. 11) or some other image manipulation program and evaluated by the dentist/ceramist team for value zones within the tooth and shade guide and tooth contrast differences. The next step is to evaluate chroma. The evaluator should ask does it appear low chroma, medium chroma, or high chroma. Again, generally it will appear as one of the three or between two of the chromas (fig. 12). Place the 2 closet chromas ideally one slightly higher in chroma and slightly lower in chroma in the same vertical plane of the tooth being evaluated and take a digital chrome image the same as for value. It is important to be able to see the differences in chroma from the shade guides and the natural teeth. A close up high quality image is then taken to be able to see color effects (mamillons), surface texture and surface luster which are also important to closely match to create an optical match. Lighting conditions both ambient and flash, camera settings (film type if using analog), visual positioning of the observer during the shade taking process and the person observing or taking the shade can drastically effect the perception of shade[4]. Without exquisite control of all of the physical parameters it is easy to get a misrepresentation of the accurate base shade and thus impossible to get a porcelain restoration to duplicate the natural shade. An important tool in our armamentarium today is a shade-taking computer. Ideally the computer is used to get the base shade and then compared with the visually derived shade and then photographically. As stated earlier the computer was found to be as or more accurate in choosing base shades than an average of 6 experiences shade takers when using the 3-D master shade guide.

The Color-Contrast Zone Build-Up System

The primary author developed a porcelain building technique called the "skeleton build-up" technique[5] that is used as the basis for teaching at the UCLA Master Dental Ceramist Residency Program. It is so named to create an image of a structure that is built from the skeleton outward one layer at a time, which are individually completed prior to veneering the skin (enamel surface), thus allowing maximum control of both shape and shade. Just as our human form is distinctly different from other primates due to the different morphology of our skeletal systems, the 3-dimensional expression of shade and shape in a porcelain crown requires the exact placement of the internal dentin layers (skeleton) to support the surface enamel layer (skin). This technique deals primarily with the systematic control of the exact thickness and 3-dimensional placement of opacious dentin, dentin, enamel and translucent layers. For a more complete discussion of the technique a full color PDF file can be downloaded at www.oralfacialarts.com (go to the downloads page). The technique did not cover color contrasts in layering porcelains, which will be covered here. This section covers how to layer color contrasts of porcelain based on the shade evaluation information obtained.

To create the illusion of a tooth a minimum of three facial color contrast zones need to be created. Using the base shade information that was taken from the patient three different color contrasts of porcelain are placed on the tray. As an example the viewer had chosen a base shade of 1M1 then to start 3 piles of 1M1 base dentin are placed on the tray (fig. 13). For the gingival 1/3 the effect chroma modifiers are added (generally 33% to 50%) this creates the higher chroma and lower value zone to be placed in the

Fig. 14 Base dentin of three different color zones built to contour

Fig. 15 Fired base dentin

Fig. 16 Built up incisal frame

Fig. 17 Fired incisal frame

Fig. 18 Fired incisal effects

Fig. 19 Built-up skin layer (translucent layer)

Fig. 20 Contoured, glazed and polished central

gingival 1/3. As a general rule for brighter shades we add Effect Chroma 3 to the 1M1 base dentin for the gingival 1/3 of the restoration. If I am matching a single central then the effect chroma chosen is based on the evaluation of the color images with the shade guides in the image taken that show the chroma levels relative to the tooth An alternative technique is to choose a higher chroma and lower value base dentin e.g. 2M2. The incisal 1/3 is cut with 50% Enamel Light (added to the 1M1 base dentin) in almost all instances. Since the other two zones were darkened slightly the middle zone (base shade area) needs to be lightened slightly to compensate so the overall average of the 3 zones still comes closest to the 1M1 chosen. The easiest way to do this is add 50% 0M1 base dentin to the 1M1 base dentin. These three masses of porcelain are built into the three zones as shown (fig. 14) and then fired (fig. 15). The next layer of porcelain to be built is the lingual incisal edge or so called "incisal frame". The authors have found a mix of porcelain that works universally for 2 value and higher cases. A 50% mix of Enamel light, 25% mix of window, and 25% mix of Effect Enamel 9 is used for the incisal frame. It is built up (fig. 16) and fired (fig. 17). Incisal or mamilon effects are placed using the MM powders, a generic mixture is 50% MM1 and 50% MM 2 and is placed in a feather or streaky like pattern in the incisal 1/3 (fig. 18). The final layer to be placed is the enamel or "skin" layer as it is called in the "skeleton build-up" technique[5]. A slight contrast is also created with this layer as with the base dentin layer. For shades of 2 value or brighter Effect Enamel 4 is placed at the gingival 2mm of the restoration, the rest of the skin layer is done with Effect Opal 1 (we generally dilute or cut this with 1/3 window to make it slightly more translucent) (fig. 19). This is then fired, final contoured, glazed and polished (fig. 20).

Fig. 21 Pre-op

Figure 20 and 21 show a finished case following this concept using Captek and VM13 (figs 21 & 22)

Fig. 22 Post-op of Captek and VM13 crown

Summary

A technique has been presented that allows the systematic process of evaluating shade based on observed and measured color contrasts that exist in natural teeth. The system of evaluating these poly-chromisites is called the "zone-color contrast system". The observed color contrasts are then used by the ceramist to develop color zones within the porcelain build up that when finished helps to create the illusion of a natural tooth. The system works for both metal-ceramics and all-ceramics.

References

1. Sorensen JA, Torres TJ. Improved Color Matching of Metal-Ceramic Restorations. Part 1: A Systematic Method for Shade Determination. J Prosthet Dent 1987;58:133-139.
2. Miller LL. Shade Selection. J Esthet Dent 1994;6:47-60.
3. Miller LL. Shade Matching. J Esthet Dent 1993;5:143-153.
4. McLaren EA. The 3D-Master Shade-Matching System and the Skeleton Buildup Technique: Science meets Art and Intuition. Quintessence Dent Technol 1999;22:55-68.
5. McLaren EA. The Skeleton Buildup Technique: A Systematic Approach to the Three-Dimensional Control of Shade and Shape. Pract Periodont Aesthet Dent 1998;10(5):587-587.

About the authors

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