Dental Office Lighting

In tandem with the explosive growth of aesthetic dentistry, color photography has become an important part of many dental practices. More than ever dentists are dealing with subtle variations in shades of color in their day-to-day practice. Color photography has become the norm in trade journals. You cannot open a dental journal without an article about dental/digital photography or gadgets costing thousands of dollars and promising accurate color-matching. Often one can’t help noticing the out-of-balance color temperatures of the before-and-after photographs.

Lack of knowledge about light and the inability to control its deviations has obviously frustrated many of our colleagues. I heard 2 well-known authors on aesthetic dentistry recommend stepping out of the office into the bright sunlight for all of the photographs in order to get proper and matching color balance! Many of us practice in high-rises. In addition, even in California it is not always sunny outside. Therefore, I do not believe stepping out for the photographs is practical advice, especially considering that it has to be noon every time for the color temperature to be exactly the same! A few dentists have totally given up and recommend sending patients to the local photo studio for professional portraits.

I firmly believe that a basic knowledge of color temperature and lighting with a few simple measures can help you consistently produce professional-looking photographs, as well as present the different areas of your office in the most desirable light.

This article touches upon the basic physical science of light as it is used in a dental office. It helps the reader understand the units used to describe the various qualities of visible light as well as the characteristics of different light sources used in dental offices. Suggestions are made as to the type of preferred lighting for the best possible clinical and photographic results. The material presented is the result of years of curiosity and study of this subject on the part of the author, and therefore lacks any specific references.

WHAT ARE COLOR TEMPERATURE AND COLOR RENDERING INDEX?

You may have noticed that many of the camcorders and some of the high-end digital cameras have a feature called “white balance.” It basically adjusts the temperature of the recorded picture so that the “white” appears as white. As sophisticated as creation is, our brain has this system built into it, and that is the reason we cannot distinguish or actually “see” the color temperature variance of the ambient light. The photographic film, however, is very objective and forgiving. More importantly in dentistry is the fact that different materials reflect the dissimilar light differently. You may have had the embarrassing experience in which you made great, matching veneers that appear perfect at chairside, only to be disappointed when the receptionist comes back to tell you that the “color does not match.” The difference is in treatment room and reception area lighting. In my office we have arranged all the common light sources and examine the new restorations under the lighting that the patient prefers. [Author above, what do you mean by “arranged”? Please clarify.]

Two different scales are used to measure and communicate the color of light sources.

Color temperature is the scale of redness (warmth) or blueness (coolness) of the light. It is measured by Kelvin degrees. The warmest naturally occurring light is a red hot red measuring at 3260°. As the temperature increases, the blueness increases. The coolest naturally occurring light is moonlight with color temperature of 27,000°.

Color Rendering Index (CRI) is the scale from yellowish green (death) to magenta (vitality and excitement). It is measured by the percentage that the light is similar to sunlight in this range. By definition, then, sunlight has a CRI of 100.

Let us now discuss the various common light sources and their characteristics.

SUNLIGHT AT NOON

Obviously, this is the most natural, completely balanced, and neutral light source. Sunlight has color temperature of 5,500°. The CRI of sunlight is 100%. It is the whitest light source and standard by which all other light sources are measured. All standard photographic films are made to produce natural colors under this light.

Why are sunset and sunrise reddish? It is important to realize that the earth’s atmosphere acts as a “filter” for sunlight. As the sun is at its minimum thickness because sunlight is passing through it at a right angle. The closer we get to sunrise or sunset, sunlight has to travel through a greater thickness of this atmospheric “filter.” The red/blue color has the shortest wavelength (400 nm) in the visible light range of the electromagnetic spectrum. The red color has the longest (700 nm) wavelength. The longer wavelength red color travels the most through the atmosphere; therefore, it is least affected by the longer distance it has to travel to reach us when the sun shines at an angle. (This is exactly the reason brake lights on cars and all other lights that need to be seen from a distance are “red” in color.)

The reason the redness/blueness of sunlight is constantly changing and unreliable for producing uniform photographs and shade-matching is that more of the blue and less of the red gets filtered out as the sunlight passes through a thicker atmosphere at sunrise and sunset.

COLOR QUALITIES OF COMMON ARTIFICIAL LIGHT SOURCES

Incandescent Lighting

This most traditional light source is used with less frequency these days due to its power consumption inefficiency. Heating the bulb element to brightness produces light. With color temperatures of 2,800° to 3,500° and CRI of 100%, it is the “warmest,” the most romantic, and kindest on the skin of the light sources (Figure 1). [Author: please verify above CRI value. Is it correct above and
in legend?) You see this lighting mostly in restaurants and homes. Some municipalities do not allow commercial use of incandescent bulbs for lighting purposes due to energy efficiency guidelines. This is the light that shows skin the smoothest and helps people look their best, so you may want to have incandescent lighting at your checkout mirror.

Halogen Lighting
Halogen bulbs produce light by heating and exciting the halogen gas in the bulb. They are generally much brighter than incandescent bulbs. Their color temperature is 3,600° to 3,800° with a CRI of 100%. (Figure 2). [Author: please verify above CRI value. Is it correct above and in legend? Also, legend gives color temp of 4,500°. PLS clarify.] They are, therefore, slightly “cooler” than the incandescent bulbs but still considered a warm light source. Everything that needs a bright light source, from ear headlights to our clinical headpieces’ light source, is usually halogen. They portray a more modern appearance than incandescent light. They are not very energy efficient because they, too, waste a lot of energy through “heat.”

Dental Chair/Surgical Light
Even though the light source in dental lights is a halogen bulb, the quality of these lights is slightly different. Halogen bulbs typically produce a lot of heat. Heat is nothing but infrared waves that are produced and emitted along with the visible light. Dental light manufacturers have designed the dental light to take advantage of the halogen bulb’s brightness without it’s undesirable heat. If you place your hand in front of a dental light, you notice the brightness but can hardly feel any heat. However, if you get close to the back of the dental light, you will notice the tremendous heat.

The reason is that while a nontransparent cap prevents the halogen bulb from shining directly on the subject, all the light shines onto a “selective reflector.” The reflector allows the longer wavelengths of infrareds to pass through to the back of the light and reflects the visible light back onto the subject. This selective pass-through of infrared rays is not precise. Along with the infrared rays, there is some seepage of orange-yellow light as well. The color of the light you see on the back of the reflector is basically the color missing from the light in front of the unit. As a result, the dental light measures slightly “cooler” or “whiter” than the direct halogen bulb light.

Fluorescent Lighting
Nothing can ruin an otherwise well-exposed photograph better than a commercial fluorescent light. Fluorescent bulbs do not use heat as a means for light energy production; hence they are much more power efficient in lighting than the previously discussed light sources. This accounts for their widespread use in office spaces. In fact, many cities now require commercial buildings to use this type of lighting. Every dental office operator that I have seen has had this type of lighting as its main light source. A typical fluorescent tube produces a predominantly green light with a CRI of 75 to 85%. This gives human skin a “dead” appearance. In fact, this kind of lighting is used in movies to create the “dead” look for the subjects. The so-called warm fluorescent bulbs have warmer color temperatures (redness closer to incandescent lighting), but still have a CRI of 75 to 85%, which means they still look greenish (Figure 4).

In recent years manufacturers have developed fluorescent lights that are closer in color to sunlight. The closest commercially available bulb is 5,500°K and 97% CRI. [Author: is above sentence correct as edited?] This light bulb is about 8 times more expensive than the traditional bulb, but it is well worth it for treatment rooms. To neutralize the slight green hue of this light, a color meter calls for a one-half magenta filter (Figure 5).

Photography Flash Light
This artificial light source is the closest to sunlight. It has a CRI of 100% and a temperature of 5,600°K (slightly bluer than sunlight).
PHOTOGRAPHY

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INFLUENCE OF WALLS, FLOORS, AND WINDOWS

Depending on the style of lighting fixtures, part or all of the light present in any room is the light reflected from the walls and other items nearby. As a result, the chromatic values of the walls and furniture influence the color temperature and CRI of the light. The saturation and brightness of their color and the reflectivity of surfaces determine the extent of this influence.

A great manipulator of color temperature and CRI is the “tint” of the windows. In a professional building, the architect usually predetermines and sets this tint. It can vary from gray to greenish to brownish or any other mixture according to the designer’s plans and tastes. Unless this tint is a neutral-density gray, which rarely is the designer’s choice for appearance, it acts like a color filter for the light that passes through it. You can easily see how a shade-match that is done in the dentist’s office with greenish tint windows can turn out differently when the laboratory with a brownish window tint mixes the porcelain. One easy way to eliminate this influence is to close the window shutters at the time of color-sensitive work, and provide all the other factors are equal, advise your laboratory to do the same.

IDEAL DENTAL OFFICE LIGHTING

The true characteristic of lighting is the combined result of the artificial light sources and the light that is filtered through the windows and reflected off the furniture, floors, and walls.

For the purpose of this discussion we can divide the office into different areas.

Treatment Rooms and Lab

Treatment rooms and the lab are color-sensitive areas. It is critical that these areas have “balanced lighting” so we can correctly and accurately evaluate our work. This means 5,500K with 100% CRI. [Author: is above sentence correct as edited? An easy way to standardize all your photographs is to use an electronic flash as the sole light source. Technically speaking, this means that there should be no ambient light to influence the color. While this may be impractical for day-to-day photography in the dental office, it can be achieved by turning off as many lights as possible for the photographs and using a small aperture and high flash guide number to minimize the influence of ambient light.

Reception Area and Breakroom

“Before they smell, they see; before they hear, they see; so why not make them see pleasantly?” This is where you want people to feel good about themselves. Indirect lighting (2,800K) are most suitable for the reception area. This projects a warm, homely feeling for patients. In addition, warmer colors are more relaxing and “forgiving” for skin imperfections. The next best choice is halogen lighting (3,400K), followed by “warn” that is less than 4,000K fluorescent lights. Power conservation codes of many municipalities have guidelines and limitations on types of lights you can use for reception areas. Your architect is usually familiar with these codes and can guide you accordingly.

Business Area and Private Office

My choice for the business area and private office is daylight-balanced (5,500K) fluorescent lighting with at least 90% CRI and/or halogen lighting. Indirect light and warm fluorescent light are too fatiguing to the eyes. Regular or standard fluorescent light is too “industrial” for a dental office.

Sterilization Area

This is where you can benefit from cooler-than-daylight (greater than 5,500K) lighting. Bluish light of about 6,500K to 7,000K portrays purity and emphasizes attention to cleanliness. You may have to fine-tune the colors using filters to bring about the effect you are looking for. High CRI is certainly a plus, even though it is not critical to have it at 100%.

RECOMMENDATIONS FOR OFFICE LIGHTING

Obviously your ability to create an ideally lighted office depends on how much influence you can have in selection of surface materials, light fixtures, and bulbs used in the office. At the present time there are no commercially available fluorescent light bulbs that can give us the 6,500K to 7,000K we are looking for. None of the 4-foot and/or small, handheld devices, whether LED or fluorescent, that are marketed and sold as “daylight-balanced” lights satisfy this criteria. Most of these bulbs have a color temperature equal to daylight but have a CRI of less than 95%. Therefore, my recommendation to the color-conscious dentist is to buy a colorimeter device and fine-tune the total available light of the treatment rooms by placing appropriate filters above the light tubes.

Alternatively, you can rent a colorimeter from a high-end camera store. If we choose the best commercially available lights with other influencing factors being neutral, a one-fourth to one-half magenta cellophone filter (Figure 8) around the tubes produces the perfect balance we are looking for. Cellophone filters are available from local camera stores. However, remember that these filters “fudge” when subjected to the heat of the bulb, and they will have to be replaced every year or so.

You can also mix and match the filters and lights for various reasons but achieve the same perfect results. So that I do not end up covering each and every tube in my office, in the sterilization area and the lab I use full magenta filters on one out of 3 tubes (Figure 9) instead of a one-third magenta filter on every tube, as it was suggested by the colorimeter. The light mixture results in perfectly balanced lighting (Figure 6).