Review Article

THE ROLE OF DIGITAL CAMERA IN SHADE SELECTION: A REVIEW

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Abstract

Dental Photography has evolved at an astounding rate over the past few years. It has helped dentists identify, diagnose, record, and present their cases will unimaginable accuracy and details. It not only improved the overall quality of treatment, but it also helped ease communications with fellow dentists and dental laboratories. Shade selection procedures are often limited by the colour of the prefabricated shade tabs of the manufacturers and force dentists to select only those shades that are provided in the shade guides. It makes it extremely difficult to convey the exact optical properties of the patient's teeth to the dental laboratory. The solution to this problem was the introduction of digital photography in shade selection procedures. However, digital photography can only be used for shade selection if the dentist is able to immaculately capture the true colours of the patient's teeth. This requires an in-depth knowledge about the working of the digital camera, its limitations, and ways to overcome these limitations.

Keywords: Digital Camera, Dental Photography, Construction, Functioning, Exposure, White Balance, Grey Card, Flashlight, Software

One of the biggest problems of shade selection has been the amount of information that can be communicated to the dental laboratory. Conventional shade guides simply convey the base colour of the prosthesis not any other characteristics that the prosthesis may need.[1]

Dentists often use "shade communication diagrams" for a more detailed illustration of what is required in the prosthesis, but even these lack the details required for accurate results.

Hybrid devices fixed this issue to a great extent, but the dental laboratories also needed complex software and sometimes even hardware to efficiently utilize this information

Digital cameras thus presented as a perfect solution to both of these problems

ADVANTAGES OF A DIGITAL CAMERA[2]

With a series of images, they can communicate the tooth's:

1. Shade
2. Surface texture
3. Translucency
4. Form
5. Size
6. Characteristics

And on the other hand, the dental laboratory simply needs a digital screen in order to process all the details provided

This makes the digital camera an important tool, regardless of the methods of shade selection and laboratory communication used.

DISADVANTAGES OF A DIGITAL CAMERA[3]

The use of a digital camera to aid in shade selection encounters some unique problems.

1. A learning process is required before the dentist can effectively use the digital camera for shade selection
2. The digital camera has various setting that alter the way the object (tooth) appears, which depend on:
    a. The environmental lighting conditions
    b. The flash of the camera (if used)
3. The apparatus required may be expensive

For the proper use of a digital camera/ DSLR (Digital Single Lens Reflex) camera for shade selection procedures it is extremely important to first understand its construction and settings.

CONSTRUCTION OF A DSLR CAMERA:[4]

The following image (*Fig. 1)* depicts the internal structure of a DSLR camera.

Notice the various parts of a DSLR camera and the path the light takes to enter the viewer's eyes. Each of these parts plays a key role in the outcome of the final image and ultimately contributes to the esthetics of the final restoration.

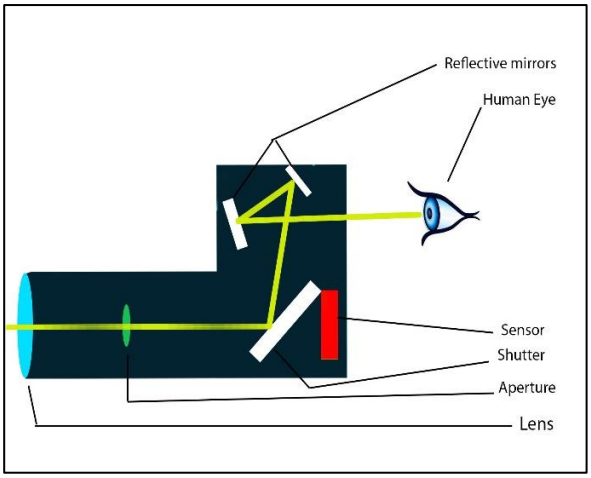

Fig 1: Internal Structure of a Camera

FUNCTIONING OF A DSLR CAMERA[5]

Light first enters the DSLR camera via the "Lens". This lens then converges the image which then passes through an "Aperture".

The opening of the aperture can be altered to change the amount of light that falls on the sensor.

The light then falls on a "Shutter" which usually remains closed but can be opened to allow light to fall on the sensor to generate an image.

The closed shutter acts as a reflector of light. This pairs with the reflective mirrors in the prism of the eyepiece to direct the light/image into the "Viewfinder".

SETTINGS OF THE CAMERA

The two main settings of the camera that need to be adjusted are:

1. Exposure
2. White Balance

EXPOSURE[6]

Exposure of an image is a measure of the amount of light captured by the sensor of the camera.

Higher the exposure, more the light falling on the sensor and brighter the image.

Exposure is of key importance in shade selection using a DSLR camera as the exposure of the image should match the illumination of the teeth and shade tab guides seen by the human eye. Any discrepancy in this will result in inaccurate shade selection.

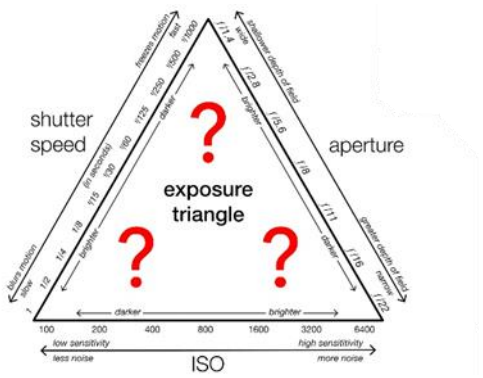

Fig 2: Exposure Triangle

As can be seen in *Fig. 2* the exposure of an image can be controlled by 3 settings on the DSLR camera:

1. Shutter speed (higher shutter speed decreases exposure)
2. Aperture (higher aperture decreases exposure)
3. ISO (higher ISO increases exposure)

The combination of Shutter speed, Aperture and ISO constitutes an "Exposure Triangle"

SHUTTER SPEED[7]

The shutter speed of a DSLR lets the user alter the speed with which the shutter opens and closes.

Faster the shutter speed, lesser the light that falls onto the sensor and thus lesser the exposure of the image.

This is measured in terms of "seconds"

The recommended shutter speed for dental photography is around 1/90th second to 1/125th second[8,6]

APERTURE[9]

Aperture is the setting that enables the user to alter the size of the Aperture of the camera.

It is measured in terms of F-number or F-stops.

The F-stops indicate the ratio of the system's focal length to the diameter of the entrance of the lens.

A larger F-number indicates a smaller aperture, and thus lower the exposure

ISO[10]

ISO stands for International Organization for Standardization.

It indicates the light sensitivity of the sensor of the camera.

Higher the ISO, greater the sensitivity and thus greater the exposure of the image.

The recommended ISO for dental photography is 100[11]

WHITE BALANCE [12]

The "White Balance" setting alters the colour temperature in degrees kelvin of the image.

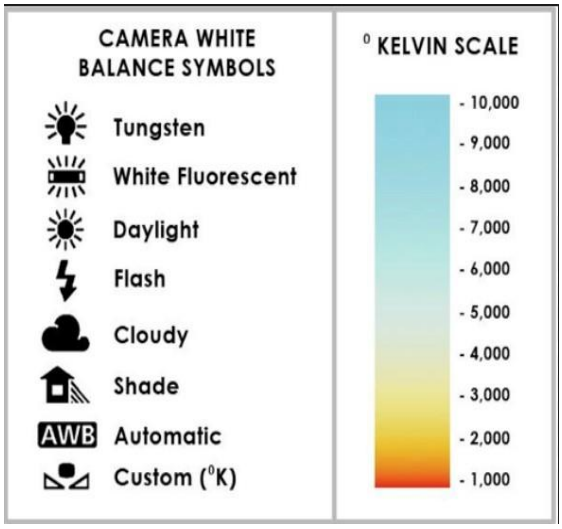

Fig 3: White Balance and Kelvin Scale

This setting affects the tint (or hue) of the image.

A higher degree kelvin will impart a bluish tint to the image, while a lower degree kelvin will impart a reddish tint to the image.

Fig. 3 demonstrates the various white balance setting of the DSLR, and colour temperature settings associated with it in degrees kelvin.

Note the change in gradation from a lower to a higher colour temperature.

If the white balance of the photograph is incorrect then the hue of the tooth completely changes. This would completely hamper the shade selection procedure and result in the fabrication of a prosthesis with the wrong shade and thus necessitate expensive and time-consuming remakes of the dental prosthesis.

Fig. 4: White Balance Settings.

Fig. 5: More White Balance Settings

Fig. 4 and fig.5 demonstrate the effect of various white balance settings on an object.

The use of these settings is to obtain an image that depicts the object as it would appear when viewed under the midday light in western Europe.[13]

Example: If an object is viewed on a "shady" day then it would appear to have a slight dull bluish tint. To counteract this, the user may use the "Shade" setting in the white balance of the camera. This would negate the effect of the environment's bluish tint by imparting its own reddish hue to it (3000ᵒK)

The "Auto" mode automatically detects the neutral greys in the background of the image and adjusts the white balance accordingly.

The remaining settings require the user to manually observe and adjust the White Balance as required.

GREY CARD CORRECTIONS[14]

Capturing the true colours of the teeth in their original form is difficult even after correctly setting the camera.

Even the best camera can produce pictures with errors and can be incapable of recording the true colours consistently.

Despite using the manual settings colours may show alterations in the pictures taken under different conditions. This can be managed by the use of "18% grey cards".

Using 18% grey cards and performing colour correction may reduce errors in recording colours drastically. This removes any faulty colour casts that may occur due to flashlight, angle, exposure settings, white balance settings etc.[15]

A grey card is a simple hard card which is grey in colour and is made using very high-quality protocols.

They are commonly used by professional photographers to capture accurate colours.

It is basically 18% grey and looks like credit cards which can be sterilized in an autoclave.

They are long lasting and almost never lose their colour if maintained optimally.

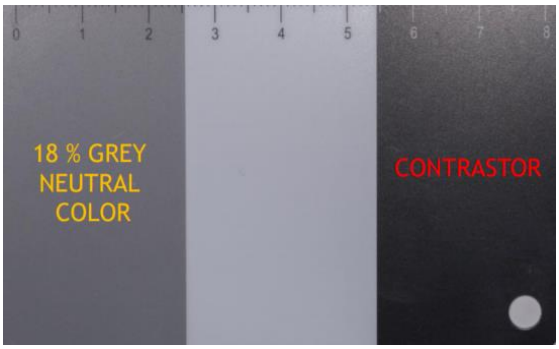

Fig. 6: 18 % Grey (Left), White (Centre) And Black (Right)

All cameras meter in a manner to achieve a "Mid Tone". This mid tone is essentially neither too white nor too black.

This enables the camera to achieve a balance between not too white and not too black tones. [16]

Neither too white nor neither too black is essentially GREY. This means every camera sees in GREY during metering or aims at achieving a neutral 18 % grey.

While performing shade selection, we keep a 18 % grey card within the confines of the image we are composing. Our objective is to tell our image processing software that in the image we have an area which is 18 % grey.

Once the image is uploaded onto a software, we select the white balance tool and point out to the image processing software as to where 18 % grey colour is present. [17]

The software has an inbuilt 18% grey shade. It compares the pointed grey area on the image with its own inbuilt 18% grey.

Fig. 7: Grey Card Correction, Left: Before Grey Card Correction, Right: After Grey Card Correction

If a difference is found between these two shades of grey, the software corrects the image by removing the colour cast.[18]

USE OF FLASH LIGHT FOR SHADE SHADE SELECTION[19]

Electronic flashes are available in two types:

1. Compact type (mounted onto the camera)
2. Studio flash.

Both the kinds are commonly used as lighting sources for dental photography.

Electronic flashes give out light that is corrected to 'photographic daylight' with a colour temperature of 5,500 K. [20]

Photographs taken with flash in daylight is ideal for dental photography as compared to just natural daylight.

This is because the three primary colours - red, green and blue, are seen in equal proportion in this colour temperature.

It is important to capture the three primary colours in equal proportions, since all types of photographs including the digital ones use the RGB model to produce the image. [21]

The electronic flash is advantageous to most scenarios since the light produced is predictable, instantaneous, and universally adaptable to any camera model.

Electronic flashes that are mounted onto the camera are available in various sizes and shapes. The types are:[22]

1. Ring-flash
2. Unidirectional.

Fig. 8: Ring Flash

Fig. 9: Unidirectional Flashes Mounted In A Bi-Lateral Configuration (Twin Flash)

Ring-flash gives out a uniform burst of light, which is useful for capturing images of difficult-to-access areas like the posterior teeth.

The problem with a ring flashes is that it produces a uniform light burst, creating a shadow-less, flat, bland image which lacks lustre as well as can be seen in *fig.10*[23]

Fig. 10: Image Clicked Using Ring Flash

Fig. 11: Image Clicked Using Twin Flash

Ring flash has shown excellent results by providing illumination of the posterior areas of the mouth. [24]

On the other hand, they fail to provide great results while taking photographs of anterior teeth or aesthetic restorations.

This occurs because the uniform burst of light obliterates the fine detail, translucency, and subtle colour changes within an individual tooth. [23]

However, unidirectional flashes produce shadows and highlights, which makes the teeth and gingiva look more three dimensional, with proper contrast and finer details as can be seen in *Fig. 11*.

In the unidirectional type of flash, the flashlight is mounted in a bilateral configuration on a bracket. This set up permits the light to be projected in a desired manner, which depends on the form of the patient's dental arch and the alignment of the individual tooth. [25]

This configuration gives excellent results when taking photographs of anterior teeth and captures their detailed characterisation, colour, texture, and translucency. This feature is of paramount importance for prostheses in the aesthetic zone. [26]

Unidirectional illumination can highlight fine details within the same tooth as well, which helps the lab technician to be able reproduce those characteristics in the final prosthesis.[27]

PROCEDURE[28]

1. Perform shade selection procedure conventionally
2. Place the shade tab near the tooth with a grey card next to it.
3. Adjust the settings (exposure and white balance) of the camera and click a picture of the tooth, shade tab (showing the shade name) and the grey card.
4. Adjust the settings again and retake the photographs untill the image clicked matches the colour and exposure of the tooth, shade guide tab and grey card as seen by the naked eye.

5. The final image is then sent to the laboratory.
6. Additional black and white cards may be incorporated into the photographs which would help the laboratory technicians adjust their monitors. This is done by adjusting the settings of their motitors to match the black, white and grey cards to adequately view the image according to the intended settings.[29]

SOFTWARES FOR DSLR SHADE SELECTION

Use of certain computer softwares greatly help the dentists and laboratory in achieving better results in shade selection procedures by enabling them to perform tasks that would otherwise be impossible.

The software related tasks should only be performed if the dental photographs were clicked with grey card corrections. Otherwise the use of softwares will result in grave errors.

Computer softwares may be used by the dental laboratories to adjust the image sent by the dentist according to the settings of their computer system using their own grey cards as a referance. Once the dental laboratory recieves a dental image with a grey card in it, the laboratory can then adjust their own screen settings until the grey card in the image looks like the grey card they possess. [30]

These softwares also enable the laboratory technicians to perform their own digital shade selection with the help of a digital library of shade tabs. This digital library can be created by simply photographing the shade tabs with grey card corrections and storing a copy on the computer. Image editing softwares can then be used to identify the shade tab that possess the colour closest to the tooth used for shade selection.[31],[32]

Further, the digital colour measuring capabilities of these softwares enable the users to determine how close the colour of the tooth is to the selected shade guide tab. And wheter any change in shade selection is required.[33]

Some of the softwares that can be used for these purpose are:[32]

1. Adobe Photoshop (Creative Cloud)
2. Picasa
3. Dentrix Image
4. Image Fx
5. Visora
6. Elements
7. Thumbs Plus
8. Paint Shop Pro (Coral)

CONCLUSION:

The search for an ideal shade selection device capable of perfectly recording the colour of the object and transferring this data to the dental laboratory is still ongoing and much research is needed in this field.

The digital camera greatly aids both the dentist in conveying vital information and the laboratory technician in better understanding this information to fabricate the desired prosthesis. But, both the dentist and the laboratory technician must be well

equiped with the knowledge to use this digital technology.

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