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Lutskaya I.

Institute for Advanced Training and Retraining of Healthcare Personnel of Belarusian State Medical University, Minsk, Belarus

## Light and Color in Aesthetic Stomatology

**Conflict of interest:** nothing to declare.

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Contacts: lutskaja@mail.ru

### Abstract

**Introduction.** One of the main tasks of aesthetic dentistry is to restore the natural optical parameters of the tooth during restoration. This requires knowledge of the histology of enamel and dentine, as well as the interaction of hard tissues with light and color rays.

**Purpose.** Evaluate the influence of the light and color environment on the quality of tooth restoration.

**Materials and methods.** Analysis of scientific literature, own laboratory and clinical observations of the visual assessment of the optical properties of teeth.

**Results.** Are presented in the description of the interaction of natural and artificial light rays with enamel and dentine, as well as their influence on the perception of tooth color. A specialist's knowledge of the aesthetic indicators of dental tissues in a natural environment allows them to ensure the high quality of restorative structures.

**Keywords:** optical properties of teeth; light and color environment in dentistry

Луцкая И.К.

Институт повышения квалификации и переподготовки кадров здравоохранения Белорусского государственного медицинского университета, Минск, Беларусь

## Свет и цвет в эстетической стоматологии

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Контакты: lutskaja@mail.ru

### Резюме

**Введение.** Одной из главных задач эстетической стоматологии является восстановление естественных оптических параметров зуба в реставрации, для чего необходимы знания гистологии эмали и дентина, а также взаимодействия твердых тканей со световыми и цветовыми лучами.

**Цель.** Оценка влияния светоцветовой среды на качество реставрации зубов.

**Материалы и методы.** Анализ научной литературы, собственные лабораторные и клинические наблюдения визуальной оценки оптических свойств зуба.

**Результаты.** Изложены особенности взаимодействия лучей естественного и искусственного света с эмалью и дентином, а также влияние их на восприятие цвета зуба. Знание специалистом эстетических показателей зубных тканей в естественной среде позволит обеспечить высокое качество восстановительных конструкций.

**Ключевые слова:** оптические свойства зуба, световая и цветовая среда в стоматологии

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## ■ INTRODUCTION

In aesthetic dentistry, composite materials enable the creation of dental structures of varying complexity and functional completeness [1]. This involves recreating optimal aesthetic parameters, including the optical properties of enamel and dentine. The requirements for restoring the front teeth are particularly high [2]. The individual characteristics of the shape, size and surface relief of the crown are also important characteristics of the tooth [3]. In order to achieve the closest possible visual approximation of the restoration to the natural appearance of the teeth, the dentist must have a thorough knowledge of the classical morphological structure of the teeth and the ability to select the right shade of composite [4, 5]. On the other hand, the specialist must understand the peculiarities of the influence of light and color factors of the environment on the eye's perception of the aesthetic characteristics of the color components of the tooth [6]. Such knowledge makes it possible to reproduce the specific features of the appearance of the patient's dentition. The characteristics of modern dental materials fully contribute to the fulfilment of this task.

## ■ PURPOSE OF THIS STUDY

To evaluate the influence of the light and color environment on the quality of tooth restoration, provided that the rules for using light-cured composite are followed.

## ■ MATERIALS AND METHODS

The analysis of data from classical sources of scientific literature in the field of optics, ophthalmology, and visual perception psychology, as well as our own laboratory studies conducted using special methods and high-tech equipment. Clinical observations were carried out in dental offices in accordance with classical requirements for research work. Teeth were prepared using diamond and carbide burs. Aesthetic designs were modelled using nano-hybrid light-curing materials with high optical properties.

## ■ RESULTS

Optical tooth properties have their own specific features owing to the unique structure and composition of hard tooth tissues. They are characterized by the presence of hue, lightness and chroma (Fig. 1). To select composite or ceramic mass, the dentist uses special standards corresponding to tooth color parameters. The tooth color can be changed under the influence of force and spectral light composition as well as light source location and beams direct. Natural sunlight beams are practically parallel and illuminate the tooth surface evenly. The artificial light sources being close located cause bright illumination of vestibular surface and shading the proximal ones.



**Fig. 1. Basic characteristics of color**

The light directed to the surface is distributed irregularly forming light shades because of the macro relief of a tooth (Fig. 2). The difference in a macro relief of these teeth leads to various perception of their color and form. The brightest area reflecting the greatest light quantity creates a catch light (white color area). There is penumbra on the surface which is illuminated by a slanting, sliding beam of light. The darkest area has its own shadow.

If the tooth is close to color objects (cofferdam, painted fingernails, lips), the beams being reflected from these items form the "painted" reflex shadow on the enamel surface. As a result, the illuminated and shadow parts of the tooth also differ in color shadow. The color of cervical areas of a tooth can essentially change under the influence of gum



**Fig. 2. High level of lighting**

coloring. The hyperemic mucous membrane will give pink shades of enamel due to a reflex. The lipstick, the painted fingernails of the assistant can cause similar effect. When using cofferdam, it may cause blue or green shadows on the separate tooth area (Fig. 3).

The position of a tooth in the arcus can influence its illumination, therefore its optical perception. The tooth seems to be darker if it is located orally. If the tooth is located in vestibular position it seems to be light. The color of the shadows will also depend on mutual position of the teeth.

Reclining position of the patient in a dentist's chair will cause shade change and beams reflection and affect the tooth surface illumination. Thus, cervical crown area seems to be darker and cutting edge is very light.

The general color background in the room (dentist's office) is formed by a set of natural and artificial light, as well as the beams reflected from walls, curtains and other objects. So, the light reflected from a dark blue dressing gown contains more dark blue waves. It will affect the perception of tooth color parameters.

Color illumination can give a tooth its own coloring: pink, blue, green (Fig. 4). And the similar influence may be so much essential that it may cause some mistakes during the choice of standards not only by value, but by hue as well.

Besides, the daylight may have different spectral structure during the day: the hues have golden-pink color in the morning, they are reddish in the evening and grayish during a cloudy day. Tooth illumination with incandescent lamps can cause the mistakes during identification of tooth hue as the artificial light has more red waves and less dark blue ones in spectral structure in comparison with the sunlight.

Metamerism influences the tooth color perception and changes it depending on the nature of the light source (natural and artificial light) and the structure of the object dye (Fig. 5). In dentistry this phenomenon is caused by the fact that filling material contains pigments in its structure.

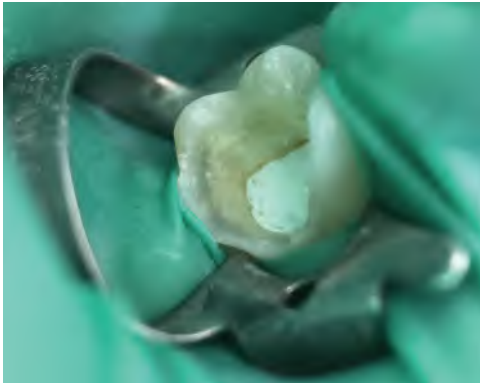
As dentine and composite pigments differ in their structure, the spectra of reflected light and, therefore, tooth color and fillings start to change as well.

The light level influences the tooth color perception. The tooth will seem to be discolored both at high and insufficient illumination. Tooth illumination should not exceed 1600–2400 lk. Higher level of illumination leads to the lowering of color depth and increasing of color value. Tooth color also loses its saturation at low illumination.

Tooth color is not distinguished at faint illumination, especially its details (the thinnest shades and gradation on saturation or color value). Tooth color is mainly defined in grey range. Change of the look from well to badly illuminated surfaces reduces visual acuity and color sensitivity.

The presence of optimal illumination is not yet a guarantee of the proper definition of tooth color hue by a dentist as there are unrealized psychological mechanisms, capable to influence the objectivity of tooth color identification. Being close together, colors can vary by color value, saturation and their tone. Therefore, the background plays an essential role in visual color definition. As it was mentioned above, it can create a reflex – the painted shadows (pink mucous gums, labium, tongue cause a pink coloration on the teeth).

This background can strengthen their own tooth hues. It may be explained by the phenomenon of simultaneous color contrast: reinforcement of perception of colors contrast (additional) intensity if they are located nearby. Dark blue color cofferdam strengthens intensity of sensation of yellow tooth hue. In the first case the perceived tooth



**Fig. 3. The influence of cofferdam color**



**Fig. 4. The effect of lighting color**



**Fig. 5. The phenomenon of metamerism**

color is yellower, and bluer than its own color in the second one. Red color of a lipstick or assistant fingernails will strengthen enamel green-blue tone. Teeth can fluoresce under the influence of ultraviolet rays (Fig. 6).

The tooth will be brighter on the dark background and darker on light one.

For example, the color of one and the same tooth differs on the background of bright lipstick or colorless labium border. Hyperemic gum makes darker background, and



**Fig. 6. The phenomenon of tooth fluorescence**

anemic one after anesthesia mucous gum makes bright background that will influence the perception.

These illusions are explained by the phenomenon of the color value contrast: the contrast of the color value sensation is reinforced on the border of two different by color surfaces. The teeth seem to be whiter on the dark skin background.

The detection of a tooth hue becomes impossible after examining it with incandescent lamp or sun glint because of the phenomenon of consistent contrast. Long consistent forms can be kept within 1–2 minutes, what makes difficult to perceive tone, color value and saturation.

If one holds a look at the colored background and then shifts onto dentition, the negative consistent form is created. The colors contrasted with the primary stimulus will be added to the tooth hue. For example, preliminary examining of the blue background will strengthen the perception of the yellowish tones in the tooth hues. The consistent form of the red stimulus (patient's clothes) will be light bluish-green and influences the perception of enamel color.

The individual attitude of a man to the color perception depends on experience, interests, knowledge, objectivity or adequacy (apperception). It considerably influences the interpretation of color and its qualities.

## ■ CONCLUSION

Objective and subjective factors influence the objectivity of color hue identification by a stomatologist. Illumination and background color are presented by the staff and patients' clothes, walls, curtains and furniture color in the dental surgery. The nearby background color is the hair, skin and patient's labia color. The presence of the background factors demands from the expert the analysis of working conditions and also keeping the references of the proper choice of the tooth color hues. However, doctors can make mistakes when choosing color if they take no account of working field illumination and background presence.

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