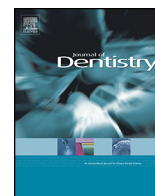




Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.intl.elsevierhealth.com/journals/jden



Dentine scattering, absorption, transmittance and light reflectivity in human incisors, canines and molars

Ioana-Sofia Pop-Ciutrita^{a,*}, Razvan Ghinea^b, Maria del Mar Perez Gomez^b,
Horatiu Alexandru Colosi^c, Diana Dudea^d, Mandra Badea^e

^a Department of Conservative Dentistry and Endodontics, Iuliu Hatieganu University of Medicine and Pharmacy, 33 Motilor Street, 400001 Cluj-Napoca, Romania

^b Department of Optics, Faculty of Science, University of Granada, Campus de Fuentenueva, s/n 18071 Granada, Spain

^c Department of Medical Informatics and Biostatistics, Faculty of General Medicine, Iuliu Hatieganu University of Medicine and Pharmacy, 6 Louis Pasteur Street, 400349 Cluj-Napoca, Romania

^d Department of Prosthodontics and Dental Materials, Iuliu Hatieganu University of Medicine and Pharmacy, 32 Clinicilor Street, Cluj-Napoca, Romania

^e Department of Preventive Dentistry, Iuliu Hatieganu University of Medicine and Pharmacy, 15 Victor Babes Street, Cluj-Napoca, Romania

ARTICLE INFO

Article history:

Received 1 April 2015

Received in revised form 23 June 2015

Accepted 25 June 2015

Available online xxx

Key words:

Scattering coefficient

Absorption coefficient

Transmittance

Light reflectivity

Human dentine

ABSTRACT

Objectives: To evaluate, using Kubelka-Munk reflectance theory, the scattering (S), absorption (K), transmittance (T) and light reflectivity (RI) of incisors, canines and molars human dentine.

Methods: Eighty-one human teeth (incisors, canines and molars) were used in this study. All teeth crowns were sectioned using a water-cooled diamond saw at low speed. The obtained dentine samples were polished to a final thickness of 2 mm. The relative spectral radiance was measured against black and white backgrounds, using a spectroradiometer in a viewing cabinet with D65 illuminant. Kubelka-Munk equations were used to calculate the scattering and absorption coefficients, transmittance and light reflectivity. Kruskal-Wallis rank sum test was performed to compare the mean values of Kubelka-Munk coefficients of human incisors, canines and molars dentine samples followed by Kruskal-Wallis multiple comparison tests for pairwise comparisons.

Results: The spectral behavior of S, T and RI exhibited similar trends for all three types of dentine samples. However, highly significant differences ($p < 0.001$) were found between their magnitudes in the three types of dentine samples ($p < 0.001$). Only the magnitudes of the K coefficients were found to be similar ($p = 0.235$) between incisors, canines and molars. Canine's dentine samples showed highest S and RI values, while human molars dentine samples exhibited highest K and T values.

Conclusions: Within the limitations of this study, the optical properties of human dentine are strongly influenced by the type of tooth. The results of the present study can be used as reference in the development of aesthetic dental restorative materials.

Clinical Implications: The significant differences identified in the optical behavior of the dentine from the three types of teeth have to be taken into consideration by the dentist and the dental technician when pursuing biomimetics with any restorative material in esthetic dentistry.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

The development of new substitutes identical to natural teeth requires a comprehensive evaluation of dental structures and a real understanding of its optical behavior. Not only the shape, size, position and surface irregularities of teeth promote a successful esthetic restoration, but also the combination of their optical properties. When light is guided towards a tooth surface, four phenomena can be described at the tooth level: (1) specular reflection and (2) diffuse light reflection at the surface, (3) absorption and scattering of the light flux within the dental structures and (4) specular transmission of the flux through the

* Corresponding author at: Department of Conservative Dentistry and Endodontics, Faculty of Dental Medicine, Iuliu Hatieganu University of Medicine and Pharmacy, 33 Motilor Street, 400001 Cluj-Napoca, ROMANIA, Fax: +0040264584216.

E-mail addresses: ioanasofia_ciutrita@yahoo.com (I.-S. Pop-Ciutrita), rghinea@ugr.es (R. Ghinea), mmperez@ugr.es (M.d.M. Perez Gomez), hcolosi@umfcluj.ro (H.A. Colosi), ddudea@umfcluj.ro (D. Dudea), mindrabadea@yahoo.com (M. Badea).

hard tissues [1]. The correlation between tooth color and the reflectance spectra has been investigated by several authors [2,3].

Kubelka-Munk described in 1948 [4] a simplified mathematical model of light traveling through translucent materials. Based on the two flux theory of light that comes in and out of a turbid or light scattered material, Kubelka-Munk treated, in a theoretical manner, the reflectance and transmittance of scattering and absorbing materials (homogeneous and nonhomogeneous) placed on different colored backings [5]. They expressed, through hyperbolic functions and practical formulas, the scattering (S) and absorption (K), wavelength dependent parameters of translucent materials, taking into account their thickness and the influence of the background.

For years, various reflectance measurements were performed in order to understand and explain the optical properties of enamel and dentine. The accuracy of Kubelka-Munk reflectance theory was demonstrated several times on tooth structures, in order to confirm whether this theory was capable of an accurate prediction of the reflectance spectra and color for specimens with different thicknesses on varying backings [2,6]. Kubelka-Munk equations were also used to quantify and calculate the absorption and scattering coefficients of different shades of resin composites [7,8] and porcelain materials [9–11]. It has been previously demonstrated that inherent color at infinite thickness, as well as color at any thickness on any backing, and translucency of direct restorative materials at any thickness can be accurately predicted using the Kubelka-Munk reflectance model [12]. The reflectance and transmission of dental enamel was measured by means of an integrating sphere at a wavelength in the range of 200–700 nm [1]. By computing the scattering and absorption coefficients, it was observed that the optical absorption of hard dental tissue is influenced by its organic components, respectively aromatic amino acids. Different studies reported that, by measuring the angular scattering distributions at a precise wavelength, for enamel and dentine samples of different thicknesses, the scattering and absorption coefficients of dentine, contrary to enamel, did not change significantly with wavelength [10,13]. The enamel scattering is stronger for shorter wavelengths (blue range) than for larger wavelengths (red range). The more the enamel scatters, the lighter the tooth [2]. In addition, the absorption coefficient of enamel is small [1]. Therefore, tooth color and appearance is mainly determined by the properties of dentine. However, it was demonstrated that in dentine the scattering processes are due mainly to the tubules, while other anatomical structures, such as collagen fibrils and the mineral crystals, are playing only a minor role [14–16]. With the purpose of better understanding the causes of tooth color and in order to explain the intensity of scattered light as a function of the scattering angle, several authors studied the direction of incident and scattered light within dentine. When the scattering coefficient was measured in the plane parallel to the tubules, its value was lower than the one obtained in the plane perpendicular to the tubules [17]. Although several studies on the reflectance spectra of enamel and dentine have been reported, to our knowledge, no comparison of these optical properties between different types of teeth has been performed so far. It is known that the distribution of the hard dental structures varies according to its morphology, as well as the thickness of enamel and dentine layers.

Therefore, the purpose of the present study was to measure and evaluate the spectral behavior of scattering, absorption, transmittance and light reflectivity of incisors, canines and molars human dentine, using Kubelka-Munk reflectance theory. The null hypothesis tested by our study was that scattering, absorption, transmittance and light reflectivity of dentine samples from human incisors, canines, and molars are not significantly different.

2. Materials and Methods

2.1. Preparation of human dentine samples

This study, approved by the Ethical Board of the local university (decision number 406), was conducted on 81 human teeth (33 maxillary central and lateral incisors, 7 canines and 41 molars). All teeth were extracted for orthodontic or periodontal reasons, cleaned from any debris under water jet with brushes and stored in distilled water at room temperature until their preparation. Teeth of small sizes or with pathological discolorations, cracks or fractures, caries, conservative or prosthetic restorations were excluded from the study. Every tooth was embedded in a mass of transparent acrylic resin (Premacryl Plus, Spofa Dental, Poland), leading to 81 cylindrical prisms of 3.5 cm height and 3.0 cm in diameter. Anterior maxillary teeth (canines, central and lateral incisors) were embedded with their labial surface towards the base of the prism, while molars were included inside the acrylic resin with their occlusal surface towards the base of the prism. The prisms with the teeth were sectioned using a diamond disc in a water-cooled diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA) at low speed (250/min). A custom-made metal support was used to fix the prisms in a perpendicular position to the saw blade. Therefore, the occlusal enamel for molars and the labial enamel for incisors and canines were removed through horizontal cutting from each prism, exposing the superficial dentine.

The samples were further manually polished by the same operator, under constant pressure, with wet 400-, 600-, 800-, 1000-, 1500- and 2000-grit silicon-carbide paper (Klingspor Schleifsysteme GmbH & Co., KG, Haiger, Germany), until 2 mm uniformly thick samples of mid coronal dentine, with a circumferential line of enamel, included in the center of a transparent acrylic mass of resin, was obtained (Fig. 1). The final thickness of the specimens was measured three times, using an electronic digital caliper (Powerfix Profi+, OWIM GmbH&Co.KG, Neckarsulm, Germany). All the samples were cleaned for 10 min in an ultrasonic bath with distilled water prior to measurements.

2.2. Spectral measurements

The relative spectral radiance ($W/sr \cdot m^2$) of all dentine samples were measured against a white ($L^* = 94.2$, $a^* = 1.3$ and $b^* = 1.7$) and a

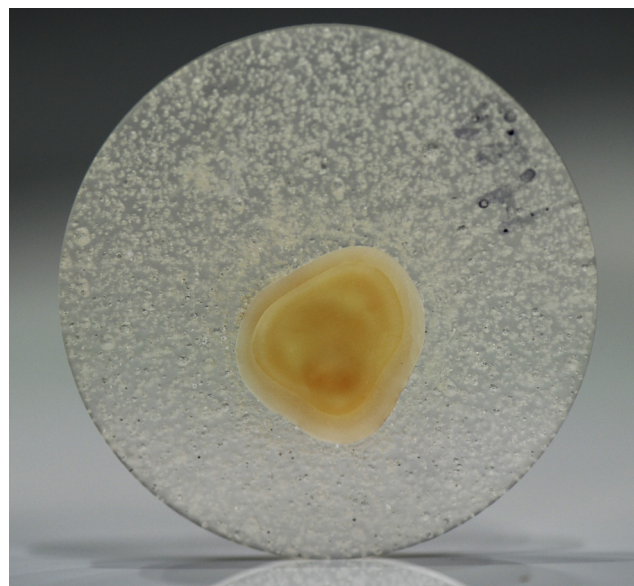


Fig. 1. Molar dentin sample.

Download English Version:

<https://daneshyari.com/en/article/6053080>

Download Persian Version:

<https://daneshyari.com/article/6053080>

[Daneshyari.com](https://daneshyari.com)