

Goncharuk-Khomyn Myroslav Yuriiovich,
PhD, Head of the Department of Therapeutic Dentistry,
Uzhhorod National University
ORCID ID: 0000-0002-7482-3881
Uzhgorod, Ukraine

Yasemin Yavuz,
PhD, Associate Professor, Department of Restorative Dentistry,
Harran University
ORCID ID: 0000-0001-5961-4996
Sanlıurfa, Turkey

Nesterenko Mariia Leonidivna,
Teaching Assistant at the Department of Therapeutic Dentistry,
Uzhhorod National University
ORCID ID: 0000-0002-4504-2947
Uzhhorod, Ukraine

Gangur Ivan Yuriiovich,
Senior Lecturer at the Department of Therapeutic Dentistry,
Uzhhorod National University
ORCID ID: 0000-0003-0651-0653
Uzhhorod, Ukraine

Use of caries annotation principles for caries assessment on intraoral scans to retain quality of clinically-oriented dental education

Introduction. Considering all the variety of the instruments that can be used during online study mode there is a significant amount of possibilities to improve its quality in general, while also to compensate lack of clinical component of the study to some extent.

Objective. To develop algorithm of intraoral scans-based caries annotation principles implementation into the online study process to retain quality of clinically-oriented dental education.

Materials and methods. Intraoral scans were obtained from dental patients of University Dental Clinic (Faculty of Dentistry, Uzhhorod National University) with the use Medit I500 device. Exocad view was used as an application to view intraoral scans of the patients. G.V. Black's and Mount & Hume's classification of caries were used for caries annotation, while students were also asked to specify the surface location of the caries and its spread as it was seen over intraoral scan.

Results and discussions. Use of caries annotation principles for caries assessment on intraoral scans helps to get students involved into modern digital dental technologies advance starting from the pre-clinical course level. Implementation of such approach on usual bases will help to get students familiar with features of intraoral scans as 3D graphical objects and manipulation with them, support understanding of intraoral scanning process in general, expand their knowledge regarding intraoral scans as patient's objective data which may be used for the diagnostics and treatment planning purposes.

Conclusion. Usage of caries annotation principles for caries assessment on intraoral scans tends to improve quality of caries topics teaching among undergraduate dental students and partially compensates limitations caused by the online mode of studying within ongoing war conditions in Ukraine. Digitalization of some parts of clinically-oriented dental education with the formulation of so-called «digital dental patient» education concept helps to retain proper clinical component of dental education in general, even though it is not tends to replace it, but to deepen original clinical knowledge based on the use of modern digital technologies.

Key words: digital dentistry, dental education, caries, intraoral scans.

Гончарук-Хомин Мирослав Юрійович, доктор філософії, завідувач кафедри терапевтичної стоматології, ДВНЗ «Ужгородський національний університет», ORCID ID: 0000-0002-7482-3881, м. Ужгород, Україна

Ясемін Явуз, кандидат медичних наук, доцент кафедри терапевтичної стоматології, Університет Харран, ORCID ID: 0000-0001-5961-4996, м. Шанлиурфа, Туреччина

Нестеренко Марія Леонідівна, асистент кафедри терапевтичної стоматології, ДВНЗ «Ужгородський національний університет», ORCID ID: 0000-0002-4504-2947, м. Ужгород, Україна

Гангур Іван Юрійович, старший викладач кафедри терапевтичної стоматології, ДВНЗ «Ужгородський національний університет», ORCID ID: 0000-0003-0651-0653, м. Ужгород, Україна

Використання принципів анотації карієсу для оцінки каріозних уражень на внутрішньоротових сканах з метою підтримки якості клінічно-орієнтованого стоматологічного навчання

Вступ. Враховуючи чисельну різноманітність інструментів, які можуть бути використані під час онлайн-навчання, існує значна кількість можливостей покращити його якість в цілому, а також певною мірою компенсувати відсутність належної клінічної складової.

Мета. Розробити алгоритм впровадження принципів анотації карієсу на основі внутрішньоротових сканів в онлайн-режим навчального процесу для підтримки якості клінічно-орієнтованого стоматологічного навчання в цілому.

Матеріали та методи. Внутрішньоротові скани були отримані від стоматологічних пацієнтів Університетської стоматологічної клініки (стоматологічний факультет, ДВНЗ «Ужгородський національний університет») за допомогою апарату Medit I500. Exocad view використовувався як додаток для перегляду внутрішньоротових сканів пацієнтів. Для анотації карієсу використовували класифікацію карієсу за Блеком та за Mount & Hume, а також студентів просили анотувати локалізацію карієсу по поверхням та його поширення за ознаками, візуалізованими на інтраоральних сканах.

Результати та обговорення. Використання принципів анотації карієсу для оцінки каріозних уражень на інтраоральних сканах допомагає ознайомити студентів із сучасними цифровими стоматологічними технологіями, починаючи з рівня доклінічного курсу навчання. Реалізація такого підходу допоможе ознайомити студентів з особливостями внутрішньоротових сканів як тривимірних графічних об'єктів та принципами роботи з ними, сприятиме формуванню розуміння процесу внутрішньоротового сканування в цілому, та розширить їхні знання щодо внутрішньоротових сканів як об'єктивних даних пацієнта, які можуть бути використані з метою діагностики та планування лікування.

Висновок. Використання принципів анотації карієсу для оцінки каріозних уражень на внутрішньоротових сканах сприяє підвищенню якості викладання тем, присвячених вивченню карієсу, студентам-стоматологам, і частково компенсує обмеження, спричинені онлайн-режимом навчання в умовах війни, що триває в Україні. Цифровізація деяких компонентів клінічно-орієнтованої стоматологічної освіти з формулюванням так званої концепції цифрового стоматологічного пацієнта допомагає підтримувати належний рівень клінічної складової процесу стоматологічного навчання в цілому, та поглибити клінічні знання на основі використання сучасних цифрових технологій.

Ключові слова: цифрова стоматологія, стоматологічна освіта, карієс, внутрішньоротові скани.

Introduction. Online mode of studying among Ukrainian state higher education institutions have been presented as one of the ways to retain ongoing education process during COVID-19 pandemic era [1, 2, 3]. Meanwhile, among all other humanitarian losses war on the territory of Ukraine caused by Russian military invasion also compromised integrity of educational process in general [3, 4, 5]. Due to the principal tendency of keeping students health and life out of any danger within education institution, online mode of studying again was chosen as one of the most appropriate at present ongoing war conditions among many of state universities [3, 4, 5].

But even considering all the advantages of online mode of studying either during COVID-19 sanitary restrictions, or during limitations caused by the war-associated impact, such educational approach could not compensate all the needs and requests among specialties with obligatory clinical component included in their study programs [3, 4, 5, 6]. Considering all the variety of the instruments that can be used during online study mode there is a significant amount of possibilities to improve its quality in general, while also to compensate lack of clinical component of the study to some extent [7].

Digitalization of dental education process has been widely described in number of previous studies, and is closely related with the improvements of digital dentistry in general [8, 9, 10]. Nowadays access to the variety of digital dental instruments and software is rather simple and non-limited, so their implementation into study process of dental students seems to be logical and perspective [8, 9, 10, 11].

Objective. To develop algorithm of intraoral scans-based caries annotation principles implementation into the online study process to retain quality of clinically-oriented dental education.

Methodology and methods of research. Intraoral scans (IOS) were obtained from dental patients of University Dental Clinic (Faculty of Dentistry, Uzhhorod National University) with the use Medit I500 device (MEDIT Corp., Seoul, Republic of Korea), which was provided to the Department of Restorative Dentistry (Uzhhorod National University) as a part of humanitarian educational help by LYRA etk company (Sallanches, France). All the patients have signed informed consent form regarding potential

use of their anonymized dental scans for the research or educational objective with no disclosure of any of their personal information or identity. IOS data was exported with obtainment of *.ply format of the file.

Exocad view (exocad GmbH, Darmstadt, Germany) was used as an application to view intraoral scans of the patients. It may be used either in the form of cell-phone application, or online via web-browser (<https://webview.dental/>) (fig. 1).



Fig. 1. Interface of Exocad webview for the analysis of intraoral scans

Annotation of caries lesions after IOS analysis within Exocad view application was held at the Excel Spreadsheet Software (Microsoft, USA), where all the numbering of teeth was already provided.

G.V. Black's and Mount & Hume's classification of caries were used for caries annotation, while students were also asked to specify the surface location of the caries and its spread as it was seen on the intraoral scan.

Algorithm of caries annotation principles on the base of IOS was implemented into the study process of 3rd year students by the following manner developed for the one class with 90 minutes duration:

1) students were advised to download Exocad view application on their smartphones, or used it via online mode in browser;

2) set of intraoral scans in the amount of 5 and pre-filled Excel Spreadsheet Form were sent to students' university-linked emails;

3) students opened obtained IOS through the Exocad view;

4) students were asked to fill the Excel Spreadsheet Form with already provided numbering of the teeth notating the presence of caries lesions within different teeth and its classification by the G.V. Black and Mount & Hume's, while also specifying its location on the tooth surface and extent if possible;

5) filled Excel spreadsheet forms were sent back to the teaching assistant for the review;

6) analysis of correct manner of annotation was held together with students and teachers in the discussion online mode by sharing the screen with intraoral scan representation and pointing on the main features of caries lesions.

Main material presentation. Above-presented algorithm of caries annotation based on the intraoral scans helps to demonstrate students real-life clinical situations with caries lesions and to deepen their knowledge regarding caries localization and classification due to the generally-accepted criteria (Fig. 2).

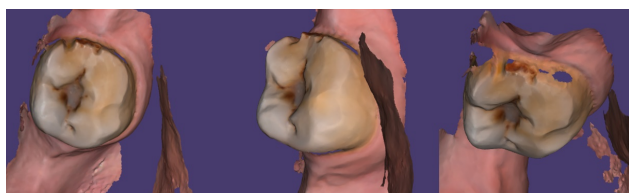


Fig. 2. Visualization of caries on mandibular molar in different projections using Exocad webview

In present approach we propose to use two classifications of caries by G.V. Black and Mount & Hume respectively, since the first one focused on caries categorization mostly based on different localization, while other one consider factor of caries lesion extent over hard dental tissue [12]. Moreover, it is important to blend students' knowledge by using two classification approaches to demonstrate more clinically-important peculiarities of caries pathology, while also representing how different approaches of caries classification could complement each other [9, 10, 11, 13, 14] (fig. 3).

Use of caries annotation principles for caries assessment on intraoral scans also helps to get students involved into modern digital dental technologies' advances starting from the pre-clinical course level [13, 14]. Implementation of such approach on usual bases will help to get students familiar with features of intraoral scans as 3D graphical objects and manipulation with them, support understanding of intraoral scanning process in general, expand their knowledge regarding intraoral scans as patient's objective data which may be used for the diagnostics and treatment planning purposes [10, 11, 12, 13].

In future it is planned to organize study process in the manner that students will not just annotate caries within spreadsheet form in descriptive manner, but also will have possibility to contour caries lesion over problematic tooth in "painting mode" over IOS as graphical 3D object.

Purpose of this paper is just to demonstrate already developed and implemented approach, which is aimed to compensate clinical component deficiency during online mode of studying held either during COVID-19 pandemic sanitary restrictions, or nowadays during ongoing war-related limitations. Future studies will be dedicated to the quantification of such approach effect on the quality of dental education and students subjective satisfaction with such blended method of teaching.

Modern advances in digital dentistry expand teaching possibilities to the great extent by providing instruments for sharing features of intraoral and lab-scanning, 3D printing, CAD-CAM technology, virtual and augmented reality, CBCT analysis and complex treatment planning, while modern online teaching tools made it possible to directly involve students into all above-mentioned processes through the adapted software [8, 9, 10, 11, 12].

Proposed approach is promoting step into development of so-called «digital dental patient» education concept, part of which has been already implemented in the form of caries annotation over obtained intraoral scans. Nevertheless, it should be kept in mind that primary goal of digital-based dental education is to improve and enhance understanding of clinical aspects, but not to replace clinical component of the education itself; even though in the condition of limited

Teeth	Class by Black	Site	Size	Surface	Severity																														
1.7	I	1	2 Occlusal	Within dentine																															
Black's classification		Classification by Mount and Hume																																	
G.V. Black																																			
<table border="1"> <thead> <tr> <th>SITE</th> <th colspan="5">SIZE</th> </tr> <tr> <th></th> <th>No Cavity 0</th> <th>Minimum 1</th> <th>Moderate 2</th> <th>Enlarged 3</th> <th>Extensive 4</th> </tr> </thead> <tbody> <tr> <td>Pit/fissure 1</td> <td>1.0</td> <td>1.1</td> <td>1.2</td> <td>1.3</td> <td>1.4</td> </tr> <tr> <td>Contact area 2</td> <td>2.0</td> <td>2.1</td> <td>2.2</td> <td>2.3</td> <td>2.4</td> </tr> <tr> <td>Cervical 3</td> <td>3.0</td> <td>3.1</td> <td>3.2</td> <td>3.3</td> <td>3.4</td> </tr> </tbody> </table>						SITE	SIZE						No Cavity 0	Minimum 1	Moderate 2	Enlarged 3	Extensive 4	Pit/fissure 1	1.0	1.1	1.2	1.3	1.4	Contact area 2	2.0	2.1	2.2	2.3	2.4	Cervical 3	3.0	3.1	3.2	3.3	3.4
SITE	SIZE																																		
	No Cavity 0	Minimum 1	Moderate 2	Enlarged 3	Extensive 4																														
Pit/fissure 1	1.0	1.1	1.2	1.3	1.4																														
Contact area 2	2.0	2.1	2.2	2.3	2.4																														
Cervical 3	3.0	3.1	3.2	3.3	3.4																														

Fig. 3. Representation of caries annotation held within Microsoft Excel spreadsheet based on the received intraoral scans

access to the real-time clinical study digital approach may compensate it to some extent if such would be properly used in structured manner.

Conclusion. Usage of caries annotation principles for caries assessment on intraoral scan tends to improve quality of caries topics teaching among undergraduate dental students and partially compensates limitations caused by the online

mode of studying within ongoing war conditions in Ukraine. Digitalization of some parts of clinically-oriented dental education with the formulation of so-called «digital dental patient» education concept helps to retain proper clinical component of dental education in general, even though it is not tends to replace it, but to deepen original clinical knowledge based on the use of modern digital technologies.

ЛІТЕРАТУРА

1. Paudel P. Online Education: Benefits, Challenges and Strategies During and After COVID-19 in Higher Education. *International Journal on Studies in Education*. 2021. Vol. 3(2). P. 70-85.
2. Teymori A. N., Fardin M. A. COVID-19 and educational challenges: A review of the benefits of online education. *Annals of Military and Health Sciences Research*. 2020. Vol. 18(3). P. In press.
3. Armitage R., Pavlenko M. Medical education and war in Ukraine. *British Journal of General Practice*. 2022. Vol. 72(721). P. 386-386.
4. Impact of war on foreign students' satisfaction with quality of dental and medical education in Ukraine / M. Goncharuk-Khomyn, V. Kaliy, R. Pohorilyak et al. *Brazilian Oral Research*. 2023. Vol. 37. P. e026.
5. Medical education in times of war: a mixed-methods needs analysis at Ukrainian medical schools / A. Mayer, O. Yaremko, T. Shchudrova et al. *BMC Medical Education*. 2023. Vol. 23(1). P. 804.
6. War on Ukraine: Impact on Ukrainian medical students / B.S. Srichawla, M.A.K. Tabari, M.A. Găman et al. *International journal of medical students*. 2022. Vol.10(1). P. 15.
7. Pei L., Wu H. Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Medical education online*. 2019. Vol. 24(1). P. 1666538.
8. Digital undergraduate education in dentistry: a systematic review / N.U. Zitzmann, L. Matthisson, H. Ohla et al. *International journal of environmental research and public health*. 2020. Vol. 17(9). P. 3269.
9. Saghiri M. A., Vakhnovetsky J., Nadershahi N. Scoping review of artificial intelligence and immersive digital tools in dental education. *Journal of Dental Education*. 2022. Vol. 86(6). P. 736-750.
10. Park J. C., Kwon H. J. E., Chung C. W. Innovative digital tools for new trends in teaching and assessment methods in medical and dental education. *Journal of Educational Evaluation for Health Professions*. 2021. Vol. 18. P. 13
11. Digital technology in dental education during COVID-19 pandemic: worldwide experience of professors and students / E.D. Costa, D.M. Brasil, G.M. Santaella et al. *Odovtos International Journal of Dental Sciences*. 2021. Vol. 23(3). P. 179-208.
12. A review of dental caries classification systems / M. Shruthi, D. Srinivasan, S. Eagappan et al. *Research Journal of Pharmacy and Technology*. 2022. Vol. 15(10). P. 4819-4824.
13. Deep learning for caries detection and classification / L. Lian, T. Zhu, F. Zhu et al. *Diagnostics*. 2021. Vol. 11(9). P. 1672.
14. Self-supervised learning methods for label-efficient dental caries classification / A. Taleb, C. Rohrer, B. Bergner et al. *Diagnostics*. 2022. Vol. 12(5). P. 1237.

REFERENCES

1. Paudel, P. (2021). Online Education: Benefits, Challenges and Strategies During and After COVID-19 in Higher Education. *International Journal on Studies in Education*, 3(2), 70-85.
2. Teymori, A. N., & Fardin, M. A. (2020). COVID-19 and educational challenges: A review of the benefits of online education. *Annals of Military and Health Sciences Research*, 18(3).
3. Armitage, R., & Pavlenko, M. (2022). Medical education and war in Ukraine. *British Journal of General Practice*, 72(721), 386-386.
4. Goncharuk-Khomyn, M., Kaliy, V., Pohorilyak, R., Cavalcanti, A., Keniuk, A., Yavuz, Y., & Olena, B. (2023). Impact of war on foreign students' satisfaction with quality of dental and medical education in Ukraine. *Brazilian Oral Research*, 37, e026.
5. Mayer, A., Yaremko, O., Shchudrova, T., Korotun, O., Dospil, K., & Hege, I. (2023). Medical education in times of war: a mixed-methods needs analysis at Ukrainian medical schools. *BMC Medical Education*, 23(1), 804.
6. Srichawla, B. S., Tabari, M. A. K., Găman, M. A., Munoz-Valencia, A., & Bonilla-Escobar, F. J. (2022). War on Ukraine: Impact on Ukrainian medical students. *International journal of medical students*, 10(1), 15.
7. Pei, L., & Wu, H. (2019). Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Medical education online*, 24(1), 1666538.
8. Zitzmann, N. U., Matthisson, L., Ohla, H., & Joda, T. (2020). Digital undergraduate education in dentistry: a systematic review. *International journal of environmental research and public health*, 17(9), 3269.
9. Saghiri, M. A., Vakhnovetsky, J., & Nadershahi, N. (2022). Scoping review of artificial intelligence and immersive digital tools in dental education. *Journal of Dental Education*, 86(6), 736-750.
10. Park, J. C., Kwon, H. J. E., & Chung, C. W. (2021). Innovative digital tools for new trends in teaching and assessment methods in medical and dental education. *Journal of Educational Evaluation for Health Professions*, 18.
11. Costa, E. D., Brasil, D. M., Santaella, G. M., Cascante-Sequeira, D., Ludovichetti, F. S., & Freitas, D. Q. (2021). Digital technology in dental education during COVID-19 pandemic: worldwide experience of professors and students. *Odovtos International Journal of Dental Sciences*, 23(3), 179-208.
12. Shruthi, M., Srinivasan, D., Eagappan, S., Louis, J., Natarajan, D., & Meena, S. (2022). A review of dental caries classification systems. *Research Journal of Pharmacy and Technology*, 15(10), 4819-4824.
13. Lian, L., Zhu, T., Zhu, F., & Zhu, H. (2021). Deep learning for caries detection and classification. *Diagnostics*, 11(9), 1672.
14. Taleb, A., Rohrer, C., Bergner, B., De Leon, G., Rodrigues, J. A., Schwendicke, F., ... & Krois, J. (2022). Self-supervised learning methods for label-efficient dental caries classification. *Diagnostics*, 12(5), 1237.