

## ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

# Variability in the integration of minimum intervention principles in caries management among dental students

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## SUMMARY

**Introduction/Objective** The aim of the study was to assess the knowledge and attitudes of dental students and young dentists towards caries management and principles of minimum intervention cariology.

**Methods** Students filled in the online questionnaire that included: 1) attitudes and knowledge about the use of caries risk (CR) assessment tools in clinical practice; 2) treatment plans in clinical case scenarios of smooth surface and occlusal caries in relation to CR; 3) impact of different diagnostic procedures on the management of dentin caries, tooth preparation and preferred restoration techniques and materials.

**Results** The majority of students thought that CR should influence the treatment plan. Oral hygiene was considered the most important CR factor. More invasive treatment was chosen in high CR patients. The most important criterion for caries removal was dentin hardness. The majority of students would completely remove soft dentine in deep caries lesions, either in one-step or two-step preparation technique. Composite was the most frequently selected restorative material.

**Conclusion** Conventional approach to caries management is still widely accepted among students and young dentists. Their knowledge of minimum intervention dentistry is limited. Periodic assessment of implemented curriculum and teachers' calibration could serve as resources for improving the teaching process.

**Keywords:** dental students; knowledge; cariology; minimum intervention

## INTRODUCTION

Operative treatment of dental caries traditionally involved removal of all infected tissues and their replacement with a restoration [1]. For many decades, teaching operative dentistry was based on demonstrating techniques for complete caries removal. The most recent understanding of caries pathophysiology, advancement in the field of remineralization agents, and the accessibility to adhesive materials, changed the conventional caries management towards minimum intervention (MI) oral care [2]. However, many dental practitioners consider MI procedures as temporary aid in caries treatment [3, 4].

School of Dental Medicine of the University of Belgrade is the oldest dental school in the Western Balkans region. The Curriculum in Cariology for undergraduate students shares similar learning outcomes with European Core Curriculum in Cariology [5]. Students are introduced to the fundamental mechanisms of dental caries in pre-clinical courses, such as General and Oral Biochemistry, and Microbiology and Immunology. As students progress to the final undergraduate year, they gain knowledge about various aspects of caries prevention and management. Theory and

practice are integrated into the course of Preventive Dentistry, Restorative Odontology, Pediatric Dentistry, Public Health, and elective courses. The courses are designed to equip students with knowledge on both traditional and contemporary aspects of delivering oral health care. Curriculum sets general learning objectives, but the presentation of information, expertise, and resources may vary among faculty members. This variation can be either beneficial or counterproductive for future graduates. Understanding MI can be complex and overwhelming for students, especially at the beginning of their education.

The aim of the study was to assess the knowledge and attitudes of dental students and young dentists towards caries management and principles of MI cariology.

## METHODS

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee (document 36/10). The following groups of undergraduate students were invited to fill in the online questionnaire: fourth-year students who completed the Preventive Dentistry course and

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participated in the clinical course of Restorative Dentistry; fifth-year students who passed Restorative Dentistry and were currently practicing Pediatric Dentistry, and sixth-year students who finished the aforementioned courses. Additionally, students enrolled in the internship program were invited to participate in survey.

The questionnaire was based on the ones previously used to evaluate attitudes towards caries risk (CR) assessment (CRA) [6, 7], enamel [6, 7], and dentin [8] caries treatment, and cavity restoration [9]. Two bilingual researchers experienced in conducting surveys translated the selected questions from the aforementioned questionnaires from English to Serbian. An independent bilingual researcher conducted the back-translation to English with only a few discrepancies. Research team reviewed translations and reached consensus on the final version. The questionnaire was pilot-tested by 45 undergraduate students (15 students from each study year). Students completed the questionnaire, provided their feedback, and confirmed understanding of all the questions.

Besides demographics, the questionnaire included three parts. Questions in the first part were related to attitudes and knowledge about the use of CRA in clinical practice, and the impact of different CR factors. The second part analyzed the choice of caries treatment for smooth and occlusal surfaces according to CR in clinical case scenarios. The third part aimed to assess students' understanding of how different diagnostic procedures influence dentin caries treatment, their attitudes towards caries removal criteria and methods, and preferred cavity restoration techniques.

Students were invited through the website of the Belgrade School of Dental Medicine, and social media. Google Forms was used as the platform to create the online questionnaire and collect data. E-mail verification was used to prevent the multiple participation. In a short note preceding the questionnaire, students were informed on the research purpose, and that their participation was voluntary and anonymous. Completing the questionnaire and submitting of the answers were considered to be the consent to participate in the survey. Students were allowed to select multiple answers and write explanations to further clarify their opinions. The survey was opened for six weeks.

Statistical analysis was performed using IBM SPSS Statistics 20.0 (IBM, Armonk, N.Y., USA). Data were first descriptively analyzed. The groups were compared using Fisher's exact test, with statistical significance set at  $p < 0.05$ . In order to account for multiple comparisons, the Bonferroni correction was applied, and statistical significance was determined using a Bonferroni-corrected significance level.

The article was written in accordance with the ethical standards of the institutions and the journal.

## RESULTS

A total of 221 questionnaires were completed resulting in an average response rate of 41%. Specifically, 35% of the fourth-year, 32% of the fifth-year, 48% of the sixth-year

undergraduate students, and 64% of graduate students participated.

### Caries risk assessment

Most of the participants (96%) believed that a patient's CR should influence the treatment plan, but only 41% performed the CRA in their clinical practice (Table 1). The CRA was not consistently implemented because teaching staff did not enforce it (39%). Some students lacked the knowledge of how to perform CRA (21%), while others did not have time to do it (21%), and 11% considered the CRA unnecessary. Oral hygiene, patient's motivation and diet were considered to be the top three factors for determining CR.

**Table 1.** Attitudes towards caries risk assessment

Variable	4th-year students	5th-year students	6th-year students	DDS	Total
Do you perform CRA?					
Yes (%)	30	46	43	44	41
No (%)	70	54	57	56	59
Should CRA influence the treatment plan?					
Yes (%)	95	98	97	97	97
No (%)	5	2	3	3	3
How well are you informed about CRA?					
Well (%)	23	37	25	9	25
Partially (%)	36	22	23	38	28
Insufficiently (%)	41	41	52	53	47

CRA – caries risk assessment;  
DDS – doctors of dental surgery

### Enamel caries

Selected options for the treatment of smooth and occlusal surfaces are presented in Table 2.

For the white spot lesion, students chose more invasive treatment for high CR compared to low CR patients. No differences in the selected treatment options were found between undergraduate students of different study years (except for obvious cavity in high CR patients), between students and young dentists, or between male and female students.




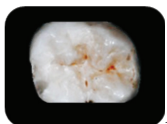

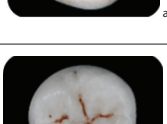
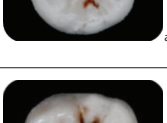
The upward trend in selecting more invasive treatment for occlusal caries was noticed in both low and high CR patients. A small number of students stated that they would need additional diagnostic tools in the decision-making process.

### Dentin caries

A thorough anamnesis was considered crucial for the proper diagnosis of dentin caries, followed by radiographic findings and vitality testing.

Seventy-six percent of respondents would perform tooth preparation using rotary instruments. Rotary in combination with hand instruments in pulp proximity were the preferred method of caries removal for 23%, mainly senior students (Table 3).

**Table 2.** Treatment options for enamel lesion according to the caries risk (%)

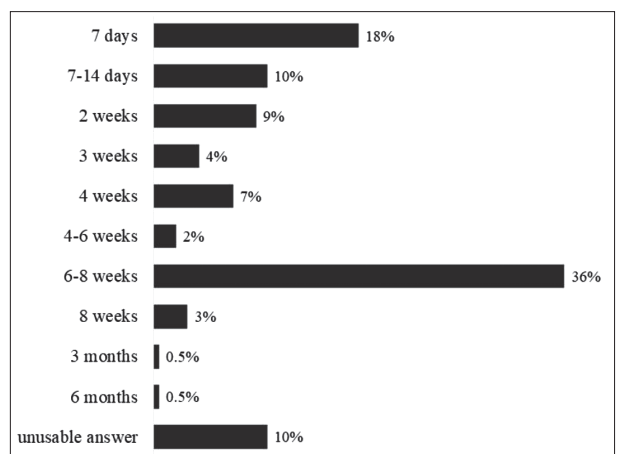
Treatment options	Low CR					High CR					
	4th-year students	5th-year students	6th-year students	DDS	Total	4th-year students	5th-year students	6th-year students	DDS	Total	
 a	O	30	24	32	28	29	4	0	4	72	13
	REM	64	76	68	72	69.5	53	57	71	28	57
	REST	2	-	-	-	0.5	39	41	25	-	29
	NA	4	-	-	-	1	4	2	-	-	1
 a	O	7	4	8	3	6	2	-	3	-	1
	REM	45	52	63	66	56	12	13	20	9	15
	REST	36	39	29	28	33	77	88	74	91	80
	NA	12	5	-	3	5	9	2	3	-	4
 b,c	O	2	2	3	-	2	3	-	4	-	2
	REM	7	11	11	16	11	2	2	3	-	2
	REST	86	87	83	84	85	86	98	93	100	94
	NA	5	-	3	-	2	9	-	-	-	2
 a	O	21	19	7	28	17	2	9	1	-	3
	REM	20	11	18	9	15	11	7	12	19	11
	FS	54	70	75	63	66.5	62	69	62	62	65
	REST	2	-	-	-	0.5	20	15	25	19	20
 a,b	O	12.5	11	14	22	14	-	6	-	-	1
	REM	11	7	12	9	10	7	9	5	9	7
	FS	32	52	34	53	41	25	26	6	22	18
	REST	32	26	39	16	31	57	59	89	69	71
 a,d	O	9	11	-	13	7	-	4	-	-	1
	REM	7	4	9	6	7	3	2	2.5	6	3
	FS	27	20	16	31	22	9	7	2.5	3	5
	REST	52	65	72	50	62	77	87	95	91	88
 a,d	O	3	2	2.5	-	2	3	-	-	-	1
	REM	2	2	2.5	-	2	2	-	2.5	-	1
	FS	7	2	2.5	3	4	2	-	-	-	0.5
	REST	85	94	92.5	94	91	90	100	95	100	95.5
NA	3	-	-	3	1	3	-	2.5	-	2	

CR – caries risk; O – observation; REM – remineralization; FS – fissure sealing; REST – restoration; NA – do not know; DDS – doctors of dental surgery; <sup>a</sup>p = 0.000 (Fisher's exact test) between low and high caries risk; <sup>b</sup>p < 0.0125 (Fisher's exact test, Bonferroni-corrected p-value) for the treatment choice in high caries risk patients among students of different study years; <sup>c</sup>p < 0.0125 (Fisher's exact test, Bonferroni-corrected p-value) between low and high caries risk; <sup>d</sup>p < 0.0125 (Fisher's exact test, Bonferroni-corrected p-value) for the treatment choice in low caries risk patients among students of different study years

Dentin hardness was reported as the most important criterion for assessing the endpoint of caries removal. Even in deep cavities, the vast majority (99%) would excavate all softened dentin, and finished the preparation in either leathery or hard dentin. Half of the respondents did not consider the color of dentin a relevant criterion. Eighty-one percent of students believed that all microorganisms should be removed from the cavity, otherwise caries might progress (Table 3). Senior students tended to prefer conservative treatment compared to their younger peers.




Treatment choices for clinical scenario involving an asymptomatic tooth with dentin caries were usually removal into leathery or hard dentin (Table 3). In deep asymptomatic caries lesions, 86% of students opted for complete caries removal. Stepwise excavation was the preferred option for incomplete dentin removal (Table 4).

Students were indecisive when choosing calcium hydroxide treatment duration for deep caries (Figure 1).



**Figure 1.** Duration of calcium hydroxide treatment

**Table 3.** Attitudes towards caries excavation (%)

Variable	4th-year students	5th-year students	6th-year students	DDS	Total
<b>Preferred caries removal method<sup>a</sup></b>					
Rotary instruments	87	80	67	72	76
Hand instruments	4	-	1	-	1
Combination	9	20	32	28	23
<b>Hardness</b>					
Soft dentin should be removed	98	100	97	100	98.6
Leathery dentin should be removed	2	-	-	-	0.4
Irrelevant	-	-	3	-	1
<b>Color<sup>b</sup></b>					
Normal dentin	75	28	36	41	44
Stained dentin	2	7	6	-	5
Irrelevant	23	65	58	59	51
<b>Microorganisms<sup>c</sup></b>					
All bacteria need to be removed, otherwise caries might progress	95	89	71	72	81
Some bacteria may be left beneath a tightly sealed restoration	5	9	28	28	18
Depends on restorative strategy	-	2	1	-	1
<b>Cariou dentin<sup>c</sup></b>					
Cariou dentin should always be removed completely, otherwise it might influence the pulp vitality	84	65	52	88	68
Cariou dentin in close proximity to the pulp should be left to avoid pulp exposure	14	30	46	12	29
Depends on restorative strategy	2	5	2	-	3
<b>Border of the preparation<sup>c</sup></b>					
	7	9	13	22	12
	70	41	29	53	46
	21	42	52	25	38
More tissue should be removed (all dentin with changed color)	-	4	1	-	1
Cannot decide without probing	2	4	5	-	3

DDS – doctors of dental surgery;

<sup>a</sup>p < 0.0125 (Fisher's exact test, Bonferroni-corrected p-value) between students of different study years;

<sup>b</sup>p = 0.000 (Fisher's exact test) between students of different study years;

<sup>c</sup>p < 0.001 (Fisher's exact test) between students of different study years

Glass-ionomer (47%) and zinc phosphate cement (44%) were usually chosen as temporary restorations.

Most students would opt to place a liner/base under a permanent restoration of deep cavity. Composite was the most frequently selected material for permanent restoration (Table 4).

## DISCUSSION

The field of MI dentistry and advancements in biomaterials have been continuously expanding. It is important for undergraduate dental students to be exposed to and gain experience with new technologies and techniques. However, many professionals and dental educators resist successful implementation of MI across the oral healthcare sector. Students' answers might reflect the way they were educated.

There was no consensus among students regarding caries diagnostics, non-restorative and restorative management. Often, students are overwhelmed with information and faced with numerous possibilities, yet they lack the specific tools needed to define the appropriate approach to caries management. Various methodological tactics, instructional strategies, practical applications, and teachers' attitudes could potentially lead to confusion or overconfidence among students. The insecurities often become apparent during final exams and later in graduate programs.

Individual treatment plan should rely on the patient's CR. Dentists must be able to identify the components of the disease and create appropriate treatment plan. General dentists usually perform CRA, but often without specific forms and clear rules [6, 7, 10]. The present study revealed that students felt insufficiently informed about CRA. The CR factors and assessment methods are taught meticulously in the course of Preventive Dentistry during the second study year. It seems that CRA demonstration and practice are neglected during the fourth study year in the Restorative Dentistry course. In the fifth study year, CRA is presented as obligatory during clinical practice in Pediatric Dentistry. The inconsistencies in the educational process limit students' ability to determine the correct approach. Students are left uncertain whether CRA is a necessity in the diagnostic process or just an occasionally employed tool. Similarly, French students expressed confusion regarding the necessity of CRA [11]. Some stated

that CRA was not adequately demonstrated (31%), while others admitted having insufficient knowledge (23.5%). CRA was not important for 11% of Serbian students and for 2% of their French peers. Serbian and French students agreed on the hierarchy of CRA factors. Nasseripour et al. [12] highlighted the importance of addressing the lack of knowledge and motivation to perform the CRA not only among students but, more importantly, also among educators in the future cariology curricula.

Early intervention was more likely to be chosen in patients with high CR. Although non-invasive caries

**Table 4.** Restoration of a deep caries lesion (%)

Variable	4th-year students	5th-year students	6th-year students	DDS	Total
Restoration of deep caries lesion <sup>a</sup>					
complete removal of carious dentine + temporary restoration + definitive restoration in next visit	53	31	38	34	40
complete removal of carious dentine + definitive restoration	34	46	53	50	46
partial removal to soft dentine + temporary restoration + definitive restoration in next visit	11	17	5	16	11
partial removal to soft dentine + definitive restoration	2	6	1	-	2
depends on a case scenario	-	-	3	-	1
Materials for indirect pulp capping					
Ca(OH) <sub>2</sub> -based liner	73	70	72	66	71
MTA	22	26	23	28	24
Biodentine	5	4	4	6	4.5
No liner	-	-	1	-	0.5
Materials for permanent restoration <sup>b,c</sup>					
GIC	37	17	18	6	21
Composite	30	78	69	53	59
"Sandwich" technique	29	5	13	35	18
Amalgam	4	-	-	6	2

GIC – glass-ionomer cement, MTA – mineral trioxide aggregate;

<sup>a</sup>p < 0.0167 (Fisher's exact test, Bonferroni-corrected p-value) between students of different study years;

<sup>b</sup>p = 0.000 (Fisher's exact test) between students of different study years;

<sup>c</sup>p < 0.0167 (Fisher's exact test, Bonferroni-corrected p-value) between undergraduate and postgraduate students

management is recommended for non-cavitated smooth surface lesions [13], one third of students would perform invasive treatment in high-CR patients. This finding might provoke two possible explanations. The first one suggests a lack of knowledge about caries development, and the concept of non-invasive caries management. The second is that students might be uncertain about their knowledge and experience with non-invasive procedures, so they chose "safer" invasive treatment to avoid errors.

Recent literature suggests that resin infiltration might be a suitable option for esthetically concealing white spot lesions with a greater masking effect than remineralization techniques [14]. It is only recently that the resin infiltration technique has become a part of the cariology curriculum at the Belgrade School of Dental Medicine. For that reason, it was not offered as an option for the smooth surface treatment in the questionnaire.

For "suspicious" non-cavitated fissures that could have benefit from fissure sealing [13], the majority of students chose restorative treatment. Booth et al. [15] reported that high CR led to early restorative intervention of non-cavitated occlusal lesions. Similarly, French students tend to perform operative treatment for "suspicious" occlusal surfaces [16], due to the fear of existing caries progression under the sealant [11].

The most often selected cavity preparation technique was rotary instruments. Senior undergraduate students were in favor of a less invasive approach to caries removal in comparison to the younger ones. Gasqui et al. [17] reported frequent use of hand instruments in the close

proximity of pulp among French students, who also chose chemo-mechanical caries removal and polymer/ceramic burs. Although dental professionals in Serbia are familiar with novel cavity preparation techniques, they do not routinely use them. Limited availability and relatively high price hinder widespread implementation of these methods.

In the present study, dentin hardness was accentuated as the most important criterion for caries removal. When students analyzed the clinical scenario of a deep caries lesion, the majority selected the picture that reflected to either 'firm' or 'leathery' dentin. As shown in literature, the majority of dental practitioners preferred removal of all soft dentine, either in the one-step or two-step preparation technique [18, 19]. Growing evidence support selective caries removal to soft dentine in deep cavities, in order to protect pulpal health [20]. However, many dentists are reluctant to perform such treatment and leave caries behind [18].

Dentin color and moisture are recognized as additional clinical judgment criteria for caries removal [20]. The color was not significant for caries removal (51% of respondents). Conversely, 44% of students would perform a cavity preparation to reach dentin with 'normal' color. Similar results were reported in a group of French students [17]. Although the concept of extensive cavity preparation to remove bacteria is outdated [20], 81% of students believe that all cariogenic microorganisms need to be removed. The same attitude was present in 39% of French students [17].

Students demonstrated a lack of understanding for the management of deep caries lesions, in relation to the duration of treatment with calcium hydroxide. The source of their misconception could be that they learn from teachers who have different opinions on the subject. As shown in previous studies [9, 21], most of students would choose to place the liner material under permanent restoration, probably due to the traditional belief that pulp should be protected in order to heal after exposure to cariogenic agents [9].

Composite material was the most popular choice for restoring deep cavity lesions, which is consistent with previous findings [22]. The adequate restoration material should seal the lesion, and resist fracture. Bonding of composite material to caries-affected dentine, which has reduced mineral content, increased porosity and altered collagen structure, is less successful than to the sound dentine [23]. This could lead to the fracturing of the restoration. New generations of glass-ionomer and glass-hybrid cements may be able to tightly seal dentine, while providing the necessary strength for the restoration [24]. It seems that students should be more informed about advantages and limits of contemporary restorative materials.

The potential limitation of the present study could be the response rate. However, the proper response rate for online surveys in the research papers has not been determined yet, and average online survey response rate in education-related fields is 44.1% [25]. Additionally, the survey was conducted in one dental school. Nevertheless, School of Dental Medicine in Belgrade is the largest school that educates approximately 60% of all dental students in the country. The present study demonstrates students' understanding of cariology, but more importantly, it provides answers to questions regarding the way teachers educate and communicate. Results provide evidence of variations in the content being taught with a mixture of modern and traditional concept. It appears that MI approach has not been adequately translated into clinical teaching. The ability to adopt the MI philosophy is a learning curve because it necessitates a change in mindset and perspective, and seeing beyond simple tooth restoration. The problem of cariology being taught in separate departments/clinics, each with its own methodology, has been emphasized in numerous dental schools worldwide [26]. The results of this study could help identify gaps in current teaching and practices and assist in tailoring a new educational process in the field of cariology.

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## CONCLUSION

Conventional approach to caries management is still widely accepted among students and young dentists. Their knowledge of MI dentistry is limited. A strong cariology curriculum and adoption of evidence-based strategies for the management of dental caries is mandatory in dental education system. Maintaining the high level of caries management competency of faculty members through active training and calibration should be a priority in educational process. Periodic assessment of implemented curriculum and teachers' calibration could serve as a resource and tools for improving the teaching process.

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## Разлике у усвајању принципа минималне интервенције у кариологији међу студентима стоматологије

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### САЖЕТАК

**Увод/Циљ** Циљ рада је био да се испитају знање и ставови студената и младих доктора стоматологије о лечењу каријеса и принципима минималне интервенције у кариологији.

**Метод** Студенти су попуњавали електронски упитник који је обухватао: 1) ставове и знања о процени ризика за настанак каријеса (КР); 2) избор терапије каријеса глатких и оклузалних површина у зависности од КР; 3) избор дијагностичких процедура у лечењу каријеса дентина, техника препарације и материјала за рестаурацију зуба.

**Резултати** Већина студената сматра да би КР требало да утиче на план третмана. Орална хигијена је најзначајнији фактор КР. Код пацијентата са високим КР биран је инвазив-

нији приступ. Најважнији критеријум за уклањање каријеса је чврстоћа дентина. Већина студената сматра да би код дубоких каријесних лезија требало уклонити сав размекшани дентин, било једносеансно или двосеансно. Најчешће изабран рестауративни материјал је композит.

**Закључак** Међу студентима и младим докторима стоматологије још увек је широко заступљен конвенционални приступ лечењу каријеса. Њихово познавање принципа минималне интервенције у кариологији је ограничено. У циљу унапређења наставног процеса, потребна је периодична евалуација курикулума и калибрација наставника.

**Кључне речи:** студенти; знање; кариологија; минимална интервенција