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***Research Article***

**Title**

Changes in management preference of deep carious lesions and exposed pulps: questionnaire studies with a 10-year interval among dentists in Lithuania

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**Short title:** Management of deep lesions and exposures

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## Abstract

We aimed to investigate changes in management preferences for deep carious lesions and pulps exposed during carious tissue removal that occurred during the last 10 years and identify associated dentists' background factors. The data was collected among dentists registered with the Lithuanian Dental Chamber at two time points using a similar questionnaire. In 2011, 400 randomly selected dentists received a questionnaire by mail, and 153 (38.3%) responded. In 2021, an electronic invitation to an online questionnaire was sent to all members of the Lithuanian Dental Chamber, and 213 (8.9%) dentists responded. The questionnaire included the definitions of management options, a radiograph and a clinical picture of a deep carious lesion reaching to the inner fourth of dentine in a mature permanent tooth, asked management preferences in four different scenarios, as well as participants' background characteristics, reasons for management, and procedural preferences. Data was analyzed using bivariate and multivariable analyses. Compared to 2011, participants in 2021 had 60% lower odds of preferring nonselective versus selective caries removal (OR 0.4, 95% CI 0.2-0.7) and endodontic treatment versus nonselective and selective caries removal (OR 0.4, 95% CI 0.2-0.6) in the scenario of asymptomatic and symptomatic (indicating reversible pulpitis at most) deep lesions, respectively. For exposed pulp, participants in 2021 had lower odds than in 2011 of preferring endodontic treatment versus vital pulp therapy (direct pulp capping and pulpotomies) for both scenarios without symptoms (OR 0.4, 95% CI 0.2-0.7) and with symptoms (OR 0.2, 95% CI 0.1-0.4). A higher proportion of respondents in 2021 reported using rubber dam (44% versus 17% in 2011,  $p < 0.001$ ) and hydraulic calcium silicate cements as a capping material (68% versus 40% in 2011,  $p < 0.001$ ). The management preferences were associated with the university of graduation and the number of years in

dental practice, indicating 'recommended in textbooks' and 'recommended in scientific publications' as reasons for management preferences. To conclude, a change towards less invasive management options was observed. To a certain extent, dentists have implemented evidence-based recommendations in dental practice. To ensure further adoption of scientific evidence, dentists should be encouraged to update themselves on the newest evidence-based practices.

## **Introduction**

A deep carious lesion is a clinical diagnosis when the carious process has penetrated deep into the dentine where complete carious tissue removal may result in pulpal exposure [Leksell et al., 1996; Bjørndal et al., 1997; Maltz et al., 2002; Orhan et al., 2010]. In the studies performed a decade ago or earlier, including the ones referred to above, a great variation in the depth of deep carious lesions was observed, ranging from the inner  $\frac{1}{2}$  to the inner  $\frac{1}{4}$  of the dentine. Historically, for such deep lesions and pulps exposed during carious tissue removal, several different management options have been proposed [Ricketts et al., 2013]. In the case of a deep carious lesion, carious dentine may be removed completely from the pulpal wall (total caries removal) [cited in Jordan and Suzuki, 1971] or it can be removed partially, leaving some carious dentine on the pulpal wall. Partial removal may be performed in one step [Eidelman et al., 1965; Fitzgerald and Heys, 1991] or there is an alternative with an intermediate step having a temporary restoration, which is referred to as stepwise caries removal [Bodecker, 1938; Bjørndal et al., 1997]. The above defined management modalities fall under the umbrella of vital pulp therapy for carious lesion. In case of a pulpal exposure during carious tissue removal, one may choose to perform pulpectomy followed by root canal treatment (endodontic treatment) or vital pulp therapy [Bergenholtz et al., 2013]. Vital pulp therapy preserves tooth vitality and, in case of pulpal exposure, it includes direct pulp capping [Haskell et al., 1978; Baume and Holz, 1981; Dammaschke, 2008], partial [Cvek, 1978] and full pulpotomies [Zander, 1939]. While endodontic treatment is a more invasive management option, it is claimed to have more predictable long-term outcomes for exposed pulps.

A decade ago, the evidence about recommended management options for deep carious lesions in adults was limited to several scientific papers [Fitzgerald and Heys, 1991; Matsuo

et al., 1996; Bjørndal et al., 2010; Miles et al., 2010] and a few recommendations [European Society of Endodontology, 2006; Socialstyrelsen, 2011]. The lack of clear recommendations is evident from multiple questionnaire studies demonstrating non-uniform dentists' preferences for management of deep lesions and pulps exposed during carious tissue removal [Oen et al., 2007; Weber et al., 2011; Frisk et al., 2013; Stangvaltaite et al., 2013].

During the last decade, there has been an explosion of clinical studies, systematic reviews, recommendations, consensus and position statements of various associations, and expert collaborations [Innes et al., 2016; Asgary et al., 2017; Galani et al., 2017; Kundzina et al., 2017; Taha and Khazali, 2017; Bjørndal et al., 2019; European Society of Endodontology, 2019; Schwendicke et al., 2016; American Association of Endodontists, 2021; Schwendicke et al., 2021]. In 2016, the International Caries Consensus Collaboration (ICCC) systematized terms, changing 'total caries removal' to 'nonselective caries removal' and 'partial caries removal' to 'selective caries removal' [Innes et al., 2016; Schwendicke et al., 2016]. In addition, the depth of a deep lesion was defined as in the inner 1/3 or the inner 1/4 of the dentine. It has been demonstrated that nonselective caries removal results in a higher risk of failures, including pulp exposures, than selective caries removal [Bjørndal et al., 2017; Schwendicke et al., 2021], and according to ICCC recommendations, nonselective caries removal is no longer supported for management of deep carious lesions in a permanent teeth.

For pulps exposed during carious tissue removal in an adult patient, if there are no symptoms or symptoms of reversible pulpitis and the depth of the lesion in the inner 1/4 of dentine with a zone of dentine between the lesion and the pulp detected radiographically, the European Society of Endodontology (ESE) in its position statement recommends direct pulp capping or partial pulpotomy following enhanced management protocol and using hydraulic

calcium silicate cements, or full pulpotomy as an alternative to endodontic treatment in case of partial irreversible pulpitis [European Society of Endodontology, 2019].

To the best of our knowledge, there are no studies reporting preferred management options over time and assessing to which extent the growing scientific evidence has been translated into clinical practice. Therefore, the aim of this study was to investigate the preferred management options of deep carious lesions and pulps exposed during carious tissue removal, and to evaluate the changes that eventually occurred within 10 years. In addition, we identified dentists' background factors, which were associated with the preferred management options.

## **Material and methods**

### *Study design, participants, and sample size calculation*

The present study had a repeated cross-sectional design. Data was collected at two time points using a questionnaire. In the year 2011, out of 2974 general dental practitioners registered at the Lithuanian Dental Chamber, 400 dentists were randomly selected and invited to participate. The sample size was calculated taking into consideration a response distribution of 50%, a confidence level of 95%, an acceptable error margin of 5%, and an expected response rate of 85%. The dentists were contacted by mail, a letter included the invitation explaining the purpose of the study, the questionnaire, and a prepaid coded return envelope. A second identical letter was sent 8 weeks later as a reminder. In total, 153 dentists responded (response rate of 38.3%). This sample is hereafter referred to as *2011*.

In the year 2021, assuming a low response rate, all dentists registered at the Lithuanian Dental Chamber who gave a consent to be contacted for research purpose (n=2383), received

an electronic invitation to an online questionnaire. After three reminders, 213 dentists responded (response rate of 8.9%). This sample is referred to as *2021*.

### *Questionnaire*

For both times, a similar questionnaire was used, which included the same terms and definitions of management modalities. However, in *2021*, the questionnaire included an additional option of full pulpotomy as a management for pulps exposed during carious tissue removal. We utilized a questionnaire that consisted of 20 close-ended questions which was previously used by Stangvaltaite and co-workers in Norway [Stangvaltaite et al., 2013]. The English version of the questionnaire was translated/back-translated into Lithuanian/English. The face validity of the questionnaire was assessed by two experts independently, and only minor changes were implemented in the final version. The background characteristics of participants included sex, number of years in dental practice (<5 years, 5-10 years, > 10 years), practice type (public, private, both), location of practice (rural, urban), and university of graduation (Vilnius University (VU), Lithuanian University of Health Sciences (LUHS), other). The questionnaire asked management preferences for deep carious lesions and pulps exposed during carious tissue removal in a permanent tooth in a scenario without symptoms and other scenario with symptoms (sharp transient pain or sensitivity on cold/hot, which indicated reversible pulpitis at most). The participants were also asked to indicate the three most important reasons and patient-related factors that influence their management preference. The reasons included the following response options: ‘easy procedure’, ‘good results’, ‘biological justification’, ‘recommended by colleagues’, ‘recommended in continuing education courses’, ‘recommended in textbooks’, ‘recommended in scientific publications’,



‘other’. The listed patients-related factors were: ‘general health’, ‘age’, ‘attitude’, ‘tooth type’, ‘final restoration’, ‘oral health status’, ‘treatment duration’, ‘other’. The participants were invited to report their procedural preferences when managing deep carious lesions and pulps exposed during carious tissue removal, which are presented in Table 3. A bitewing radiograph, showing a carious lesion into the inner  $\frac{1}{4}$  of dentine with a zone of dentine between the lesion and the pulp chamber on the distal surface of an upper right first premolar, which would be classified by ESE as a deep carious lesion [European Society of Endodontology, 2019], and a clinical picture of the same tooth supplemented the questionnaire [Stangvaltaite et al., 2013].

### *Statistical analyses*

The SPSS software version 28.0 (IBM, SPSS, Armonk, New York) was used for statistical analyses. Chi-square test of independence was used to compare background characteristics of respondents, their procedural and management preferences between 2011 and 2021. To assess representativeness of the samples, one proportion Z-test and chi-square goodness of fit test were used for the variables with two and three categories, respectively. Univariable and multivariable binary logistic regression analyses were used to investigate association between management preferences (outcome) and survey year, all background characteristics of participants, as well as three selected reasons for management preferences (‘recommended in scientific publications’, ‘recommended in textbooks’, and ‘recommended in continuing education courses’). The outcomes in four scenarios were as following: nonselective versus selective caries removal in the scenario of deep lesion without symptoms; endodontic treatment versus vital pulp therapy (selective and nonselective caries removal) –

for deep lesion with symptoms; endodontic treatment versus vital pulp therapy (direct pulp capping and partial pulpotomy in 2011, direct pulp capping, partial and full pulpotomy in 2021) – for exposed pulp without and with symptoms. The Hosmer–Lemeshow goodness-of-fit statistic yielded  $p > 0.05$  for all models. The assumption of multicollinearity (tolerance and VIF statistics) was not violated in any of the models. The statistical significance was set at  $p < 0.05$ . Crude odds ratios (crORs) and adjusted odds ratios (adORs) were presented with their 95% confidence intervals (CIs).

## **Results**

### *Background characteristics*

The distribution of respondents' background characteristics was similar in 2011 and 2021, except that a higher proportion of respondents in 2021 were graduates from Vilnius University, had 5-10 years in dental practice, and a lower proportion had more than 10 years in dental practice compared to respondents in 2011 (Table 1). When comparing those who were invited versus those who participated, there was an overrepresentation of participants having less than 5 years and underrepresentation of participants having 5-10 years in dental practice in 2021. In addition, in both surveys, there was an overrepresentation of dentists who had dental practice in urban location (Table 1).

### *Deep carious lesion without symptoms*

In 2021, slightly more of the respondents preferred selective caries removal (44%) compared to nonselective removal (40%), while in 2011, nonselective caries removal was the most preferred management option (68%) followed by selective removal (27%) (Fig. 1).

According to multivariable binary logistic regression analysis, respondents in 2021 survey had 60% lower odds of preferring nonselective caries removal compared to respondents in 2011 (adOR 0.4, 95% CI 0.2-0.7). Preference for nonselective caries removal was associated with LUHS (versus VU) and other university of graduation (versus VU): adOR 15.5, 95%CI 3.0-80.5 and adOR 13.2, 95% CI 1.5-117.0, respectively (Table 2).

#### *Deep carious lesion with symptoms*

In 2011, the majority of respondents preferred endodontic treatment (60%). In 2021, the majority (53%) did not choose endodontic treatment; nonselective removal was preferred by 43% and selective removal by 10% of respondents, while endodontic treatment was preferred by 47% of respondents (Fig. 1).

According to multivariable binary logistic regression analysis, respondents in 2021 had 60% lower odds of preferring endodontic treatment compared to respondents in 2011 survey (adOR 0.4, 95% CI 0.2-0.6). The participants who graduated from other university (versus VU) and those who did not indicate reason 'recommended in scientific publications' had higher odds for endodontic treatment: adOR 4.9, 95%CI 1.1-22.0 and adOR 2.0, 95%CI 1.1-3.6, respectively (Table 2).

#### *Pulps exposed during carious tissue removal without symptoms*

In both 2011 and 2021, the majority of participants preferred vital pulp therapy, mainly direct pulp capping (74% and 85%, respectively) and a few chose partial or full pulpotomy (1% and 3%, respectively) (Fig. 2).

According to multivariable binary logistic regression analysis, respondents in 2021 had 60% lower odds of preferring endodontic treatment compared to respondents in 2011 survey (adOR 0.4, 95% CI 0.2-0.7). The university of graduation (LUHS versus VU) and not indicating reason 'recommended in textbooks' (adOR 0.4, 95% CI 0.2-0.9 and adOR 0.3, 95% CI 0.2-0.7, respectively) reduced odds, while more than 10 years in dental practice (versus less than 5 years) increased odds (adOR 2.7, 95% CI 1.2-6.4) for endodontic treatment (Table 2).

#### *Pulps exposed during carious tissue removal with symptoms*

The most preferred management option in 2011 and 2021 was endodontic treatment (89% and 64%, respectively). There were few respondents (7%) who preferred full pulpotomy as permanent management in 2021 (Fig. 2).

According to multivariable binary logistic regression analysis, respondents in 2021 survey had 80% lower odds of preferring endodontic treatment compared to respondents in 2011 survey (adOR 0.2, 95% CI 0.1-0.4). The participants who did not indicate reason 'recommended in scientific publications' had three times higher odds of preferring endodontic treatment (adOR 3.0, 95% CI 1.7-5.4). Not indicating a reason 'recommended in textbooks' was associated with 80% lower odds for endodontic treatment (adOR 0.2, 95% CI 0.1-0.6) (Table 2).

#### *Reasons and patient-related factors*

The two main reasons of preferred management in 2011 and in 2021 were the same, 'good results' and 'biological justification'. In 2021, one-third of the respondents reported

‘recommended in scientific publications’ and ‘recommended in continuing education courses’ as reasons while in 2011 these two reasons were reported only by every 10<sup>th</sup> and 5<sup>th</sup> respondent, respectively.

Both in 2011 and in 2021, among the three most reported patient-related factors that influenced dentists’ preferences in management of deep carious lesions were ‘age’ and ‘oral health status’. In 2011, participants have also reported ‘final restoration’, while in 2021 ‘attitude’ was among the three most important patient-related factors.

*Procedural preferences related to management of deep carious lesions and pulps exposed during carious tissue removal*

In 2021 compared to 2011, more participants reported using rubber dam and performing a follow-up. There was also a change in preference of materials used for direct pulp capping: more dentists preferred to use hydraulic calcium silicate cements in 2021 than in 2011 (Table 3).

## **Discussion**

The present study assessed change in preferred management options for deep carious lesions and pulps exposed during carious tissue removal within a 10-year interval among dentists in Lithuania. A change towards less invasive management options was observed. In addition, there was a change towards using hydraulic calcium silicate cements as a capping material. The management preferences were associated with the university of graduation, the number of years in dental practice, and the reasons for management choice ‘recommended in scientific publications’ and ‘recommended in textbooks’.

To the best of authors' knowledge, this is the first study to assess management preferences of deep carious lesions using very similar and thus presumably comparable questionnaires and targeting the same background population within a 10-year interval. Nevertheless, the study has some limitations, and the results should be interpreted with caution. Even though dentists from the list of the Lithuanian Dental Chamber were invited to participate, the sampling strategies in *2011* and *2021* were different; in *2011* a random sample was used, while in *2021*, all dentists who gave a consent to be contacted for research purposes were invited. Some questions suffered from missing values. There was a low response rate and a small sample size which may limit the generalization of our findings to all Lithuanian dentists. On one hand, there is no scientifically accepted critical level of response rate to be able to extrapolate findings to a target population. On the other hand, taking into consideration the relevant background characteristics of our study participants, one may conclude that the samples of dentists in both surveys were representative by sex, although an overrepresentation of dentists who had less than 5 years working experience and underrepresentation of dentists who had working experience of 5-10 years and who worked in a rural area may be noted. Data about invited dentists' working experience was available only for *2021*. In addition, in *2021* the response rate (8.9%) was much lower than in *2011* (38.3%). This is in line with previous studies, which demonstrated that web-based surveys among health care professionals have usually lower response rates than mail-based surveys [Shih and Fan, 2008; Cho et al., 2013].

Regarding deep carious lesions without symptoms, the respondents in *2021* had lower odds of preferring nonselective caries removal (versus selective), which suggests that the preferred management option has shifted towards more minimal invasive approach within 10

years. The ICCC recommendation for management of a deep carious lesion extending into the inner 1/3 or ¼ in pulpal dentine with the risk to expose the pulp in permanent tooth is selective caries removal, whether it is performed in one-step or stepwise [Schwendicke et al., 2016]. The ESE recommendation is selective removal (one-step or stepwise) if “radiographic assessment indicates caries has progressed no deeper than the pulpal quarter with a zone of dentine separating the carious lesion from the pulp chamber” [European Society of Endodontology, 2019]. A Cochrane systematic review and network meta-analysis indicated very low-certainty evidence for the probability of failure to be greatest for a deep lesion managed by conventional nonselective caries removal compared to selective removal in one-step and moderate-certainty evidence compared to stepwise caries removal [Schwendicke et al., 2021]. In addition, the latter systematic review concluded with the moderate-certainty evidence that the odds of failure were higher for stepwise caries removal compared to selective removal in one-step. Therefore, the shift from nonselective to selective caries removal (including removal in one-step and stepwise removal) among Lithuanian dentists may be interpreted as following evidence-based recommendations.

Despite presence/absence of pulp exposure, the symptoms of sharp transient pain or sensitivity on cold/hot, referring to reversible pulpitis at most, led to the preference of endodontic treatment. It has been proposed that pain severity might be important for deep carious lesion management outcomes [Wolters et al., 2017; Hashem et al., 2019]. Previous questionnaire studies demonstrated that the presence of symptoms was associated with a preference for endodontic treatment [ Stangvaltaite et al., 2013; Careddu et al., 2021], even though symptoms of reversible pulpitis are not an indication for endodontic treatment, neither in the absence nor presence of exposure [Schwendicke et al., 2016; European Society of

Endodontology, 2019; American Association of Endodontists, 2021]. One may speculate that the remuneration system might influence dental practitioner preference towards more expensive management options. In Lithuania, there is a two-tier dental care delivery model including both public and private dentistry. Adults receiving dental treatments in public clinics funded by the National Health Insurance Fund agreement have to cover only the cost of the dental materials, while dental patients in private clinics need to cover the full cost of dental treatments. In the present study, no difference in management preferences was observed between dentists working in public and private sector, suggesting that other factors than costs may influence management preferences.

If there are symptoms not more severe than reversible, in case of an exposed pulp, ESE recommends vital pulp therapy for exposed pulp, namely, direct pulp capping or partial pulpotomy following enhanced management protocol [European Society of Endodontology, 2019]. Direct pulp capping has shown excellent results in a 3-year randomized controlled trial in adult molars with deep lesions reaching inner 1/3 of dentine, thus regarded as not deep according to the new ESE definition, although half of the cases were symptomatic (reversible at most) [Kundzina et al., 2017]. A recent systematic review and meta-analysis demonstrated low-certainty evidence supporting a high success rate of direct pulp capping in permanent teeth (4-5 years success has been estimated to be 81%) [Cushley et al., 2021]. Of note, that in the latter systematic review, the depth of the lesion was not regarded as an inclusion criterium. In the present study, the respondents in 2021 compared to 2011, had lower odds of preferring endodontic treatment in scenarios with symptomatic deep lesion and symptomatic exposed pulp. This finding may be interpreted as translating evidence into practice. In our study, the participants who did not report the reason 'recommended in scientific publications' for their



management preference had higher odds to perform endodontic treatment. The similar association was observed among Japanese dentists where reading scientific articles was associated with preference for less invasive management alternatives when treating deep carious lesion with mild pulpitis [Kakudate et al., 2019]. Moreover, this finding is in accordance with a previous questionnaire study among dentists in France, Germany and Norway, where having read scientific articles about minimal intervention dentistry and cariology/operative dentistry within the last 5 years was associated with a preference for direct pulp capping in scenario of exposed pulp [Stangvaltaite et al., 2017]. It is not surprising, as the newest scientific evidence firstly is reported in scientific publications, and it takes time until it is presented in continuing education courses and textbooks. Therefore, those who had access to scientific publications reported to practice evidence-based dentistry faster than those who received newest evidence via other information channels. In Lithuania, the right to practice dentistry is re-assessed every five years by designated health authority and under strict legal regulations. The documentation of clinical dental practice during the 3 years within last 5 years and 120 hours of accredited continuing education courses must be provided. Therefore, a dental practitioner without special interest in reading scientific publications should receive the newest evidence via these courses. Interestingly, in our study the reason ‘recommended in continuing education courses’ were not significantly associated with any management preferences.

The previously mentioned systematic review concluded that hydraulic calcium silicate cements (like mineral trioxide aggregate (MTA) and Biodentine) performed better than calcium hydroxide when used as a capping material for direct pulp capping [Cushley et al., 2021]. In the present study, direct pulp capping was the most preferred management option

for exposed pulps without symptoms. According to the ESE position statement, in the presence of a preoperative deep carious lesion, pulp exposure is expected to be through an infected zone and pulp is likely to be inflamed, therefore, an enhanced operative protocol is recommended, including magnification, aseptic procedure, disinfection material, and hydraulic calcium silicate cements as capping material [European Society of Endodontology, 2019]. Around half of respondents, slightly more in 2021 compared to 2011, reported to use disinfection materials. Moreover, in 2021 (versus 2011) a statistically significantly higher proportion of respondents reported to use rubber dam and hydraulic calcium silicate cements. We cannot conclude that respondents adhere to enhanced operative protocol when performing direct pulp capping, however, when comparing responses from 2011 and 2021, it seems to be an improvement. In addition, the fact that more dentists reported to perform a follow-up in 2021 than in 2011 adds support to the translation of scientific evidence into clinical dental practice.

In scenario of asymptomatic exposed pulp, the preference of endodontic treatment was associated with university of graduation, more years in dental practice, and indicating reason 'recommended in textbooks'. Indeed, in three out of four deep lesion and exposed pulp scenarios presented in this paper, the management preferences were associated with the university of graduation. In order to further facilitate scientific evidence adoption into clinical practice, it might be beneficial to update university curricula with the newest evidence as undergraduate curricula seems to have a strong impact for future management preferences as demonstrated in a previous questionnaire study [Stangvaltaite et al., 2013]. According to multivariable analysis, only in one scenario of exposed pulp without symptoms, more years in dental practice was associated with endodontic treatment preference. This may be explained

that the younger colleagues follow what was taught in undergraduate curricula, while more experienced colleagues might prefer management, which works well in their hands. This argument may be supported by our finding that one of the two main reasons for management preference was ‘good results’.

For teeth with partial irreversible pulpitis, ESE recommends full pulpotomy [European Society of Endodontology, 2019]. A systematic review demonstrated a high success rate for full pulpotomy when treated teeth had signs and symptoms of irreversible pulpitis. Nevertheless, the authors noted that these results were based on heterogeneous studies with high risk of bias [Cushley et al., 2019]. There were few participants in 2021 who preferred full pulpotomy for exposed pulps. Unfortunately, this management option was not included in 2011 questionnaire; when 2011 survey was launched, the concept of full pulpotomy as a permanent management was not widespread and there was hardly any scientific evidence. Therefore, the 10-year comparison related to this management option is not possible.

To conclude, our study demonstrated that in 10 years, a change towards less invasive management options was observed. Dental practitioners seemed to be aware of evidence-based recommendations and to a certain extent implement them in practice. To ensure further and faster adoption of scientific evidence into dental practice, the undergraduate curriculum and continuing education courses should be revised accordingly, and dentists should be encouraged to update themselves of the newest evidence-based practices.

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**Statement of Ethics:** This study was performed in compliance with Good Clinical Practice and the Declaration of Helsinki. Ethical approval was not required as the aim of the study falls outside the bioethics law and no data about patients' health and disease was collected. Informed consent was obtained from all participants to participate in this study.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

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**Author Contributions:** Lina Stangvaltaite-Mouhat drafted the manuscript; Indre Stankeviciene and Sergei N. Drachev substantively revised it. Lina Stangvaltaite-Mouhat, Alina Puriene and Vilma Brukiene made a substantial contribution to the conception of this work. Lina Stangvaltaite-Mouhat, Indre Stankeviciene, Alina Puriene, Vilma Brukiene and Sergei N. Drachev contributed to the design of the study. Lina Stangvaltaite-Mouhat, Indre Stankeviciene, Alina Puriene and Vilma Brukiene collected data and contributed to the preparation of the manuscript. Lina Stangvaltaite-Mouhat and Sergei N. Drachev analyzed the data.

All authors approved the final version of the manuscript and agreed to be personally accountable for their own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even parts in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

**Data Availability Statement:** All data generated and analysed during this study are included in this article. Further enquiries can be directed to the corresponding author [LS-M, [linas@viken.no](mailto:linas@viken.no)].

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Legend to the figures.

Figure 1. Preferred management options of deep carious lesion among respondents in *2011* (n=153) and *2021* (n=213) expressed as percentages of those who answered the question and absolute numbers are presented on the bars. The difference between *2011* and *2021* management options was statistically significant in scenario of no symptoms (chi-square test value=22.178, df=2, p<0.001) and symptoms (chi-square test value=27.148, df=2, p<0.001).

Figure 2. Preferred management options of pulps exposed during carious tissue removal among respondents in *2011* (n=153) and *2021* (n=213) expressed as percentages of those who answered the question and absolute numbers are presented on the bars. Full pulpotomy option was not included in *2011* questionnaire, therefore the results are not applicable (N/A). The difference between *2011* and *2021* management options was statistically significant in scenario of no symptoms (chi-square test value=10.431, df=2, p<0.005) and symptoms (chi-square test value=29.857, df=2, p<0.001). For the analysis, numbers for partial and full pulpotomy were summed up.

Table 1. Background characteristics of dentists who responded and who were invited to participate in 2011 and 2021 surveys.

	<i>2011</i>		p-value <sup>1</sup>	<i>2021</i>		p-value <sup>2</sup>	p-value <sup>3</sup>
	Responded n=153 (%)	Invited n=400 (%)		Responded n=213 (%)	Invited n=2383(%)		
<b>Sex</b>	153	400	NS	213	2383	NS	NS
Female	138 (90)	341 (85)		184 (86)	1948 (82)		
Male	15 (10)	59 (15)		29 (14)	435 (18)		
<b>University of graduation</b>	153	N/A	N/A	213	N/A	N/A	0.003
VU	10 (7)			40 (19)			
LUHS	137 (89)			165 (77)			
Other	6 (4)			8 (4)			
<b>Practice type</b>	153	N/A	N/A	213	N/A	N/A	NS
Public	28 (18)			45 (21)			
Private	95 (62)			117 (55)			
Both	30 (20)			51 (24)			
<b>Years in dental practice</b>	152	N/A	N/A	213	2383	0.015	0.005
Less than 5	39 (26)			56 (26)	464 (20)		
5-10	12 (8)			42 (20)	648 (27)		
More than 10	101 (66)			115 (54)	1271 (53)		
<b>Location of practice</b>	151	400	0.048	213	2383	<0.001	NS
Rural	9 (6)	44 (11)		11 (5)	415 (17)		
Urban	142 (94)	356 (89)		202 (95)	1968 (83)		

N/A – data not available

NS – not statistically significant,  $p > 0.05$

VU – Vilnius University

LUHS – Lithuanian University of Health Sciences

p-value<sup>1</sup> – was calculated using one proportion Z-test to compare dentists who responded and who were invited to participate in 2011.

p-value<sup>2</sup> – was calculated using one proportion Z-test for two categories and chi-square test goodness of fit for three categories between dentists who responded and who were invited to participate in *2021*.

p-value<sup>3</sup> – was calculated using chi-square test of independence between dentists who responded in *2011* and *2021*.

Table 2. Odds ratios (ORs) and 95% confidence intervals (CIs) for the association between management preference and survey year, participants' background characteristics, and selected reasons for the management preference in four different scenarios, according to univariable and multivariable binary logistic regression analyses.

	Management preference/ <i>scenario</i>							
	Nonselective (vs selective) caries removal <i>Deep carious lesion Without symptoms</i>		Endodontic treatment (vs VPT <sup>i</sup> ) <i>Deep carious lesion With symptoms</i>		Endodontic treatment (vs VPT <sup>ii</sup> ) <i>Exposed pulp Without symptoms</i>		Endodontic treatment (vs VPT <sup>2</sup> ) <i>Exposed pulp With symptoms</i>	
	OR (95% CI)							
<b>Background characteristics</b>	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
<b>Survey year</b>								
2011	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
2021	0.4 (0.2-0.6)	0.4 (0.2-0.7)	0.4 (0.2-0.6)	0.4 (0.2-0.6)	0.4 (0.2-0.7)	0.4 (0.2-0.7)	0.2 (0.1-0.4)	0.2 (0.1-0.4)
Nagelkerke R <sup>2</sup> for survey year		0.074		0.078		0.044		0.120
<b>Sex</b>								
Female	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
Male	NS	NS	NS	NS	NS	NS	NS	NS
<b>University of graduation</b>								
VU	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
LUHS	14.8 (3.3-67.5)	15.5 (3.0-80.5)	2.2 (1.1-4.4)	NS	NS	0.4 (0.2-0.9)	NS	NS
Other	10.5 (1.5-73.7)	13.2 (1.5-117.0)	5.5 (1.4-21.5)	4.9 (1.1-22.0)	NS	NS	NS	NS
<b>Practice type</b>								
Public	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
Private	NS	NS	NS	NS	NS	NS	NS	NS
Both	NS	NS	NS	NS	NS	NS	NS	NS
<b>Years in dental practice</b>								
Less than 5	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
5-10	NS	NS	NS	NS	NS	NS	NS	NS
More than 10	2.2 (1.1-4.2)	NS	NS	NS	NS	2.7 (1.2-6.4)	NS	NS
<b>Location of practice</b>								
Rural	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
Urban	NS	NS	NS	NS	NS	NS	NS	NS

Nagelkerke R <sup>2</sup> for background characteristics	0.213		0.083		0.098		0.153	
<b>Reasons for preferred method: recommended in</b>								
<b>Scientific publications</b>								
Yes	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
No	3.3 (1.5-7.0)	NS	2.3 (1.3-4.1)	2.0 (1.1-3.6)	NS	NS	3.4 (2.0-5.8)	3.0 (1.7-5.4)
<b>Textbooks</b>								
Yes	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
No	NS	NS	NS	NS	0.4 (0.2-0.8)	0.3 (0.2-0.7)	0.3 (0.1-0.7)	0.2 (0.1-0.6)
<b>Continuing education courses</b>								
Yes	ref.	ref.	ref.	ref.	ref.	ref.	ref.	ref.
No	NS	NS	NS	NS	NS	NS	NS	NS
Nagelkerke R <sup>2</sup> for the whole model	0.248		0.153		0.132		0.242	

ref. – reference category

NS – not statistically significant, p>0.05

VU – Vilnius University

LUHS – Lithuanian University of Health Sciences

Crude ORs (95% CI) are presented from univariable binary logistic regression analyses

Adjusted ORs (95% CI) are presented from multivariable binary logistic regression analyses when adjusted for all covariates

<sup>i</sup> Vital pulp therapy for deep carious lesion: nonselective and selective carious tissue removal

<sup>ii</sup> Vital pulp therapy for exposed pulp: in 2011, direct pulp capping and partial pulpotomy; in 2021, direct pulp capping, partial and full pulpotomy

Table 3. Procedural preferences of respondents in management of deep carious lesions and pulps exposed during carious tissue removal in 2011 (n=153) and 2021 (n=213).

	<b>2011</b> <b>n (%)</b>	<b>2021</b> <b>n (%)</b>	p-value
<b>Rubber dam</b>	151	213	<0.001
Yes	25 (17)	94 (44)	
No	126 (83)	119 (56)	
<b>Caries indicator</b>	150	213	NS
Yes	29 (19)	32 (15)	
No	121 (81)	181 (85)	
<b>Instrument</b>	153	213	N/A
Excavator	74 (49)	144 (68)	
Rose bur	99 (64)	166 (78)	
Other	26 (17)	67 (31)	
<b>Disinfection material</b>	152	208	NS
Yes	67 (44)	112 (54)	
No	85 (56)	96 (46)	
<b>Liner material</b>	153	205	N/A
CaOH slurry	3 (1)	2 (1)	
CaOH paste	72 (40)	51 (25)	
Glass ionomer cement	72 (40)	83 (40)	
Hydraulic calcium silicate cements	21 (12)	36 (18)	
Direct bonding	12 (7)	33 (16)	
<b>Direct capping material</b>	153	209	<0.001*
CaOH slurry	16 (9)	5 (2)	
CaOH paste	70 (39)	40 (19)	
Combination of both CaOH forms	5 (3)	10 (5)	
ZnOE	10 (6)	-	
Hydraulic calcium silicate cements	72 (40)	143 (68)	
Other	6 (3)	8 (4)	
<b>Satisfied with results</b>	153	213	NS
Yes	45 (29)	74 (35)	
Partially	106 (69)	134 (63)	
No	2 (2)	5 (2)	
<b>Performing follow-up</b>	152	213	<0.001
Yes	120 (79)	196 (92)	
No	32 (21)	17 (8)	

The number of respondents varies in each question, and in some questions, respondents marked several options.

p-values according to chi-square test of independence

N/A – non-applicable due to several options marked by respondents

NS – not statistically significant,  $p > 0.05$

\* calculated comparing hydraulic calcium silicate cements versus all other options (not violating the assumption of independence of observations).



