




# Knowledge and opinions of French dental students related to caries risk assessment and dental sealants (preventive and therapeutic)

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## Abstract

**Objectives** A national questionnaire study was performed to document knowledge and opinions of French dental students (FDSs) about minimal intervention (MI) in dentistry especially caries risk assessment (CRA) and dental sealants (DSs).

**Materials and methods** A questionnaire was administered to the fifth-year dental FDSs ( $n = 1370$ ) from the 16 French dental schools. Descriptive and statistical analyses were performed.

**Results** The response rate was 84.5%. A large majority of respondents (87.8%) linked MI with minimally invasive dentistry and 77.4% considered MI as a concept based on prevention. About 80% stated they use CRA in clinical practice, mostly without any specific form. If 80.4% of the respondents would base their treatment plans on CRA, only 55.1% would regularly plan preventive regimens according to individual risk level. However, while 96.6% declared they perform preventive DSs, only 44.3% considered therapeutic sealants as a routine treatment. Although 75.1% of FDSs stated that they had sufficient learning and training related to CRA, 55.9% thought that they need further education about preventive and therapeutic DSs.

**Conclusion** Although FDSs seem to be aware of the importance of CRA and preventive strategies, this study shows the need to harmonize the teaching in cariology according to the latest European recommendations.

**Clinical relevance** A national questionnaire study showed variability towards knowledge and opinions of FDSs related to MI in cariology. This may impact care provisions in their future professional life showing the urgent need to harmonize the teaching of MI in cariology in France.

**Keywords** Minimal intervention dentistry · Caries risk assessment · Dental sealants · Dental students · Questionnaire survey

## Introduction

Minimal intervention in dentistry (MID) in general and in cariology in particular was first described in the literature with two major articles in the early 1990s [1, 2]. Indeed, Dawson and Makinson introduced an emerging movement in the late 1980s in UK, which denounced the inadequacy between patient needs and care provision in restorative dentistry. In 1992, the foundations of MID were thus laid as these two authors suggested that “Prevention”,

“Remineralization”, “Minimal intervention” and “Reducing the rate of restoration placement” could be combined to achieve a less destructive form of dental treatment [2]. Since then, in the light of accumulated knowledge in cariology (histology, microbiology, pathophysiology, validated clinical procedures), this has led to the development of various diagnosis and treatment concepts [3–8]. The latest comprehensive practice guide Caries Care International [8] promotes a patient-centered, risk-based approach to caries management designed for dental practice. It advocates for a health outcome-focused system that aims to maintain oral health and preserve tooth structure in the long term. In that context, this is obvious that caries risk assessment (CRA)

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as well as preventive and non-invasive cares [such as dental sealants (DSs)] are essential in caries management.

Questionnaire surveys were conducted in France to assess professional dental practice in terms of minimal intervention (MI) in caries management. In general, studies investigating various domains of caries management (CRA use, DSs placement, restorative threshold for both occlusal and approximal lesion and deep caries management) showed that MI is still insufficiently implemented in everyday clinical practice by French general dental practitioners (FGDPs) practicing in France [9–13]. It is known that changing professional practice takes time [14] and is subordinated to a range of factors related to financial considerations (such as remuneration or risk of losing incomes), patients demands and expectations, organizational factors (delegation possibility), GDPs personal attitudes (personal resistance and inertia to change) and, of course, to GDPs education (pre- and post-graduate) [15]. It might be speculated that the gap between science and clinical practice described among FGDPs and worldwide [16] could find its origin in dental schools. In that context, the French national college of teachers in conservative dentistry (collège national des enseignants en odontologie conservatrice or CNEOC) started giving thought to what French dental students (FDSs) of the 16 French dental schools know about MI.

A study, which is the first of its kind in France, was thus undertaken to investigate the knowledge and opinions of FDSs at a national level about several areas of MI in cariology, namely CRA, DSs (preventive and therapeutic), restorative threshold and strategies for approximal and occlusal lesions, and deep carious lesion management. The present manuscript focuses on the first two above-mentioned areas i.e. CRA and DSs.

## Materials and methods

A questionnaire survey was administered during spring 2018 to the fifth-year FDSs from the 16 French dental schools. This project is institutionally supported by the CNEOC. The printing and postal-mailing costs were sponsored by Colgate® France.

### Population study and questionnaire administration

The study involved all fifth-year (penultimate year before graduation) FDSs ( $n = 1370$  in 2018) from the 16 French dental schools (Bordeaux, Brest, Clermont-Ferrand, Lille, Lyon, Marseille, Montpellier, Nancy, Nantes, Nice, Paris Descartes, Paris Diderot, Reims, Rennes, Strasbourg and Toulouse).

A compilation of five questionnaires that had been previously used for surveys among FGDPs and French university

teachers [9–13, 17] was auto-administrated (paper format—18 pages) to the FDSs in a specific session organized in each of the 16 French dental schools. It consisted of several question formats (yes/no questions, closed-ended questions with forced choice or multiple allowable answers and open-ended questions with open-ended written); five different parts can be identified and can be divided in the following sections:

Section 1: demographic characteristics of the respondents (birth year and gender); and a question related to the reading of scientific articles about MI in cariology in addition to academic lectures and tutorials;

Section 2: 13 questions related to CRA [12];

Section 3: 16 questions related to preventive and therapeutic DSs [11];

Section 4: 17 questions related to restorative threshold for approximal and occlusal carious lesions, to two clinical cases of minor or questionable occlusal lesions (based on occlusal views and radiographs) and to beliefs about selected aspects of caries diagnosis/treatment [9, 10, 17];

Section 5: 13 questions related to deep carious lesion management (including three clinical cases) [13].

The content of the different sections is detailed in the principles articles [9–13, 17].

### Capture and analysis of data

Data were entered into Excel spread sheets by four people (three dentists (MAG, DS, SD) and a Master student (LDB)). Descriptive and statistical analyses were performed with SPSS® (IBM SPSS Statistics Version 19). A  $\chi^2$  test was used to assess the associations between responses related to, on one hand, CRA, DSs, restorative threshold/strategies for approximal and occlusal lesions and deep carious lesion management and, on the other hand, gender and additional reading of scientific articles about MI in cariology. Univariate and multivariate logistic regressions (LRs) were performed; odd ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated to correlate the use of CRA in everyday practice and the sociodemographic characteristics of the respondents. The level of significance was placed at 5% for all analyses. Only factors with univariate  $p$  value  $< 0.20$  were included in the multivariate models.

The present paper only focuses on the results related to sections 1 and 2, namely CRA and preventive and therapeutic DSs. The following subgroups were used for statistical analysis:

Question on the importance of different factors in treatment planning for adult patients: “not or marginally

important” (grade 1) versus “moderately important” (grade 2) versus “very to extremely important” (grade 3); Question on the respondents’ opinions about general concerns related to preventive and therapeutic DSs: “disagreement (partial or total)” (grade 1) versus “neutral” (grade 2) versus “agreement (partial or total)” (grade 3).

**Results**

All of the 16 French dental schools participated to the survey. A total of 1158 fulfilled questionnaires were collected, leading to a response rate of 84.5% (from 32.9 to 100%). The respondent population was composed of 53.5% of women (*n* = 619) and 46.5% of men (*n* = 539). The average age of the participants, at the time of the study, was 24.5 (± 2.12) year-old (min. 21–max. 44). Approximately, one-third of the respondents (35%) had already read publications about MI in cariology. Men were more likely to read scientific articles than women (*p* = 0.032).

**CRA**

Interestingly, 81.1% of respondents stated they use CRA in clinical practice, most of them without any specific form (73.5%). The reasons for not using CRA are listed in Table 1. Lack of time appears to be the most important

factor identified (67.7%) followed by lack of teaching during undergraduate education (30.9%) and insufficient knowledge on CRA (23.5%). Among those who answered they do not assess the caries risk of their patients, 73.6% would appreciate the delegation of this task to other dental personnel, i.e. dental hygienists (69.9%) or other GDPs (3.7%), when 12% would not delegate CRA (14.4% having no opinion). Men were more likely than women to denounce the problem of billing and reimbursement as barriers to the CRA use (*p* = 0.037). Table 2 shows the results of the univariate and multivariate LRs investigating the correlation between the use of CRA and sociodemographic data. The LR shows that respondents who considered initial training on CRA as sufficient were more likely to perform CRA than the others (OR: 2.46; 95% CI: 1.79–3.37; *p* value < 0.001).

If 80.4% of the respondents would base their individual treatment plans on CRA, only 55.1% would regularly plan preventive regimens according to risk level. Respondents who are more likely to establish individual preventive strategies based on CRA are MI scientific article readers (*p* = 0.028). Table 3 shows a summary of preventive treatments proposed by respondents: DSs (83.4%), fluoride (F) varnish application (69%) and F toothpaste > 1500 ppm prescription (41.6%) were the most cited options. FDSs who already read scientific publications about MI were more likely to indicate > 1500 ppm F toothpaste (*p* = 0.046), CPP/ACP (for casein phosphopeptide—amorphous calcium

**Table 1** Reasons cited by French fifth-year dental students for not using CRA (*n* = 217)

Reasons for not using CRA	Citation frequency <sup>a</sup> (%)	Significantly related respondents’ characteristics
Lack of time	67.7	–
No teaching of CRA during undergraduate education	30.9	–
Insufficient knowledge on CRA	23.5	–
Problem of billing or reimbursement	19.4	Men ( <i>p</i> = 0.037)
Irrelevance of CRA	1.8	–

<sup>a</sup>Some participants checked off more than one option

**Table 2** Results of the logistic regressions related to the use of CRA in everyday practice according to sociodemographic characteristics of the respondents

	Respondent sociodemographic characteristics	OR	95% CI	<i>p</i> value
<b>Univariate LR</b>	Age (years) ( <i>n</i> = 1101)	1.02	0.95–1.10	0.5734
	Gender (women/men) ( <i>n</i> = 1147)	1.11	0.83–1.49	0.4925
	Reading articles about MI (yes/no) ( <i>n</i> = 1140)	1.15	0.84–1.57	0.3885
	Considering initial training on CRA as sufficient (yes/no) ( <i>n</i> = 1143)	2.46	1.79–3.37	< 0.001*
<b>Multivariate LR</b>	Considering initial training on CRA as sufficient (yes/no) ( <i>n</i> = 1143)	2.46	1.79–3.37	< 0.001*

Only factors with univariate *p* value < 0.20 were included in the multivariate models

LR logistic regression, OR odd ratio, 95% CI 95% confidence interval, MI minimal intervention, CRA caries risk assessment

\*Statistically significant

**Table 3** Overview of preventive treatments performed by French fifth-year dental students ( $n = 1153$ )

Preventive options	Citation frequency <sup>a</sup> (%)	Significantly related respondents' characteristics
Sealants	83.4	
In-office F varnish application	69	Women ( $p = 0.001$ )
Prescription of > 1500 ppm F toothpaste	41.6	Articles reading ( $p = 0.046$ )
Prescription of < 1500 ppm F toothpaste	25.2	
Prescription of F mouthwashes	23.7	
In-office F gel application	10.3	Articles reading ( $p = 0.001$ )
Prescription of CPP-ACP agents	5.4	Articles reading ( $p < 0.001$ )
Prescription of dental products with arginine	4.8	

Not all participants answered to the question

CPP-ACP casein phosphopeptide—amorphous calcium phosphate, F fluoride, ppm parts per million

<sup>a</sup>Some participants checked off more than one option

phosphate) agents ( $p < 0.001$ ) and F gel professional application ( $p = 0.001$ ) than the others. Almost 80% ( $n = 905$ ) of the respondents declared combining regularly from two to four preventive options.

Table 4 summarizes the hierarchy of factors being considered in a CRA in adult patients. The three most cited factors

considered as important were current oral hygiene (87.4%), patient's motivation (45%) and the presence of active carious lesion (37%). The three most cited factors considered as irrelevant were reimbursement (73.7%), dentist's subjective assessment (53.2%) and patient's age (31.6%). Table 5 indicates the results of the uni- and multi-variate LRs performed

**Table 4** Hierarchy of factors considered in a CRA for adults by French fifth-year dental students ( $n = 1156$ )

Factor	Factor of importance in CRA (%)	Less important factor in CRA (%)
Current oral hygiene	<b>87.4</b>	0.9
Patient's motivation	<b>45</b>	1.4
Presence of active carious lesion	<b>37</b>	2.1
Reimbursement	0.9	<b>73.7</b>
Dentist's subjective assessment	1.3	<b>53.2</b>
		Women ( $p < 0.001$ ) <sup>a</sup>
Age	5.5	<b>31.6</b>
Current diet	36.3	9.2
	Women ( $p = 0.044$ ) <sup>a</sup>	Men ( $p = 0.048$ ) <sup>a</sup>
Presence of several large restorations	13.8	4.7
	Women ( $p = 0.040$ ) <sup>a</sup>	
	No articles reading ( $p = 0.003$ ) <sup>a</sup>	
Comprehension of the causes of caries	15	6.4
		No articles reading ( $p = 0.029$ ) <sup>a</sup>
Regularity of patients visits	11	5.1
Decreased saliva function	10.6	5
	Articles reading ( $p = 0.045$ ) <sup>a</sup>	
Current use of F toothpaste	10.4	11.4
Recent carious lesions	9.4	7
	Women ( $p = 0.003$ ) <sup>a</sup>	
Socioeconomic status	8.6	24.8
Presence of dental appliances	1.8	20
Gingival recession or exposed roots	1	25.3

Not all participants answered to the question

Bold values indicate the three most cited factors

CRA caries risk assessment, F fluoride

<sup>a</sup>Significantly related respondents' characteristics (gender and additional reading of scientific articles about MI)

**Table 5** Results of the uni- and multi-variate LRs performed to indicate the associations between the CRA use and factors considered as being important in a CRA in adults

Factors considered as being important	OR	95% CI	<i>p</i> value
<b>Univariate LR (n = 1146)</b>			
Age	0.75	0.41–1.36	0.3354
Current diet*	1.71	1.23–2.37	0.0015
Current oral hygiene	0.70	0.42–1.14	0.1526
Dentist's subjective assessment	0.63	0.20–2.01	0.4390
Gingival recession or exposed roots	0.69	0.19–2.58	0.5856
Socioeconomic status	0.66	0.41–1.07	0.0899
Decreased saliva function	0.87	0.54–1.39	0.5570
Presence of several large restorations	1.16	0.74–1.80	0.5169
Reimbursement*	0.23	0.07–0.80	0.0203
Presence of dental appliances	0.46	0.18–1.14	0.0945
Regularity of patients visits	0.80	0.51–1.25	0.3291
Patient's motivation	0.81	0.60–1.09	0.1556
Comprehension of the causes of caries	1.37	0.88–2.14	0.1651
Presence of active carious lesion	1.29	0.94–1.77	0.1083
Recent carious lesions	1.37	0.79–2.38	0.2624
Current use of fluoride toothpaste	0.76	0.48–1.20	0.2380
<b>Multivariate LR (n = 1145)</b>			
Current diet*	1.80	1.25–2.59	0.0014
Current oral hygiene	0.66	0.39–1.11	0.1172
Socioeconomic status	0.76	0.46–1.27	0.2957
Reimbursement*	0.26	0.07–0.94	0.0393
Presence of dental appliances	0.50	0.19–1.31	0.1597
Patient's motivation	0.95	0.68–1.33	0.7752
Comprehension of the causes of caries*	1.61	1.00–2.58	0.0497
Presence of active carious lesion	1.41	0.98–2.03	0.0619

Only factors with univariate *p* value < 0.20 were included in the multivariate models

LR logistic regression, OR odd ratio, 95% CI 95% confidence interval

\*Statistically significant difference

to investigate the associations between the use of CRA in adults and factors considered as being important. In multivariate analysis, current diet was, by far, the factor with the strongest statistical association with CRA use (OR: 1.80; 95% CI: 1.25–2.59; *p* value: 0.0014). Considering reimbursement and patient's comprehension of the causes were other significantly related factors (*p* = 0.0393 and *p* = 0.0497, respectively).

Table 6 shows the factors that are considered by FDSs to be important for the treatment plan in adults. The three most cited factors were as follows: current oral hygiene (95.7%), patient motivation (91.9%) and the regularity of patient visits (75.6%). The respondent sociodemographic characteristics appeared to influence their answers. For example, women are more likely to designate the presence of several large restorations, the presence of dental appliances, the patient comprehension of the causes of caries and the regularity of patient

visits as important factors (*p* = 0.045; *p* = 0.005; *p* < 0.001 and *p* = 0.007, respectively). FDSs who read articles on MI also mentioned the presence of active carious lesion (*p* = 0.041), the current use of F toothpaste (*p* = 0.001) and the current diet (*p* < 0.001) as main factors in a treatment plan for adults more likely than the others.

## Understanding/perception of the term “MI” in cariology

Table 7 provides an overview of the understanding/perception of the term “MI” in cariology. A large majority of respondents (87.8%) linked MI with minimally invasive dentistry while 77.4% considered it as a concept based on prevention. Women were more likely to answer that MI is based on prevention (*p* = 0.013) and that MI could be implemented into private practice (*p* < 0.001). Moreover, 6.4% reported that they did not exactly know what MI in cariology means.

### Preventive and therapeutic DSs

While 96.6% of the respondents declared they perform preventive DSs (PDSs), only 44.3% considered therapeutic DSs (TDSs) as a routine treatment. FDSs who read articles on MI were more likely to perform TDSs (*p* < 0.001) than the others. The lack of formation, the risk of progression of pre-existing carious lesion and the lack of recommendations appeared to be the main reasons for not considering TDSs in their panel of caries management strategies (Fig. 1). Table 8 summarizes the respondents' degree of agreement regarding six statements about DSs: 76.4% considered there are strong evidence on the effectiveness of DSs to prevent dental caries and 92.4% were aware that DSs placement implies a follow-up.

Table 9 shows the preferences of the respondents for PDSs and TDSs in terms of patient profile (age and caries risk level) and the choice of material. Composite resin is the preferred material (PDSs: 60.6%; TDSs: 37%), especially for respondents who read articles on MI (*p* < 0.001). Almost 85% (especially women (*p* = 0.042) and respondents who read articles on MI (*p* = 0.018)) combined PDSs with other preventive measures—based on the age of patient (Table 10).

### DSs and task delegation

Almost half of the respondents (48.8%) would appreciate the possibility of task delegation to other dental personnel. Respondents who read articles on MI were more likely to refuse task delegation (*p* = 0.043).

### National recommendations and need for further education toward CRA and DSs

Only 26.1% of the respondents seemed to be familiar with the French national recommendations of the French High

**Table 6** Importance of different factors to be considered for the development of a treatment plan in adults

	Not or only marginally important (grade 1) (%)	Moderately important (grade 2) (%)	Very to extremely important (grade 3) (%)	Significantly related respondents' characteristics
Age ( $n = 1149$ )	15.8	34.9	49.3	–
Socioeconomic status ( $n = 1144$ )	17.9	37.3	44.8	Men: grade 3 ( $p = 0.015$ )
Current oral hygiene ( $n = 1147$ )	0.8	3.5	95.7	–
Presence of active carious lesion ( $n = 1138$ )	5.3	19.8	74.9	Articles reading: grade 3 ( $p = 0.041$ )
Recent carious lesions ( $n = 1144$ )	13.9	36.4	49.7	–
Presence of several large restorations ( $n = 1145$ )	6.6	26.7	66.7	Women: grade 3 ( $p = 0.045$ )
Presence of dental appliances ( $n = 1146$ )	13.6	36.1	50.3	Women: grade 3 ( $p = 0.005$ )
Gingival recession or exposed roots ( $n = 1151$ )	16.7	39.3	44	Men: grade 1 Women: grade 3 ( $p = 0.003$ )
Current use of F toothpaste ( $n = 1150$ )	28.2	34.5	37.3	Articles reading: grades 2 and 3 ( $p = 0.001$ )
Current diet ( $n = 1149$ )	21.9	27.9	50.2	Articles reading: grades 2 and 3 ( $p < 0.001$ )
Dentist's subjective assessment ( $n = 1145$ )	33.5	39.9	26.6	Men: grade 3 ( $p = 0.009$ )
Decreased salivary function ( $n = 1152$ )	12.2	24.1	63.7	–
Patient comprehension of the causes of caries ( $n = 1150$ )	7.9	18.9	73.2	Men: grades 1 and 2 Women: grade 3 ( $p < 0.001$ )
Regularity of patient visits ( $n = 1147$ )	4.7	19.7	75.6	Men: grade 2 Women: grade 3 ( $p = 0.007$ )
Patient motivation ( $n = 1147$ )	1.4	6.7	91.9	–
Reimbursement ( $n = 1151$ )	38.6	39.5	21.9	–

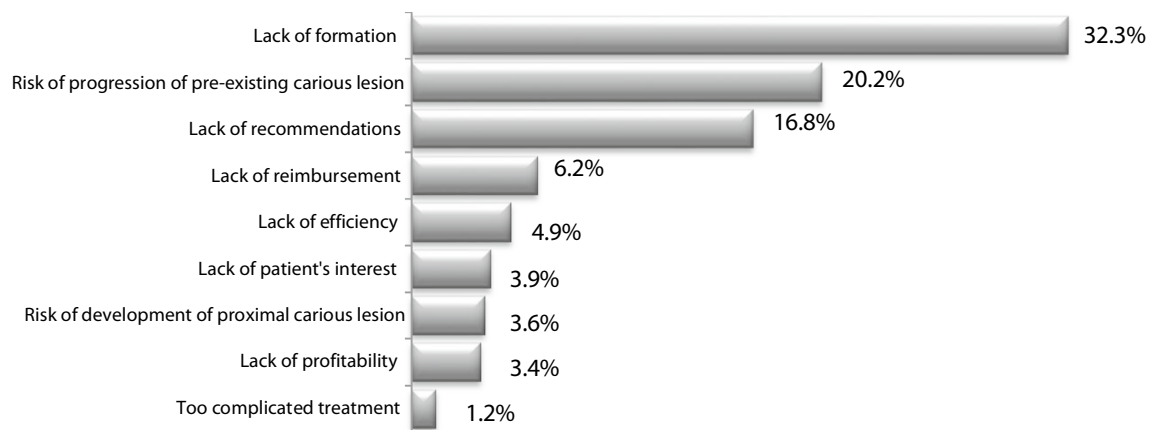
F fluoride

**Table 7** What do French fifth-year dental students understand by the term “MI in cariology”? ( $n = 1157$ )

What is MI?	Citation frequency <sup>a</sup>
A treatment concept based on minimally invasive dentistry	87.8% Articles reading ( $p = 0.002$ ) <sup>b</sup>
A treatment concept based on prevention	77.4% Women ( $p = 0.013$ )
A treatment concept that can be implemented into private practice	61.5% Articles reading ( $p = 0.002$ ); Women ( $p < 0.001$ ) <sup>b</sup>
A treatment concept based on the understanding of the risk factors	57.7% Articles reading ( $p = 0.002$ ) <sup>b</sup>
A treatment concept based on the use of magnification	34.7% Articles reading ( $p < 0.001$ ) <sup>b</sup>
I do not know exactly what is MI in cariology	6.4% No articles reading ( $p < 0.001$ ) <sup>b</sup>
A treatment concept that is part of the public health domain	1.6%
A treatment concept restricted for use in paediatric dentistry	1.4%

Not all participants answered to the question

<sup>a</sup>Some participants checked off more than one option<sup>b</sup>Significantly related respondents' characteristics (gender and additional reading of scientific articles about MI)



<sup>(1)</sup> Not all participants answered to the question.

<sup>(2)</sup> Some participants checked off more than one option.

**Fig. 1** Reasons cited by dental students for not performing therapeutic sealants ( $n = 1154$ ). Not all participants answered to the question. Some participants checked off more than one option

**Table 8** Respondents' knowledge about preventive and therapeutic sealants\*

	Disagreement (Grade 1) (%)	Neutral (Grade 2) (%)	Agreement (Grade 3) (%)
There is strong scientific evidence on the effectiveness of sealants to prevent dental caries ( $n = 1144$ )	3.2	20.4	76.4
There is strong scientific evidence on the effectiveness of sealing non-cavitated carious lesions ( $n = 1140$ )	5.7	35.3	59
Follow-up visits are needed when sealants are placed ( $n = 1133$ )	1.7	5.9	92.4
The loss of sealants is usually related to technical problems during the procedure ( $n = 1139$ )	17.1	23.7	59.2
Resin composites are more efficient than GICs for sealants ( $n = 1143$ )	26.1	35.7	38.2
As long as sealants are present, the sealed surface will not develop dental caries ( $n = 1141$ )	74.5	13.1	12.4

GIC glass ionomer cements

\*Not all participants answered to the question

Authority for Health (HAS). While 75.1% stated they had sufficient education towards CRA, 55.9% reported the need for further education on PDSs and TDSs.

## Discussion

The purpose of this study, the first of its kind in France and in the world, was to provide an overview of the knowledge and opinions of French fifth-year dental students related to CRA and DSs. Studies were previously carried out to assess the teaching of cariology in Europe [18] and in Oceania [19], but, to our knowledge, no publications were interested in what FDSs, following courses on MI, learn and remember. The logistical part of this study (questionnaire printing and mailing) was supported by Colgate®, but the results were independently analysed by the authors. As the questionnaire

only concerned the learning outcomes, no approval of ethical committees was required according to the French regulation. The 16 French dental schools, all supported by the French State (there are no private dental schools in France), took part in the survey and it can be hypothesized that, as the response rate is about 85%, the results are highly representative of the knowledge and opinions of all French fifth-year dental students at the time of the study. Disparities in response rates between schools could be denounced as a potential bias in the interpretation of the results. Those disparities are related to the fact that, in some schools, the presence of students at the questionnaire administration session was not compulsory. Thus, the non-responses were not linked to the content of the questionnaire and the lack of interest toward MI but only to the irregular school attendance of a fraction of the student population, varying from school to school. In that context, it can be hypothesized that

**Table 9** Preferences of the respondents for preventive and therapeutic sealants in terms of patient profile and the material choice

	Preventive sealants	Therapeutic sealants
<b>Patient profile</b>		
Age ( <i>n</i> = 1113)	Children only: 58.5% Adults only: 0.7% Children and adults: 40.8%	Children only: 37.9% Adults only: 6.2% Children and adults: 55.9% Articles reading ( <i>p</i> < 0.001) <sup>b</sup>
Caries risk level ( <i>n</i> = 1111)	Low risk: 4.4% Men ( <i>p</i> < 0.001) <sup>b</sup> High risk: 62.2% Articles reading ( <i>p</i> = 0.045) <sup>b</sup> Regardless of risk level: 33.4% Women ( <i>p</i> < 0.001) <sup>b</sup>	Low risk: 24.6% Articles reading ( <i>p</i> < 0.001) <sup>b</sup> High risk: 38.2% Articles reading ( <i>p</i> < 0.001) <sup>b</sup> Regardless of risk level: 37.3%
<b>Choice of material<sup>a</sup></b>	GIC: 45.7% ( <i>n</i> = 529) Composite resin: 60.6% ( <i>n</i> = 701) Articles reading ( <i>p</i> < 0.001) <sup>b</sup> RM-GIC: 22.1% ( <i>n</i> = 256) Arti- cles reading ( <i>p</i> = 0.029) <sup>b</sup>	GIC: 26.4% ( <i>n</i> = 305) Articles reading ( <i>p</i> = 0.001) <sup>b</sup> Composite resin: 37% ( <i>n</i> = 427) Articles reading ( <i>p</i> < 0.001) <sup>b</sup> RM-GIC: 19.2% ( <i>n</i> = 221) Articles reading ( <i>p</i> < 0.001) <sup>b</sup>

Not all participants answered to the question

GIC glass ionomer cements, RM-GIC resin-modified GIC

<sup>b</sup>Some participants checked off more than one option

<sup>c</sup>Significantly related respondents' characteristics (gender and additional reading of scientific articles about MI)

**Table 10** Preventive measures recommended in addition to preventive sealants

	Never (%)	Only in chil- dren (%)	Only in adults Only (%)	In both chil- dren and adults (%)
Toothbrushing and dental floss or interdental brushes ( <i>n</i> = 1014)	1.4	5	13.4	80.2
< 1500 ppm F toothpaste ( <i>n</i> = 910)	30.7	40.3	4.8	24.2
> 1500 ppm F toothpaste ( <i>n</i> = 942)	28.6	8	40.4	23
F mouthwashes ( <i>n</i> = 910)	52.5	3.3	26.6	17.6
Products containing CPP-ACP ( <i>n</i> = 887)	79.7	6.7	5.5	8.1
Products containing arginine ( <i>n</i> = 880)	82.7	1.5	8.8	7
In-office F varnish application ( <i>n</i> = 960)	12.9	31.5	4.8	50.8
In-office F gel application ( <i>n</i> = 886)	63.9	8.9	5	22.2

Not all participants answered to the question

CPP-ACP casein phosphopeptide—amorphous calcium phosphate, F fluoride, ppmF parts per million fluoride

the non-responses do not induce any bias in the interpretation of the results and that the present results are highly representative of the knowledge and practices of FDSs. A comparison between schools was not expected, as the aim of the study was to collectively analyse the knowledge of all future dental French practitioners and not to establish a ranking of schools. Nevertheless, this study does present some limitations. The dental course in France lasts 6 years and it could have been more pertinent to administrate the questionnaire to final year FDSs as MI in cariology is taught all along the course. Nevertheless, it would have been impossible to simultaneously organise sessions for the questionnaire administration (or within a reasonable period of time to avoid questionnaire diffusion and potential discussions/

responses through social networks) to final year FDSs in all schools. Indeed, the presence of the FDSs on site may vary dramatically from one school to another due to an internship (similar to vocational training) in private practice that takes place during this final year. Some authors denounced that there is little correlation between respondents' stated intervention strategies as reported in questionnaire surveys and their therapy decisions in clinical practice [20–22]. Nevertheless, others argued that if questionnaire surveys are not able to measure the respondents' clinical decisions, they give a good idea of their treatment philosophies [23, 24]. The present results thus help to understand FDSs knowledge toward CRA and dental sealants to modify teaching content and approaches accordingly.



The questionnaire used in the present survey consisted of a compilation of questionnaires that had been previously used for surveys among FGDPs and French university teachers [9–13, 17]. Validation of the questionnaires was not undertaken since their objective was to describe the knowledge, opinions and practices of dental professionals concerning various MI domains. This differs from questionnaires where the aim is to diagnose a disease, to screen patients according to a specific medical condition or to assess quality of life where validation is necessary. Construct validity of each original questionnaire was, however, evaluated to some extent by pilot-testing the questionnaires like stipulated in the princeps articles [9–13, 17]. Minor problems in the understanding and interpretation of some questions were discussed amongst the investigators and slight modifications to the questionnaire were made. Validation in terms of test–retest reliability of the questionnaire was not evaluated since it was considered that once the questionnaire has been administered, respondents might seek further information about some topics covered in the questionnaire, which, in turn, might subsequently change their opinions and practices. Linguistic validity was not required since the questionnaires were developed in French.

It is comforting to notice that a large majority of FDSs (81.1%) stated they regularly conduct CRA, which is recognized to be the cornerstone of MI treatment planning [25, 26]. However, similarly to FGDPs, very few FDSs based their CRA on the use of a specific form [12, 27–29]. Despite the criticism about the lack of clear-cut validation of the proposed protocols/models, CRA forms are intended to help practitioners in managing a treatment plan strategy suitable for each patient [25, 30]. CRA forms also allow a more objective and standardized collection of information, which could help gathering lots of epidemiological data in French hospital dental services, as it has been done at UCSF dental school for more than a decade [31, 32]. Moreover, like FGDPs [12], FDSs consider current oral hygiene (87.4%) and patient's motivation (45%) as critical factors in a CRA for adult patients. Similar findings were reported in questionnaire studies among US and Japanese dentists [29, 33].

Like FGDPs, lack of time appears to be the most important factor identified among FDSs for not using CRA (FGPs: 67.2%; FDSs: 67.7%) [12]. However, it is surprising to note that 54.4% also mentioned the lack of teaching and insufficient knowledge on CRA as reasons for not using CRA in everyday practice, knowing that CRA should be properly implemented in dental curriculum like suggested in the latest (at the time of the study) European curriculum recommendations in cariology [34, 35]. Most of respondents would appreciate a task delegation to other dental personnel like dental hygienists but unfortunately the profession of dental hygienists is still not recognised in France. Like FGDPs, some FDSs also denounce the problem of reimbursement

(19.4%) as barriers to the use of CRA at a regular basis [11, 12]. Indeed, the Common Classification of Medical Acts (Classification Commune des Actes Médicaux or CCAM), which defines codification and billing of fees for procedures performed in dental practices in France, does not include a code for CRA, while the national recommendations (HAS) encourage CRA in daily routine [36]. Regrettably, while the periodontal assessment has a classification code, the absence of CRA in the CCAM illustrates the lack of consideration of this critical step in the caries prevention, which should be a major public health concern.

DSs are part of the panel of primary and secondary prevention [37, 38]; PDSs and TDSs are respectively indicated for caries initiation prevention in sound surfaces (ICDAS 0) in deep pits and fissures or for non-invasive management of non-cavitated carious lesions (ICDAS 1–3 and even ICDAS 1–4 for some authors). The state of evidences behind DSs is robust [39–44]. The present results show that almost all FDSs (96.6%) declared placing PDSs at a regular preventive option. Nevertheless, only less than half of FDSs (44.3%) considered TDSs placement. Similar findings were previously reported for GDPs practicing in France [11]. Indeed, while 90% of FGDPs regularly perform PDSs, only 42% of them think about TDSs as preventive options. Lack of knowledge and risk of further lesion progression appear to be the most cited reasons (respectively, 32.3% and 20.2%) that explain the non-use of TDSs by the future practitioners studying in France. In contrast to the USA, where TDSs are part of the best practice recommendations, the HAS has not ruled on TDSs yet although it supports non-invasive strategies for non-cavitated carious lesions [37, 38]. Unlike PDSs, there is no classification code in the CCAM for TDSs, which does not encourage GDPs to integrate these treatment options in their clinical practice. Instead, the lack of a classification code promotes the use of more invasive restorations for non-cavitated carious lesions, which are reimbursed by the French social security system and complementary health insurances.

Although three quarters of respondents stated that the undergraduate education related to CRA is sufficient, more than half of them reported some lacks towards both PDSs and TDSs. Worryingly, only 26.1% declared being familiar with the current national recommendations. In other countries, similar surveys administered to dental students and practitioners showed that respondents had a suitable theoretical knowledge about pit and fissure sealants; however, these studies also showed that there is a gap between their knowledge and the implementation of these preventive options in their clinical practices [45, 46].

These results highlight several problems regarding particularly the undergraduate education stream of cariology, which appears to require further improvements. Similarly, continuing education, which has been introduced for several

years in France, is mandatory for health professionals. As the subjects of training are not imposed and are selected by GDPs themselves depending on their preference, it is alarming to note that only 37% of them were interested in MI in 2015 [12]. Many reasons can explain this situation in Europe and especially in France. Changes in practitioners' attitudes about MI will only be achieved if clear information about the scientific rationale of CRA, the availability of easy-to-use CRA tools and evidence-based recommendations emerge [47]. Indeed, giving specific and simple guidelines to students and faculty members to accurately assign the caries risk levels for their patients could help them to improve CRA [48]. Admittedly, our study is a French example but there is little doubt that the same conclusions may be drawn in most of European countries; similar studies are thus needed to compare dental students' knowledge and practices within countries and confirm this hypothesis.

Changing traditional practices into new concepts must involve common actions [15, 49]. First of all, disparities concerning the teaching and practice of cariology that exist between French dental schools may lead to variations in FDS knowledge and treatment modalities. To address this problem, the college of teachers in conservative dentistry (CNEOC) could suggest concrete measures, for example writing a teachers' guide for dental curriculum, to standardize the education of MI in cariology in all French dental schools, according to the proposals of the European Core Curriculum for Cariology [18, 34, 35, 50]. Moreover, the objectives of the French (HAS) and European recommendations could also be redefined in order to favour evolutions of the health care system and reimbursement modalities (CCAM) towards an objective of caries prevention and to reconsider MI strategies as major public health concerns.

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