

Pediatric Dentists' Educational Experiences, Attitudes, and Professional Behavior Concerning Resin Infiltration: Implications for Dental Education

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Abstract: Minimally invasive dentistry (MID) is receiving increased attention. Resin infiltration (RI) is one micro-invasive technique for treating initial caries by sealing white spot lesions on tooth surfaces. The aims of this study were to assess pediatric dentists' RI-related educational experiences, attitudes, and professional behavior and to determine if their educational experiences were significantly related to their professional attitudes and behavior regarding RI. This cross-sectional study used an online survey to collect data from members of the American Academy of Pediatric Dentistry (AAPD) in March-April 2017. Of the 2,367 AAPD members invited to participate, 43 emails could not be delivered, and 273 surveys were completed, for a response rate of 11.8%. While only 9% of the 273 respondents reported that their classroom-based dental education had informed them about RI and only 1% that it had prepared them well to use RI with pediatric patients, higher percentages said they had been informed/prepared well by their classroom-based (24%) and clinical residency education (12%). The majority wanted to learn more about RI (71%) and would like to take a related CE course (59%). The respondents' average RI-related attitudes were positive (on five-point scale with 1=worst attitude: Mean=3.84). Regarding use of RI, 28% of respondents said they used RI sometimes and 4% often/very often, with 64% considering implementing RI in their clinics. Graduation year did not correlate with RI attitudes and use. However, the more education about RI the respondents had received during their residency ($r=0.20$; $p<0.01$) and in professional development after graduation ($r=0.34$; $p<0.001$), the more they used RI in their own work. This study found that the pediatric dentists' RI-related education was positively correlated with their professional behavior. Increasing predoctoral, resident, and continuing professional education about RI should therefore be considered.

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In 2017, Dye et al. used data from the U.S. National Health and Examination Surveys from 1999 through 2004 and from 2011 through 2014 to find that untreated dental caries in primary teeth among two-to-eight-year-old children had decreased from 24% in the earlier time period to 14% in the more recent time period.¹ In contrast, they found little change in the prevalence of carious lesions in older children and adolescents, with 58% of 12-19-year-old adolescents having had carious lesions in permanent teeth in their earlier publication.² One major consideration in this situation should be to ensure that the treatment provided for these children and adolescents

does not only address the current treatment need, but also considers the long-term consequences of the treatment provided. Consequently, a paradigm shift is currently under way, moving from traditional, mostly restorative treatment to approaches that focus on prevention and noninvasive or minimally invasive techniques. While traditional restorations lead to increased tooth structure removal (with further larger restorations eventually following that could even result in loss of tooth vitality), minimally invasive procedures focus on maintaining tooth structure.³ The International Caries Classification and Management System (ICCMS) therefore included minimally

invasive and preventive protocols for low, moderate, and high risk caries activity.⁴ In moderate/high risk patients with an initial carious lesion on either a smooth or proximal surface, experts recommend that topical fluoride application and/or resin sealants or proximal resin infiltration (RI) procedures should be used.⁴⁻⁶ In 2018, the new guidelines of the American Dental Association (ADA) recommended the use of RI for interproximal incipient carious lesions.⁷

RI is a non-invasive intervention, introduced in the 1970s as an alternative treatment to more invasive dental procedures.⁸ RI was designed to occlude the enamel pores of non-cavitated smooth surface carious lesions by first eroding the surface layer of enamel white spot lesions with 15% hydrochloric acid, followed by low-viscosity light-curing resins (known as “infiltrants”).⁹ The result is a blockage of cariogenic acids and the arrest of lesion progression.¹⁰ While research showed that RI creates a significantly rougher surface than healthy enamel, clinical trials with a split-mouth design found that RI was effective.¹¹⁻¹³ For example, in 2010, Ekstrand et al.’s study on primary molars in high caries risk children found, based on radiographs, that only 23.1% of infiltrated lesions in primary molars had carious lesion progression, while in the control group 61.5% of lesions had progressed during a 12-month period.¹⁴ In 2012, Meyer-Lueckel et al. showed on radiographs that while only 4% of infiltrated lesions of young adults with moderate caries risk progressed within a 36-month follow-up period, 46% of the lesions had progressed in the control group.¹⁵ A systematic review by Domejean et al. on the effectiveness of RI of non-cavitated lesions concluded in 2015 that RI appeared to be effective in arresting the progression of those lesions.¹¹

In 2017, the American Academy of Pediatric Dentistry (AAPD) considered RI in its reference manual and came to the recommendation that there was evidence for using RI as a treatment for small, non-cavitated interproximal carious lesions in permanent teeth.¹⁶ However, the manual mentioned that most randomized clinical trials on RI had had industry support as a potential conflict of interest. In addition, the AAPD pointed out that RI has benefits when being used to restore white spot lesions formed during orthodontic treatment. In these circumstances, microabrasion techniques may be used before the RI treatment.^{17,18} In 2018, El Meligy et al. concluded in their literature review that RI treatment complements other treatments of interproximal caries by allowing the postponement of traditional and more invasive

dental treatments.¹⁹ Most recently, in 2019, Faghian et al.’s systematic review and meta-analysis concluded that RI has a “significant advantage over non-invasive preventive measures in arresting initial carious lesions in primary and permanent teeth.”²⁰

In addition to the main advantage of RI that it can be used to treat incipient carious lesions and potentially stop caries progression, which could ultimately lead to the need for caries excavation and use of the drill,^{21,22} there is a second clear advantage for using RI when treating dentally fearful children. Avoiding the need for a high-speed drill has been found to alleviate pediatric patients’ dental fear, increase successful dentist-patient interactions, and increase these patients’ trust and treatment cooperation.²³

Given these positive research results, it is not surprising that the ADA established a dental code (D2990) in 2017 for the use of RI for dental treatment.²⁴ This fact should motivate dental educators to reflect on the way RI should be covered in predoctoral dental curricula. While no research so far has surveyed dental schools concerning their coverage of RI education in their curricula, one indirect way to gain a better understanding of educational practices could be to survey dental practitioners about their RI-related educational experiences. Given the benefits of the minimally invasive nature of RI use with children, the aims of this study were to assess pediatric dentists’ RI-related educational experiences, attitudes, and professional behavior and to determine if their educational experiences were significantly related to their professional attitudes and behavior regarding RI. We will also discuss the implications of these findings for predoctoral and advanced dental education.

Methods

The Institutional Review Board (IRB) for the Health Sciences and Behavioral Sciences at the University of Michigan determined that this study was exempt from IRB oversight (#HUM00112874). Participants were members of the AAPD.

We conducted an a priori power analysis with the program package G*Power 3.1.2 (www.psych.uni-duesseldorf.de/abteilungen/aap/gpower3) to compute the needed sample size, given $\alpha=0.05$, the power=0.95, and a medium to small effect size of $\rho=0.20$, for testing if there were significant relationships between the respondents’ educational experiences and their attitudes and RI-related clinical

behavior/behavioral intentions. This analysis showed that a minimum of 262 subjects would be required to have the power to test the one-sided hypotheses that there were significant relationships among these variables.

For the study, we bought the email addresses of active AAPD members from the AAPD and sent recruitment emails to 2,367 randomly selected members. The recruitment email explained the purpose of the study and provided a link to an anonymous survey on the University of Michigan-Qualtrics website. The data were collected in March and April of 2017. No follow-up emails were sent because the AAPD does not allow sending more than one email to its members.

The questionnaire consisted of four parts. Part 1 asked for information about the respondents' general characteristics, educational experiences, and practice characteristics. Part 2 contained questions concerning the respondents' educational experiences about RI and minimally invasive dentistry. Part 3 was concerned with assessing the respondents' RI-related attitudes. The final set of five questions asked about the respondents' RI use and included two open-ended questions about what the respondents liked and disliked about RI.

The data were analyzed with SPSS, Version 24 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as percentages and means were computed to provide an overview of the responses. Two factor analyses were used to determine underlying factors of the educational items and the attitudinal items (extraction method: principle component analysis; rotation method: Varimax rotation with Kaiser Normalization). The factor analysis of the educational items resulted in six underlying factors and the factor analysis of the attitudinal items in a two-factor solution. Based on the results of the two factor analyses, indices were computed by averaging the responses to the items with factor loadings >0.40 on each factor. Cronbach's alpha coefficients were computed to determine the inter-item consistency of the items loading on each factor. All Cronbach's alpha values were over 0.70, indicating that the scales had sufficient to excellent inter-item consistency.^{25,26} Pearson correlation coefficients were used to determine relationships among the educational, attitudinal, and behavioral RI-related responses. Because numerous statistical tests were performed simultaneously when analyzing the relationships among the indices, Bonferroni corrections were used, and the alpha value was lowered to $p < 0.01$.²⁷

Two independent raters coded the open-ended answers to the questions of what the respondents

liked and disliked about RI. The consistency percentages of the coding by Rater 1 and Rater 2 ranged between 87% and 93%.

Results

Of the 2,367 AAPD members invited to participate in the survey, 43 emails could not be delivered, and 273 surveys were completed, for a response rate of 11.8%. The 273 respondents were 56% men and 44% women and ranged in age from 25 to 74 years (Mean: 46.75 years) (Table 1). The respondents graduated from dental school between 1967 and 2016 and from pediatric dental residency programs between 1969 and 2020. The fact that 2020 was listed as a graduation year from the residency program indicates that two current pediatric dental residents responded. Of the respondents, 39% worked in a group practice, 30% in a solo practice, 24% owned a practice, and 16% were associates. On average, 38% of their patients were covered by Medicaid, 45% by private insurance, and 14% by self-pay, while 50% of their patients were under six years of age and 46% over seven years of age. The respondents saw on average about 111 patients in an average week and worked on average nearly 33 hours per week. When asked about preferred patient management strategies, 53% reported using nitrous oxide, 7% oral sedations, 2% protective stabilization, and 8% general anesthesia. The ranges of responses to this question showed that some dentists did not use these techniques and that some used them quite frequently when treating pediatric patients.

Table 2 provides an overview of the respondents' educational experiences related to RI and minimally invasive dentistry (MID). The first five questions were related to the respondent's dental school education about RI. Only about 3% of the respondents strongly agreed and 6% agreed that their classroom-based dental school education had informed them about the use of RI, and only about 1% had clinical education about using RI with adult or pediatric patients. Only 4% agreed/agreed strongly that their dental school instructors had a positive view of RI. The dental school-related RI education index was formed by averaging the responses to these five items. The mean index showed that the respondents disagreed on average that they were well educated about RI in dental school. However, the scores ranged from 1=disagree strongly to 5=agree strongly.

Table 1. Participants' personal, professional, and practice characteristics, by number and percentage of total respondents (N=273)

Characteristic	Number	Percentage
Gender		
Men	151	56%
Women	118	44%
Community location of practice	8	3%
Rural (<5,000)	34	13%
Small town/city (5,000-24,999)	73	27%
Moderate-sized city (25,000-250,000)	95	35%
Suburb near large city	59	22%
Large city		
	Mean	SD, Range
Age	46.75	13, 25-74
Year of graduation from dental school	1997	14.293, 1967-2016
Year of graduation from pediatric residency program	2000	14.379, 1969-2020
	Mean %	SD, Range
How professional time spent		
Office practice	76%	27, 0-100%
Teaching	8%	21, 0-100%
Operating room	8%	13, 0-100%
Administration	6%	12, 0-100%
Practice type and role		
Solo practice	30%	46, 0-100%
Group practice	39%	49, 0-100%
Associate	16%	37, 0-100%
Partner	8%	27, 0-100%
Owner	24%	43, 0-100%
Public health	13%	33, 0-100%
Other	10%	30, 0-100%
Patients covered by		
Medicaid	38%	36%, 0-100%
Private insurance	45%	30%, 0-100%
Self-pay	14%	19%, 0-100%
Other	1%	8%, 0-100%

Five questions were related to the respondents' education about RI during their pediatric dentistry residency. A total of 24% agreed/agreed strongly that their classroom-based residency education had informed them about the use of RI and 22% that it had informed them about its benefits. Only 9% reported that their clinical residency education had prepared them well to use RI with adult patients and 12% that it had prepared them well to use RI with pediatric patients. When asked about their residency program instructors' views of RI and MID, 17% agreed/agreed strongly that their instructors had a positive view of the use of RI, and 39% that their instructors had a positive view of MID procedures.

When asked how much they had heard about RI after their formal dental education, 36% of the respondents were neutral, 36% said they had heard

a great deal about it, 54% said they had heard some information, and 9% said they never heard about RI after graduation. However, 48% reported (agreed/agreed strongly) that they had taken a continuing education (CE) course about the use of minimally invasive procedures for treating carious lesions and 29% about the use of RI. In addition, 59% said they would like to take a course about RI, and 71% would like to learn more about the use of RI. A large majority (86%) said they had read an article about the use of MID procedures for treating caries, and 76% had read an article about the use of RI.

The majority agreed/strongly agreed with five of the six positive items: that the use of RI helps avoid the use of local anesthesia with pediatric patients (72%), helps with the restoration of non-cavitated lesions (71%), has aesthetic benefits (70%), prolongs

Table 2. Respondents' educational experiences related to resin infiltration (RI) and minimally invasive dentistry (MID), by percentage of total respondents (N=273)

Variable	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Mean
Dental school education about RI						
a. My classroom-based education informed me about the use of RI.	71%	12%	8%	6%	3%	1.56
b. My classroom-based education informed me about the benefits of using RI.	73%	12%	8%	4%	2%	1.51
c. My clinical education prepared me well to use RI with adult patients.	78%	12%	8%	0.4%	1%	1.34
d. My clinical education prepared me well to use RI with pediatric patients.	78%	13%	8%	0.4%	0.4%	1.32
e. My instructors had a positive view of RI.	57%	15%	25%	2%	2%	1.78
Dental school-related RI education index (Cronbach's alpha=0.910)	Mean=1.50		SD=0.77		Range: 1-5	
Pediatric dentistry residency education about RI						
f. My classroom-based education informed me about the use of RI.	53%	9%	13%	15%	9%	2.18
g. My classroom-based education informed me about the benefits of using RI.	54%	9%	16%	14%	8%	2.13
h. My clinical education prepared me well to use RI with adult patients.	62%	14%	15%	5%	4%	1.74
i. My clinical education prepared me well to use RI with pediatric patients.	60%	14%	15%	8%	4%	1.81
j. My instructors had a positive view of the use of RI.	45%	11%	26%	11%	6%	2.21
Residency-related RI education index (Cronbach's alpha=0.946)	Mean=2.01		SD=1.16		Range: 1 to 5	
MID-related educational experiences						
k. My dental school instructors had a positive view of MID procedures.	34%	21%	23%	13%	11%	2.46
l. My residency instructors had a positive view of MID procedures.	26%	11%	24%	21%	18%	2.94
MID-related education index (Cronbach's alpha=0.745)	Mean=2.71		SD=1.25		Range: 1 to 5	
Professional experiences and education						
m. How much have you heard about RI and using it? ^a I took CE courses about:	9%	–	54%	–	36%	3.56
n. The use of MID procedures for treating caries.	30%	9%	13%	28%	20%	2.98
o. The use of RI.	40%	14%	16%	19%	10%	2.47
Professional education index (Cronbach's alpha=0.757)	Mean=3.10		SD=1.102		Range: 1.67 to 4.33	
Motivation to learn more about RI						
p. I would like to take a CE course about RI.	7%	8%	22%	30%	29%	3.71
q. I would like to learn more about the use of RI.	2%	4%	13%	34%	37%	4.45
Motivation to learn more about RI index (Cronbach's alpha=0.818)	Mean=3.89		SD=0.99		Range: 1 to 5	
In the past years, I read an article about						
r. The use of MID procedures for treating caries.	4%	2%	8%	37%	49%	4.26
s. The use of RI.	10%	4%	10%	40%	36%	3.86
Previous self-education about RI/MID index (Cronbach's alpha=0.803)	Mean=4.06		SD=1.01		Range: 1 to 5	

Note: Means were based on the following numerical scale: 1=disagree strongly, 2=disagree, 3=neutral, 4=agree, and 5=agree strongly. The dental school-related RI education index was computed by averaging the responses to items a to e. The residency-related RI education index was computed by averaging the responses to items f to j. The MID-related education index was computed by averaging the responses to items k and l. The professional education index was computed by averaging the responses to items m to o. The motivation to learn more about RI index was computed by averaging the items p and q. The previous self-education about RI/MID index was computed by averaging the responses to items r and s.

^aResponse options on this item were 1=never heard of it, 3=have heard of it somewhat, and 5=have heard a great deal on the matter.

the life expectancy of a tooth (65%), and is useful in their practice (60%) (Table 3). In addition, 49% agreed/agreed strongly that the use of RI helps prevent dental fear in their patients. On the other hand,

4% agreed/agreed strongly that RI is only of value in orthodontic practices, 6% that they did not believe in MID, 11% that RI is a fad that will disappear again, and 16% that RI is not practical for them to use.

Table 3. Respondents' attitudes about use of resin infiltration (RI), by percentage of total respondents (N=273)

Variable	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Mean
Positive attitude towards RI						
a. The use of RI has esthetic benefits.	4%	2%	26%	34%	36%	3.95
b. The use of RI helps to avoid use of local anesthesia for pediatric patients.	3%	6%	20%	37%	35%	3.95
c. The use of RI helps with restoration of non-cavitated lesions.	1%	4%	23%	37%	34%	3.99
d. The use of RI helps to prolong the life expectancy of a tooth.	2%	5%	28%	32%	33%	3.89
e. The use of RI helps me to prevent dental fear in my patients.	3%	11%	37%	26%	23%	3.55
f. This technique is useful in my practice (or can be).	3%	7%	31%	33%	27%	3.73
Positive attitude towards RI index (Cronbach's alpha=0.904)	Mean=3.84		SD=0.822		Range: 1 to 5	
Negative attitude towards RI						
g. I don't believe in minimally invasive dentistry.	71%	14%	9%	4%	2%	1.51
h. RI is a fad that will disappear again.	30%	25%	34%	10%	1%	2.27
i. It is not practical for me to use RI.	24%	24%	36%	12%	4%	2.47
j. RI is only of value in orthodontic practices.	47%	28%	22%	3%	1%	1.83
Negative attitude towards RI index (Cronbach's alpha=0.719)	Mean=2.02		SD=0.739		Range: 1 to 4	
Responses related to RI use						
I would consider implementing RI in my clinic.	4%	7%	23%	39%	25%	3.74
The fact that RI does not show up on radiographs is a problem for me.	7%	10%	24%	37%	22%	3.56
Frequency of use						
How often do you use RI in your own work?	Never	Sometimes	Often	Very Often		Mean
	69%	28%	3%	1%		1.36

Note: Means were based on the following numerical scales for positive and negative attitudes towards RI: 1=disagree strongly, 2=disagree, 3=neutral, 4=agree, and 5=agree strongly; and for frequency of use: 1=never, 2=sometimes, 3=often, and 4=very often. The positive attitude towards RI index was computed by averaging the responses to items a to f. The negative attitude towards RI index was computed by averaging the responses to items g to j.

When asked if they would consider implementing RI in their own clinic, 64% agreed/agreed strongly that they would consider implementing it. However, 59% agreed/agreed strongly that the fact that RI does not show up on radiographs is a problem for them. In response to the question how often they used RI in their own work, 69% responded that they never used it, 28% that they sometimes used it, 3% that they often used it, and 1% that they very often used it.

Table 4 shows the number of positive and negative open-ended responses related to RI. The most frequent positive responses were related to the fact that the respondents liked minimally invasive methods to arrest caries, that no tooth preparation was needed, and that RI has aesthetic benefits in the anterior region, can be used without a local anesthetic, and is easy for the patient and the dentist. The most frequently named "dislike" was that RI does not show up on radiographs, followed by answers related to RI not having reliable results and not being reimbursed by insurance.

The more recently the respondents had graduated from dental school and from their residency

program, the better they were educated about RI in dental school, in their residency program, and about MID (Table 5). However, year of graduation did not correlate with the respondents' educational experiences after graduation, their motivation to learn more about these subject matters, nor their own self-education efforts in this area. In addition, while the dental school, residency, and MID-related educational indices were intercorrelated, they did not correlate with the professional education, motivational, and self-education indices. However, the motivational and self-education indices did correlate significantly with the respondents' attitudes. In addition, the residency education index, the professional education index, and the self-education index correlated significantly with the frequency of RI use in their own work.

The respondents' graduation year from dental school and their residency programs did not correlate significantly with their RI-related attitudes and behavior (Table 6). However, their attitudes were positively associated with their RI-related behavioral responses.

Table 4. Number of open-ended resin infiltration (RI)-related responses, by rater

Response	Rater 1	Rater 2
Positive responses: "likes"		
Minimally invasive method to arrest caries	74	68
No tooth preparation needed using bur or noise from the bur	41	38
Aesthetic benefits in anterior area	27	28
Can be used without local anesthetic	21	20
Easy for patient/not painful	21	19
Easy for dentist	19	16
Arresting carious lesions or prevention	8	8
Under right circumstances, it can be beneficial	4	2
Another technique to add to our armamentarium	2	3
Don't know, unsure, or N/A	21	21
Total	238	223
Consistency %	87%	90%
Negative responses: "dislikes"		
Does not show up on radiographs	48	47
Not reliable or inconsistent results	25	24
Not reimbursed by insurance (no code or charge)	24	25
Time	24	24
More technique-sensitive than other MI treatments	21	20
Patient follow-up compliance	11	8
Needs rubber dam	12	3
Not enough research on RI	9	10
Inadequate interproximal access	9	9
RI is expensive	7	8
Technical issues (not easy to use; continually have to watch; removes tooth surface w/ acid etch)	5	4
Not enough right circumstances/indications; practicality of its use in public health not logical	5	4
Not comfortable/confident in recommending	4	5
Parent issues/difficult to explain to parent	5	3
Patient experiences pain without LA	3	3
No good aesthetic benefits for some lesions	2	2
Non-compliant or fearful kids	1	3
Not for primary teeth (going to lose anyway)	1	1
Don't know, unsure, or N/A	25	25
Total	241	228
Consistency %	90%	93%

Discussion

According to the a priori power analysis, data from 262 respondents were needed to have the power to determine if there was a positive relationship between the respondents' RI-related educational experiences and RI-related attitudes and behavior. Data from 273 respondents were collected, which ensured that this study had a sufficiently large sample size to test hypotheses about relationships between the constructs of interest. In addition, the response rate achieved in this study was 11.75%. This response rate slightly exceeds the response rate for web-based

surveys that Hardigan et al. achieved in their quasi-experimental study with dentists concerning the response rates to paper-pencil vs. web-based surveys.²⁸ Also, an analysis of the demographic and practice characteristics of the participating pediatric dentists as well as the responses concerning RI-related educational experiences, attitudes, and behavior showed that the sample was quite heterogeneous and was not biased towards a specific group of respondents.

An analysis of the respondents' RI-related educational experiences showed that while RI was not at all well covered in their dental school curricula, more than one in five respondents had RI-related classroom-based experiences in their residency

Table 5. Relationships between educational experiences related to resin infiltration (RI) and minimally invasive dentistry (MID), RI-related attitudes, and RI use

	A Dental School	B Residency	C MID- Related	D Professional	E Motivation	F Self- Education
Education						
Year completed dental school	0.36***	0.62***	0.54***	-0.07	0.04	-0.06
Year completed pediatric dental residency	0.35***	0.61***	0.54***	-0.05	0.04	-0.06
RI-related educational indices						
A=dental school-related RI education index	1	0.61***	0.52***	0.05	-0.14*	-0.01
B=residency-related RI education index	0.61***	1	0.59***	0.09	-0.07	0.04
C=MID-related education index	0.52***	0.59***	1	0.023	-0.09	0.01
D=professional education index	0.05	0.09	0.03	1	0.02	0.38***
E=motivation to learn more about RI index	-0.14*	-0.07	-0.09	0.02	1	0.13*
F=previous RI/MID-related self-education index	-0.01	0.04	0.01	0.38***	0.13*	1
RI-related attitudinal indices						
G=positive attitude towards RI index	-0.04	0.06	-0.03	0.15*	0.55***	0.23***
H=negative attitude towards RI index	0.02	-0.11	-0.11	-0.17*	-0.40***	-0.19**
RI-related behavior						
I would consider implementing RI in my clinic ^a	-0.01	0.11	0.002	0.07	0.57***	0.14*
Frequency of using RI in my own work ^b	0.07	0.20**	0.003	0.34***	-0.03	0.30***

Note: The dental school-related RI education index (A) was computed by averaging the responses to items a to e in Table 2. The residency-related RI education index (B) was computed by averaging the responses to items f to j in Table 2. The MID-related education index (C) was computed by averaging the responses to items k and l in Table 2. The professional education index (D) was computed by averaging the responses to items m to o in Table 2. The motivation to learn more about RI index (E) was computed by averaging the items p and q in Table 2. The previous RI/MID-related self-education index (F) was computed by averaging the responses to items r and s in Table 2. The positive attitude towards RI index (G) was computed by averaging the responses to items a to f in Table 3. The negative attitude towards RI index (H) was computed by averaging the responses to items g to j in Table 3. The question to determine frequency of using RI was worded as "How often do you use RI in your own work?"

^aResponse options were 1=disagree strongly, 2=disagree, 3=neutral, 4=agree, and 5=agree strongly.

^bResponse options were 1=never, 2=sometimes, 3=often, and 4=very often.

*p<0.05, **p<0.01, ***p<0.001

Table 6. Relationships between attitudes about resin infiltration (RI) and RI use and respondents' characteristics

Characteristic	G=Positive Attitude Towards RI Index	H=Negative Attitude Towards RI Index	I Would Consider Implementing RI in My Clinic	Frequency of Using RI in Own Work
Year completed dental school	0.07	-0.18	0.15*	0.06
Year completed pediatric dentistry residency	0.08	-0.21	0.15*	0.08
RI-related attitudinal indices				
G=positive attitude towards RI index	1	-0.49***	0.64***	0.17**
H=negative attitude towards RI index	-0.50***	1	-0.59***	-0.38***
RI-related behavior				
I would consider implementing RI in my clinic ^a	0.64***	-0.59***	1	0.21***
Frequency of using RI in my own work ^b	0.17**	-0.38***	0.21***	1

Note: The positive attitude towards RI index (G) was computed by averaging the responses to items a to f in Table 3. The negative attitude towards RI index (H) was computed by averaging the responses to items g to j in Table 3. The question to determine frequency of using RI was worded as "How often do you use RI in your own work?"

^aResponse options were 1=disagree strongly, 2=disagree, 3=neutral, 4=agree, and 5=agree strongly.

^bResponse options were 1=never, 2=sometimes, 3=often, and 4=very often.

*p<0.05, **p<0.01, ***p<0.001

programs, with fewer reporting clinical experiences (Table 2). These percentages are not surprising because RI has only recently become a more accepted new treatment option for interproximal incipient carious lesions.^{29,30} However, the findings that 59% agreed/agreed strongly that they would like to take a CE course about RI, that 71% would like to learn more about RI, and that 76% read an article about RI are noteworthy and have clear implications for changes in predoctoral dental curricula and pediatric dentistry graduate programs. However, these findings should also be considered in the context of the negative open-ended remarks that were made. In consideration of these negative comments, it is possible that the motivation to attend a CE course about RI might be due to the challenges considered when using this method.

In interpreting these results, it is important to consider when the respondents graduated from dental school and from their pediatric residency program because the Infiltration Concept (ICON) material used for RI treatment was not introduced in the U.S. until 2009.³¹ It is therefore not surprising that these two graduation years were significantly correlated with respondents' evaluation of their dental school, residency, and MID-related education (Table 5). However, one interesting finding in this context is that graduation years were *not* significantly correlated with the respondents' professional education nor with their motivation to learn more about RI and their own previous RI/MID-related self-education efforts. This finding shows that the professional education considerations were independent of the respondents' age. In addition, the finding of a positive correlation between the two graduation years and the respondents' willingness to consider implementing RI in their own practice deserves attention. It implies that CE efforts should be targeted towards pediatric dentists in all age groups.

Consistent with this interest in learning more about RI were the quite positive attitudes of the responding pediatric dentists (Table 3), with the majority agreeing/strongly agreeing with five of the six positive attitudinal statements. These findings are especially interesting when considering that previous research on dentists' attitudes about minimally invasive treatment methods found that attitudes ranged widely from some dentists believing that there was no strong evidence to support these technique to others arguing that minimally invasive treatment approaches were superior in some instances.^{10,11,21,32}

A recent study by Schwendicke et al. in New Zealand, Germany, and the U.S. concerning dentists' decision making when managing non-cavitated lesions explored this topic by conducting in-depth interviews.³³ Use of this qualitative method resulted in rich findings about the wide range of dentists' considerations concerning minimally invasive techniques including RI. Gaining a solid understanding of these considerations is crucial because they may ultimately determine the utilization of these approaches in dentists' daily clinical practice. In our study, the responses to open-ended questions concerning what the respondents liked vs. disliked about RI were similarly interesting. The fact that RI is a minimally invasive technique was mentioned most frequently as a positive feature, with a focus on patient-friendly aspects of this technique following. The fact that a treatment with RI does not show up on radiographs was by far the most frequently mentioned concern. Two of the next most frequently mentioned concerns were that a treatment with RI would have nonreliable or inconsistent results and be time-consuming. Concerning this first set of responses, it is important to note that a number of high-quality studies, such as systematic reviews^{34,35} and randomized controlled trials,³⁶⁻³⁸ have reported the efficacy of RI treatment over a treatment with fluoride varnish or regular care consisting of observing the lesions only. A discussion of the concern over time needed for a treatment with RI needs to consider the results of a study by Altarabulsi et al. in 2013.³⁹ These authors did not only find good patient satisfaction with the procedure, but had a mean time for infiltration of 24.3 ± 7.4 minutes, which included rubber dam application (7.7 ± 4 minutes). They reported that clinicians perceived the RI-related treatment to be comparable or even easier than a composite filling.

Given these newer findings, it is possible that the respondents in our study who listed these reasons for disliking RI may not have been aware of this empirical evidence that RI is an effective method to arrest incipient carious lesions.¹¹ They may not have known that when RI treatment is associated with fluoride therapy, it is more effective in preventing carious lesions than fluoride therapy alone in deciduous teeth.^{29,30} In addition, RI has proven benefits in preventing interproximal carious lesions progression similar to dental sealants' efficacy in occlusal surfaces.⁴⁰ The implications then might be that solid classroom-based as well as clinical education about RI is needed to ensure that this technique receives the attention it deserves.

Given the strong relationships we found between professional attitudes and behavior, attempts should be made to engage faculty members in intensive faculty development activities concerning the use of RI. Educators in dental schools as well as in pediatric dentistry residency programs should be knowledgeable about the currently available evidence concerning the benefits of using RI.^{19,20} However, given the potential conflict of interest created when past research was funded by industry support,¹⁹ future research is needed that does not depend on that form of support. Meanwhile, classroom-based and clinical opportunities to introduce predoctoral and advanced dental students to RI should be explored.

This study had three limitations. First, this study focused on pediatric dentists because RI has clear benefits when providing care for potentially fearful children. Future research should assess general dentists' thoughts concerning the use of this technique for the treatment of adult patients. Second, it would have been interesting to compare the responses of subgroups of respondents, such as by practice type. However, the subgroup sample sizes were too small to compare the average response of various groups. Future research should consider these research questions related to pediatric dentists' practice situations and how they might affect their RI-related professional behavior. Third, while the response rate to this web-based survey was acceptable, it cannot be ruled out that these respondents were more likely to have heard about RI than pediatric dentists in general.

Conclusion

Based on these data, we can draw the following conclusions. First, while the study found that the respondents' dental school curricula did not include much education about RI in classroom-based and clinical settings, their pediatric dentistry graduate programs were more likely to educate residents about this technique. This finding is consistent with the finding that while only a small percentage of dental school faculty members were perceived as being positive towards this technique, about four out of ten residency program faculty members were described as having had a positive view of RI. Second, questions concerning the respondents' professional education showed that the majority would like to take a CE course about RI and would like to learn more about RI; also, more than three out of four had read an article about MID and an article about the use of

RI. Third, the respondents' attitudes towards RI were quite positive, and more than six out of ten respondents said they would consider implementing RI in their practice. Fourth, over three out of ten respondents used RI in their own work at least sometimes. Finally, concerning the educational implications of these findings, the data showed that the more recently respondents had graduated from their dental school and residency program, the more education about MID and RI they had received. However, there was a strong interest in continuing education about RI that deserves attention. The question therefore is whether dental school and specialty program faculty members share the positive attitudes towards RI and will be able to provide the needed education.

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