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ORIGINAL ARTICLE

Periodontists and oral surgeons' peri-implantitis-related education, knowledge, attitudes, and professional behavior: A national survey

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Abstract

Objectives: Each year, approximately 5 million dental implants are placed in the United States and one out of three patients is likely to experience peri-implantitis (PI). The objectives were to compare the PI-related education, knowledge, attitudes, and professional behavior of periodontists and oral maxillofacial surgeons (OMS), and to explore relationships between these constructs of interest.

Methods: A total of 389 periodontists and 161 OMS responded to a web-based survey. Descriptive and inferential statistical analyses (independent sample *t*-tests, chi-square tests, and correlational analyses) were conducted.

Results: On average, periodontists reported a higher percentage of time spent in residency on implant surgery (21.02% vs. 7.27%; $p < 0.001$), better education about PI (5-point scale with 1 = not at all well: means: 2.86 vs. 2.59; $p < 0.001$), and better knowledge of risk factors (4.07 vs. 3.86; $p < 0.001$) than OMS. Periodontists argued that oral hygiene-related treatment (4.45 vs. 4.22; $p = 0.001$) and regeneration-focused treatments such as guided tissue regeneration (3.62 vs. 3.20; $p < 0.001$) contributed more to successfully treating PI and used these treatments more in their practices (4.86 vs. 4.56; $p < 0.001$/3.06 vs. 2.68; $p < 0.001$) than OMS. They also considered PI as a more serious problem than OMS (4.55 vs. 3.80; $p < 0.001$). The better the respondents' PI-related knowledge was, the more they considered PI as a serious problem ($r = 0.19$; $p < 0.001$). The more cases they treated per month, the more they considered PI as a serious problem ($r = 0.19$; $p < 0.001$).

Conclusions: The results of the present study highlight the lack of standardization in the specialty training of periodontists and OMS. Best practice guidelines for the diagnosis and treatment of PI are needed to optimize graduate education about this important topic.

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KEYWORDS
curriculum, dental implantation, dentists, diagnosis, education, oral and maxillofacial surgeons, peri-implantitis, periodontists, risk factors, therapeutics

1 | INTRODUCTION

Each year, approximately 5 million dental implants are placed in the United States.[1] In 2022, the global dental implant market reached 4.6 billion USD and was expected to further grow at an annual rate of approximately 10%.[1] This significant growth is due to the high demand for dental implants and the widening range of clinicians providing implant therapy. While dental implants have become a routine and highly successful treatment,[2] peri-implantitis (PI) represents a common complication.[3] PI is characterized by inflammation in the peri-implant soft tissues and progressive loss of supporting bone.[4] A recent study concluded that approximately one out of three patients and one out of five implants experienced PI.[3] In more severe cases, the removal of the failing implant is the only option.[5,6] Therefore, PI represents a growing public health concern due to its high prevalence and associated sequelae (implant and/or implant-supported prosthesis loss) and is a significant economic burden.[7]

In 2008, the First European Consensus Workshop on Implant Dentistry University Education defined the key elements for competency-based education in implant dentistry in order to guide undergraduate and postgraduate implant curricula.[8,9] Following this workshop, many dental schools and professional organizations introduced education about implant dentistry in different ways.[10] This resulted in a wide variation of predoctoral and postdoctoral implant curricula across institutions, programs, and dental disciplines.[10,11] For example, some predoctoral programs focused almost exclusively on restorative aspects of implant dentistry with minimal attention to surgical considerations.[12] This lack of standardization extended to the topics of implant site development and diagnosis and treatment of peri-implant diseases.[9,13,14] The curricula of postgraduate programs only described that the graduates should be "competent in the diagnosis; prevention and management of biological and technical complications."[10]

The Commission on Dental Accreditation (CODA) requirements for periodontists refers to the "management of peri-implant diseases" without further details.[15] However, so far, only one recent study evaluated the peri-implant disease education and diagnosis in predoctoral curricula and concluded that there was a lack of standardization in these curricula concerning the didactic and clinical management of peri-implant diseases.[13] Another study analyzed US and European periodontists' education and knowledge about PI-related risk factors, diagnostic criteria, and management of PI.[16] These authors found that less than half of the research participants in both groups had treated patients with PI during residency. There was no statistically significant difference between US and European periodontists.[16]

Peri-implant disease education should ensure that dental care providers are educated about the risk factors, diagnosis, and treatment of PI. Concerning the risk factors, they need to understand that microbial biofilm acts as an initial trigger for inflammatory reactions, and is considered the primary etiological factor for PI.[17] Recent evidence discussed that previous history of periodontitis, poor plaque control, and lack of maintenance care were the most important risk factors/indicators.[4] Other factors such as smoking, diabetes, residual cement, occlusal overload, genetic predisposition, improper implant positioning, and prosthesis design were also associated with a greater risk for peri-implant pathologies. However, the evidence for these factors was less conclusive.[4,17,18]

The education of dental care providers about the diagnosis of peri-implant diseases should be based on the most recent existing evidence.[19] Since untreated peri-implant mucositis can progress to PI at a high rate, it is critical for clinicians who offer implant therapy to understand the diagnosis and treatment of peri-implant mucositis first, and also be aware of the diagnostic criteria for PI.[19] Concerning the education about the treatment of PI, dental practitioners should know the most recent guidelines for the treatment of peri-implant diseases published by the European Federation of Periodontology (EFP).[7] These guidelines include a stepwise approach with a non-surgical step coming first in order to control peri-implant biofilm and inflammation. A re-evaluation follows and then either a surgical step or supportive care is performed.[7] The core of the non-surgical treatment is mechanical debridement. The use of local antiseptics,[20] systemic antibiotics,[21] lasers,[22] and photodynamic therapy[23] have been proposed as adjunctive measures. However, since existing evidence is inconclusive regarding the added benefit of their use, the EFP guidelines recommend against their use.[7] Given that implant dentistry represents a continuously evolving field, clinicians who offer implant therapy must commit to remaining current as new information becomes available.

When successful treatment of PI with non-surgical therapy cannot be achieved, surgical treatment is recommended in order to gain access for better implant surface decontamination.[7] Open flap debridement, resective surgery with or without implantoplasty, and reconstructive procedures including the use of various bone grafts with or without barrier membranes are some of the approaches reported in the literature.[24,25] Nevertheless, "irrespective of the surgical approach and biomaterial employed, resolution of PI is unpredictable" and current evidence does not support a gold-standard treatment.[25]

A recent study by Muñoz et al. showed that the need for implant site development is very common, yet implant curricula vary widely when it comes to teaching implant site development.[14] Similarly, PI is a very common condition, yet knowledge, attitudes, and behaviors concerning peri-implant disease vary between periodontists and oral surgeons. Furthermore, both the CODA standards for periodontics[15] and the CODA standards for oral and maxillofacial surgeons (OMS)[26] require that graduates from these programs are well trained in surgical procedures and have an in-depth understanding of the biology and physiology of oral soft and hard tissues. Nevertheless, more specific requirements concerning training on the diagnosis and treatment of peri-implant diseases are missing.[15,26] The objectives of this study were therefore to compare the PI-related education, knowledge, attitudes, and professional behavior of periodontists and OMS and to explore relationships between these constructs of interest.

2 | METHODS

This research was determined to be exempt from Institutional Review Board (IRB) oversight by the Health Sciences and Behavioral Sciences IRB at the University of Michigan (HUM00102795). This study followed the Declaration of Helsinki Ethical Principles. No written consent from the participants was required because responding to this online anonymous survey was considered as giving implicit consent to participate.

2.1 | Respondents

In order to estimate the sample size needed to use independent sample *t*-tests to test for the significance of differences in the average responses of periodontists and OMS, a priori power analysis with the G3.1.3. Power Analysis Program (http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/) was conducted. Assuming a two-sided hypothesis, a medium-to-small effect size of 0.35 on the 5-point answer scales, a statistical significance of 0.05, a power of 0.95, and a ratio of 2:1, data from 320 periodontists and 160 OMS would be needed to have the power to test these hypotheses. The ratio of 2:1 was used, because previous experiences with collecting data from periodontists and OMS had shown that the response rates of OMS were relatively lower than the response rates when collecting data from periodontists.

A total of 389 periodontists responded to a recruitment email sent to 4375 active members of the American Academy of Periodontology (AAP; response rate = 8.9%) and 161 OMS responded to a recruitment email sent to 3127 American Association of Oral and Maxillofacial Surgeons (AAOMS) members in California, Florida, Maryland, Massachusetts, Michigan, and New York (response rate = 5.4%).

2.2 | Procedure

A recruitment email was sent to active members of the AAP and AAOMS. This email explained the purpose of the research and provided a web link for accessing the anonymous survey. Follow-up reminder emails to the AAP members were sent 2 weeks and 2 months later and one follow-up email was sent 2 months later to the AAOMS members. The recipients could use the link to the survey only once.

2.3 | Material

A survey was designed based on a review of the literature and on previously validated questionnaires.[27,28] The survey consisted of five parts. Part 1 addressed the respondents' background and educational characteristics. Part 2 asked how much eight factors could put a patient at risk for PI. Part 3 inquired how important five parameters were for diagnosing PI. Part 4 asked how frequently the respondents used 15 different treatment strategies in their professional practice. The final part consisted of six questions concerning the respondents' PI-related attitudes. The questions in Parts 2–5 were answered on 5-point rating scales. The first draft of the survey was pilot tested with five periodontists and five OMS, and the final survey was developed based on the feedback given by the pilot respondents.

2.4 | Statistical analyses

The data were collected with a web-based survey provided on Qualtrics and were downloaded as an SPSS data file (IBM SPSS Statistics for Windows, Version 28.0, IBM

TABLE 1 Overview of periodontists and oral maxillofacial surgeons' (OMS) background characteristics.

Background characteristics	Periodontists $N = 389$	OMS $N = 161$	p
Gender:			
Male	312 (80.6%)	150 (94.9%)	<0.001
Female	75 (19.4%)	8 (5.1%)	
Background characteristics	**Periodontists mean (SD) range**	**OMS mean (SD) range**	**p**
Age	51.40 (13.528) 28–80	51.00 (12.143) 27–77	0.736
Percent of time at work spent:			
In a private practice setting	77.65 (37.508) 0%–100%	77.43 (35.014) 0%–100%	0.949
As a faculty member	13.14 (28.896) 0%–100%	11.77 (28.520) 0%–100%	0.613
In a hospital setting	2.06 (11.188) 0%–100%	15.54 (29.378) 0%–100%	<0.001
In another setting	3.81 (18.296) 0%–100%	1.13 (6.168) 0%–50%	0.011
Number of hours per week spent at work	30.38 (13.288) 0–80	40.84 (13.487) 6–96	<0.001
Number of patients treated per week	34.63 (30.072) 0–160	59.20 (39.910) 1–250	<0.001

Abbreviation: SD, standard deviation.

Corp.). Descriptive statistics such as frequency distributions, means, and standard deviations were computed to provide an overview of the responses of the periodontists and OMS. Four factor analyses (extraction method: principal component analysis; rotation method: varimax rotation with Kaiser normalization) were conducted with the four sets of questions concerning the risk factors for PI, the diagnostic criteria, treatments used, and PI-related attitudes to determine if indices could be constructed. Items with factor loadings over 0.40 on a specific factor were considered for creating indices. Cronbach alpha coefficients were calculated to determine if the sets of items loading on a specific factor had sufficient interitem consistency to allow creating an index. Cronbach alpha values above 0.7 were considered acceptable interitem consistencies.[29] Indices were computed by averaging the responses to the items that loaded on each respective factor.

Inferential statistics were used to test for the significance of differences of the two groups' average responses and of the relationships between the constructs of interest. Comparisons were performed using independent sample t-tests for responses measured on rating scales and chi-square tests for categorical variables. Pearson correlation coefficients were used to explore the relationships between periodontists and OMS' PI-related education and the indices of interest. Since numerous statistical tests were performed simultaneously, a Bonferroni correction was applied and the alpha value was set at $p < 0.01$.[30]

3 | RESULTS

Table 1 provides an overview of the background characteristics of the periodontists and OMS respondents. Only 19.4% of the periodontists and 5.1% of the OMS were female ($p < 0.001$). The two groups ranged in age from the late 20s to the late 70s with a mean of approximately 51 years. Approximately three out of four respondents in each group worked in private practice. OMS respondents worked on average more hours per week (40.84 vs. 30.38; $p < 0.001$) and treated more patients per week (59.20 vs. 34.63; $p < 0.001$) compared to periodontists.

3.1 | PI-related education

The two groups did not differ in the average year the respondents had graduated from dental school and/or graduate programs (Table 2). OMS respondents spent on average more years in residency (4.28 years vs. 2.68 years; $p < 0.001$), but spent a lower percentage of time during residency on implant surgeries (7.27% vs. 21.02%; $p < 0.001$) compared to periodontists. Approximately

TABLE 2 Education-related responses of periodontists and oral maxillofacial surgeons (OMS).

Educational background	Periodontists $N = 389$ mean (SD) range	OMS $N = 161$ mean (SD) range	p
Dental school graduation year	1991.4 (13.805) 1961–2016	1991.5 (12.724) 1963–2015	0.962
Graduate program graduation year	1996.1 (13.904) 1963–2019	1996.5 (12.938) 1967–2017	0.776
Length of residency in years	2.68 (0.636) 1–7	4.28 (1.163) 1–7	<0.001
Percent of residency time spent on implant surgeries	21.02% (21.774) 0%–85%	7.27% (8.062) 0%–35%	<0.001
Did you treat patients with peri-implantitis during your residency?	Yes: 154 (39.8%)	Yes: 66 (41.0%)	0.794
During your residency, how well were you educated about:	**Periodontists mean[a] (SD) range**	**OMS mean[a] (SD) range**	***p***
a. Risk factors of peri-implantitis?	3.02 (1.675) 1–5	2.72 (1.480) 1–5	0.037
b. Diagnosis of peri-implantitis?	2.99 (1.696) 1–5	2.74 (1.510) 1–5	0.091
c. Treating peri-implantitis?	2.56 (1.563) 1–5	2.33 (1.342) 1–5	0.078
"PI-related education" index[b] (Cronbach alpha = 0.959)	*2.86 (1.584)* *1–5*	*2.59 (1.381)* *1–5*	*0.022*

Abbreviation: SD, standard deviation.

[a]The answers ranged from "1" = "not at all well" to "5" = "very well."

[b]The "PI-related education" index was computed by averaging the responses to items a to c.

40% of both groups had treated patients with PI during residency.

When asked to rate the quality of their PI-related education, periodontists on average reported to be better educated than OMS (on a 5-point scale with 1 = not at all well: 2.86 vs. 2.59; $p = 0.022$). When asked how well both groups were educated during their residency about risk factors, diagnosis, and treatment of PI; periodontists on average reported to be better educated overall than OMS (on a 5-point scale with 1 = not at all well: 2.86 vs. 2.59; $p = 0.022$).

3.2 | Knowledge of risk factors, diagnostic criteria, and treatment options for PI

Table 3 provides an overview of the knowledge of PI-related risk factors, diagnostic criteria, and treatment options. Both groups evaluated poor oral hygiene and history of periodontitis on average as highly important risk factors for the development of PI (periodontists: 4.45/4.10 vs. OMS: 4.35/4.15; n.s.). However, periodontists rated smoking (4.35 vs. 3.99; $p < 0.001$), diabetes (3.90 vs. 3.52; $p < 0.001$), and genetic predisposition (3.53 vs. 3.28; $p = 0.001$) as more important risk factors for PI than OMS did.

Concerning PI diagnosis, both groups considered radiographic bone loss, clinical probing, suppuration, and bleeding as highly important diagnostic factors. Periodontists relied even more on radiographic evidence of bone loss than OMS did (4.74 vs. 4.55; $p = 0.002$). While exposure of implant surface and recession of mucosal margin were considered less important by both groups, OMS rated this factor as even more important than periodontists did (4.56 vs. 3.99; $p < 0.001$).

When asked how much different treatment strategies contributed to successfully treating PI, both groups rated patient education about oral hygiene very highly, with periodontists rating these two strategies even higher than OMS did (4.41/4.49 vs. 4.18/4.20; $p = 0.004/p < 0.001$). Both groups answered on average that antiseptics and local or systemic antibiotics were contributing to successfully treating PI. However, periodontists considered regeneration (3.73 vs. 3.31; $p < 0.001$), guided tissue regeneration (GTR) (3.62 vs. 3.20; $p < 0.001$), as well as resective surgery

TABLE 3 Periodontists and oral maxillofacial surgeons (OMS)' knowledge of risk factors for developing peri-implantitis and for diagnosing and treating peri-implantitis.

Knowledge about risk factors for developing peri-implantitis	**Periodontists $N = 389$ mean[a] (SD)**	**OMS $N = 161$ mean[a] (SD)**	***p***
a. Poor oral hygiene	4.45 (0.818)	4.35 (0.820)	0.244
b. History of periodontitis	4.10 (0.895)	4.15 (0.931)	0.498
c. Smoking	4.35 (0.783)	3.99 (0.868)	<0.001
d. Diabetes mellitus	3.90 (0.906)	3.52 (0.893)	<0.001
e. Genetic predisposition	3.53 (1.051)	3.28 (1.081)	0.011
"Risk factor knowledge" index[b] (Cronbach alpha = 0.864)	*4.07 (0.587)*	*3.86 (0.589)*	*<0.001*
Knowledge about diagnosing peri-implantitis: How important is:	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
f. Clinical probing	4.04 (1.060)	4.10 (1.048)	0.527
g. Radiographic bone loss	4.74 (0.572)	4.55 (0.675)	0.002
h. Presence of bleeding	4.17 (0.970)	4.00 (0.877)	0.050
i. Presence of suppuration	4.64 (0.674)	4.56 (0.755)	0.260
j. Implant exposure and gum recession	3.99 (0.997)	4.56 (0.954)	<0.001
Treatment-related knowledge: How much do the following treatment strategies contribute to successfully treating peri-implantitis?	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
k. Patient education about oral hygiene	4.41 (0.862)	4.18 (0.948)	0.004
l. Plaque control	4.49 (0.783)	4.20 (0.858)	<0.001
"*Oral hygiene-related treatment know-ledge" index[c] (Cronbach alpha = 0.904)*	*4.45 (0.801)*	*4.20 (0.861)*	0.001
m. Mechanical debridement	4.43 (0.813)	4.22 (0.805)	0.007
Antiseptic and antibiotic treatment	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
n. Antiseptic cleansing	3.95 (1.000)	4.08 (1.255)	0.183
o. Local/systemic antibiotic therapy	3.60 (1.107)	3.70 (1.382)	0.349
"Antiseptic and antibiotic therapy knowledge" index[d] (Cronbach alpha = 0.739)	*3.77 (0.933)*	*3.89 (1.189)*	*0.202*
Regeneration treatments	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
Regeneration	3.73 (0.954)	3.31 (1.020)	<0.001
Autograft	2.89 (1.171)	2.98 (1.102)	0.397
Allograft	3.44 (1.075)	3.10 (1.082)	0.001
Xenograft	2.92 (1.202)	2.72 (1.106)	0.080
Guided tissue regeneration	3.62 (1.035)	3.20 (1.124)	<0.001
Resective surgery	3.38 (1.038)	2.91 (1.166)	<0.001
Implantoplasty	3.08 (1.170)	2.65 (1.181)	<0.001
Laser systems	2.59 (1.313)	2.44 (1.233)	0.270
Other treatments	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
Photodynamic therapy	1.78 (0.937)	2.00 (1.000)	0.030
Mechanical debridement	4.43 (0.813)	4.22 (0.805)	0.007

Abbreviation: SD, standard deviation.

[a]The answers ranged from "1" = "not at all" to "5" = "very much."

[b]The "risk factor knowledge" index was computed by averaging the responses to items a to e.

[c]The "oral hygiene-related treatment knowledge" index was computed by averaging the responses to items k and l.

[d]The "antiseptic and antibiotic therapy knowledge" index was computed by averaging the responses to items n and o.

TABLE 4 Periodontists and oral maxillofacial surgeons' (OMS) peri-implantitis (PI)-related attitudes.

Attitudes toward PI: general dentists need to be better educated about:	**Periodontists *N* = 389 mean[a] (SD)**	**OMS *N* = 161 mean (SD)**	***p***
a. How to diagnose peri-implantitis	4.79 (0.473)	4.41 (0.808)	<0.001
b. When to refer a patient for the treatment of PI	4.88 (0.359)	4.42 (0.825)	<0.001
c. How to offer maintenance care for implants	4.76 (0.549)	4.51 (0.705)	<0.001
"PI-education-related motivation" index[b] (Cronbach alpha = 0.865)	*4.81(0.390)*	*4.45 (0.712)*	*<0.001*
General attitudes	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
d. I consider PI a serious problem currently	4.55 (0.726)	3.80 (1.090)	<0.001
e. PI will become a more serious issue in the future	4.74 (0.580)	3.90 (1.002)	<0.001
f. There is a great need for a standardized protocol for the treatment of PI	4.43 (0.835)	4.21 (0.923)	0.009
"General PI-related attitudes" index[c] (Cronbach alpha = 0.719)	*4.57 (0.534)*	*3.97 (0.841)*	*<0.001*
Single item	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
g. I would like to attend continuing education courses about the treatment of PI	4.17 (1.058)	4.08 (0.965)	0.394

Abbreviation: SD, standard deviation.

[a]The answers ranged from 1 = disagree strongly, 2 = disagree, 3 = neither disagree nor agree, 4 = agree, and 5 = agree strongly.

[b]The "PI-education-related motivation" index was computed by averaging the responses to items a to c.

[c]The "general PI-related attitudes" index was computed by averaging the responses to items d to f.

(3.38 vs. 2.91; $p < 0.001$) and implantoplasty (3.08 vs. 2.65; $p < 0.001$) as more important for successfully treating PI than OMS.

3.3 | PI-related attitudes

Periodontists agreed more strongly than OMS that general dentists need to be better educated about how to diagnose PI (4.79 vs. 4.41; $p < 0.001$), when to refer a PI patient (4.88 vs. 4.42; $p < 0.001$), and how to offer maintenance care for implants (4.76 vs. 4.51; $p < 0.001$; Table 4). Compared to OMS, periodontists also agreed more strongly with the statement that "PI is a serious problem currently" (4.55 vs. 3.80; $p < 0.001$), that "PI will become a more serious issue in the future" (4.74 vs. 3.90; $p < 0.001$), and that "There is a need for a standardized protocol for the treatment of PI" (4.43 vs. 4.21; $p = 0.009$). Both groups agreed with the statement "I would like to attend continuing education courses about the treatment of PI" (4.17 vs. 4.08; $p = 0.394$).

3.4 | Frequencies of PI-related professional behavior

OMS reported having more dental implant surgeries (19.95 vs. 13.94; $p = 0.002$), but fewer PI cases per month (1.26 vs. 2.73; $p < 0.001$) than periodontists. Table 5 provides the average frequencies of use of PI-related treatment strategies for the two groups. Periodontists used patient education about oral hygiene and plaque control even more frequently than OMS did (4.85 vs. 4.64; $p < 0.001$; 4.87 vs. 4.48; $p < 0.001$). Both groups often used antiseptics and local/systemic antibiotics and sometimes used regenerative approaches. However, periodontists used regeneration (3.56 vs. 2.94; $p < 0.001$), allografts (3.39 vs. 2.91; $p < 0.001$), and GTR (3.43 vs. 2.85; $p < 0.001$) more often than OMS. Other treatments such as resective surgery, implantoplasty, lasers, and photodynamic treatment were overall rarely used. However, periodontists were more likely to use resective surgery (3.09 vs. 2.40; $p < 0.001$), implantoplasty (2.69 vs. 1.94; $p < 0.001$), and laser systems (2.11 vs. 1.62; $p < 0.001$) than OMS.

3.5 | Correlations between PI-related education, knowledge, attitudes, and professional behavior

In addition to analyzing the differences in the responses of periodontists and OMS concerning PI-related education, knowledge, and attitudes, it was also interesting to consider the associations between education, knowledge, and attitudes with the respondents' professional behavior (Table 6). The more recently the respondents had graduated from residency program, the better they described their PI-related education ($r = 0.57$; $p < 0.001$), but the less likely they were to use antiseptic and antibiotic therapy

TABLE 5 Average frequencies of peri-implantitis (PI)-related professional behavior of periodontists versus oral maxillofacial surgeons (OMS).

Implant surgery and PI-related professional behavior	Periodontists $N = 389$ mean[a] (SD) range	OMS $N = 161$ mean[a] (SD) range	*p*
Number of implant surgeries per month	13.94 (13.322) 0–100	19.95 (21.798) 1–200	0.002
Number of PI cases per month	2.73 (3.501) 0–20	1.26 (2.352) 0–20	<0.001
Treatment frequency: Oral hygiene-related treatment	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
a. Patient education about oral hygiene	4.85 (0.489)	4.64 (0.709)	<0.001
b. Plaque control	4.87 (0.457)	4.48 (0.863)	<0.001
"Oral hygiene-related treatment" index[b] (Cronbach alpha = 0.922)	*4.86 (0.468)*	*4.56 (0.741)*	*<0.001*
Antiseptic and antibiotic treatment	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
c. Antiseptic cleansing	4.25 (1.025)	4.11 (1.046)	0.165
d. Local/systemic antibiotic therapy	3.87 (1.085)	3.69 (1.238)	0.101
"Antiseptic and antibiotic therapy" index[c] (Cronbach alpha = 0.681)	*4.06 (0.897)*	*3.90 (1.046)*	*0.046*
Regeneration treatments	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
e. Regeneration	3.56 (1.041)	2.94 (1.237)	<0.001
f. Autograft	2.40 (1.274)	2.40 (1.252)	0.998
g. Allograft	3.39 (1.150)	2.91 (1.279)	<0.001
h. Xenograft	2.61 (1.363)	2.37 (1.328)	0.070
i. Guided tissue regeneration	3.43 (1.114)	2.85 (1.382)	<0.001
"PI-related regeneration-related treatment" index[d] (alpha = 0.754)	*3.06 (0.849)*	*2.68 (0.977)*	*<0.001*
Other treatments	**Periodontists mean[a] (SD)**	**OMS mean[a] (SD)**	***p***
Resective surgery	3.09 (1.096)	2.40 (1.196)	<0.001
Implantoplasty	2.69 (1.210)	1.94 (1.188)	<0.001
Laser systems	2.11 (1.459)	1.62 (1.075)	<0.001
Photodynamic therapy	1.32 (0.751)	1.24 (0.607)	0.238
Mechanical debridement	4.77 (0.570)	4.29 (0.945)	<0.001

Abbreviation: SD, standard deviation.

[a]The answers ranged from "1" = "never," 2 = "rarely," 3 = "sometimes," 4 = "often," and 5 = "always."

[b]The "oral hygiene-related treatment" index was computed by averaging the responses to items a and b.

[c]The "antiseptic and antibiotic therapy" index was computed by averaging the responses to items c and d.

[d]The "PI-related regeneration-related treatment" index was computed by averaging the responses to items e to i.

($r = -0.13$; $p < 0.01$). The more positively they described this education, the better was the knowledge concerning PI-related risk factors ($r = 0.12$; $p < 0.01$).

The knowledge about risk factors correlated positively with the knowledge about oral hygiene-related treatments ($r = 0.37$; $p < 0.001$) and about antiseptic and antibiotic treatments ($r = 0.21$; $p < 0.001$), and with more positive PI-related attitudes. Furthermore, there was a positive correlation between the knowledge about oral hygiene-related treatments and the frequency of use of oral health-related treatments ($r = 0.43$; $p < 0.001$), antiseptic/antibiotic therapy ($r = 0.16$; $p < 0.001$), and regeneration treatments ($r = 0.13$; $p < 0.01$). The knowledge about antiseptics/antibiotics correlated positively with the frequency of application of antiseptics and antibiotics ($r = 0.57$; $p < 0.001$) and the use of regeneration treatments ($r = 0.24$; $p < 0.001$).

The more positively respondents considered the need to educate general dentists about PI, the more frequently they engaged in oral hygiene-related treatments ($r = 0.24$;

TABLE 6 Correlations between peri-implantitis (PI)-related education, knowledge, attitudes, and professional behavior.

	Education		Knowledge			Attitudes	
Peri-implantitis-related education	**A**	**B[a]**	**C[b]**	**D[c]**	**E[d]**	**F[e]**	**G[f]**
A = Residency graduation year	1	0.57***	0.05	−0.04	−0.06	−0.01	0.07
B[a] = "PI-related education" index	0.57***	1	0.12**	0.09*	0.02	0.06	0.06
Peri-implantitis-related knowledge	**A**	**B[a]**	**C[b]**	**D[c]**	**E[d]**	**F[e]**	**G[f]**
C[b] = "Risk factor knowledge" index	0.05	0.12**	1	0.37***	0.21***	0.15***	0.24***
D[c] = "Oral hygiene-related treatment knowledge" index	−0.04	0.09*	0.37***	1	0.39***	0.12**	0.16***
E[d] = "Antiseptic and antibiotic therapy knowledge" index	−0.06	0.02	0.21***	0.39***	1	0.03	0.09*
Peri-implantitis-related attitudes	**A**	**B[a]**	**C[b]**	**D[c]**	**E[d]**	**F[e]**	**G[f]**
F[e] = "PI-education-related motivation" index	−0.01	0.06	0.15***	0.12**	0.03	1	0.46***
G[f] = "General PI-related attitudes" index	0.07	0.07	0.24***	0.16***	0.09*	0.46***	1
Peri-implantitis-related professional behavior	**A**	**B[a]**	**C[b]**	**D[c]**	**E[d]**	**F[e]**	**G[f]**
"Oral hygiene-related treatment" index[g]	−0.05	0.04	0.27***	0.43***	0.19***	0.24***	0.18***
"Antiseptic and antibiotic therapy" index[h]	−0.13**	−0.09*	0.14***	0.16***	0.57***	0.07	0.16***
"PI-related regeneration treatment" index[i]	0.05	0.06	0.08	0.13**	0.24***	0.11*	0.23***
# Peri-implantitis cases per month[10]	−0.07	0.05	0.07	0.04	0.02	0.11*	0.19***

[a]The "PI-related education" index was created by averaging the responses to items a, b, and c in Table 2.
[b]The "risk factor knowledge" index was created by averaging the response to items a to e in Table 3.
[c]The "oral hygiene-related treatment knowledge" index was computed by averaging the responses to items k and l in Table 3.
[d]The "antiseptic and antibiotic therapy knowledge" index was computed by averaging the responses to items n and o in Table 3.
[e]The "PI-education-related motivation" index was computed by averaging the responses to items a to c in Table 4.
[f]The "general PI-related attitudes" index was computed by averaging the responses to items d to f in Table 4.
[g]The "oral hygiene-related treatment" index was computed by averaging the responses to items a and b in Table 5.
[h]The "antiseptic and antibiotic therapy" index was computed by averaging the responses to items c and d in Table 5.
[i]The "PI-related regeneration-related treatment" index was computed by averaging the responses to items e to i in Table 5.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

$p < 0.001$), and the more positive their general PI-related attitudes were, the more frequently they engaged in all types of PI-related treatment and the more PI cases they encountered per month ($r = 0.19$; $p < 0.001$).

4 | DISCUSSION

The objectives of the present study were to compare PI-related educational experiences, knowledge, attitudes, and professional behavior of periodontists and OMS and explore the associations between these constructs of interest. An a priori power analysis was conducted to determine the sample sizes of the two groups that were needed to have the power to test whether the average responses of the two groups differed. The number of responses in both groups exceeded the number of needed responses, showing that the sample sizes were sufficient to conduct the analyses of interest. In addition, the background characteristics of both groups resembled the characteristics of periodontists and OMS in the United States. For example, in 2014, approximately 21% of periodontists in the United States were female,[31] and in this study, 19.4% of the periodontists were female. In 2015, female OMS residents represented 6% of all OMS residents in the United States.[32] This percentage is close to the 5.1% of female OMS respondents in this study. The wide range of age and of graduation years in both groups allowed to study the relationships between PI-related education and the constructs of interest.

The finding that OMS encountered fewer PI cases per month than periodontists is consistent with previous findings that also showed that OMS saw significantly fewer PI cases per year than periodontists.[27] Since PI treatment is heavily based on the evidence used when treating periodontitis,[24] it could be that general dentists refer patients with PI mostly to periodontists.[27]

The fact that both groups completed residency on average in the 1990s might explain why they reported to be only "a little" to "somewhat" educated about PI-related risk factors, diagnostic criteria, and treatment approaches. In addition, the graduation years correlated positively with the reported quality of PI-related education. This is to be expected since the fundamental principles for competence-based teaching of implant dentistry in postgraduate education were only outlined in the European consensus workshop in 2008,[8] and a PI-related review was not published until the 2017 World Workshop.[17]

Poor oral hygiene, history of periodontitis, and smoking were the most strongly endorsed risk factors by both groups. Diabetes mellitus and genetic predisposition were considered as less important. These results are in line with the current literature[17] and are consistent with the results of previous studies.[28,33,34] In response to an open-ended question concerning additional risk factors for PI, the respondents named the presence of excess cement, adverse occlusal loading, lack of keratinized tissue, poor emergence profile of restoration, improper implant position, systemic diseases and medications, poor surgical skills, type and quality of bone, and lack of patient compliance with maintenance as additional risk factors. While the lack of maintenance care has been recognized as a major risk indicator for PI, the role of the rest of these mentioned factors is still not well understood.[4,17]

Concerning the diagnosis of PI, both groups considered radiographic bone loss, clinical probing, and presence of bleeding and suppuration as very important criteria.[4] Consistent with previous results by Russel et al.,[27] and with the guidelines published at the 2017 World Workshop,[4] implant exposure and mucosal recession were overall considered as relatively less significant for the diagnosis of PI.

As far as the management of PI is concerned, both groups considered the non-surgical step including oral hygiene instructions, plaque control, and mechanical debridement as very important and used it nearly always in PI patients. This is in line with the current evidence, which recognizes biofilm accumulation as the main etiologic agent for PI.[24] Therefore, inflammation control through removal of the plaque biofilm is a key element of PI treatment, like the treatment of periodontitis.[24] Compared to OMS, periodontists considered the aforementioned approaches as more important and used them more frequently. This difference might be related to the different educational backgrounds between OMS and periodontists.[15,26] OMS are trained for at least 4 years in a hospital-based residency. The body of knowledge that oral surgeons need to master is impressive. The broad scope of oral and maxillofacial surgery training includes trauma, orthognathic, reconstructive/cosmetic surgery, and pathology as well as the treatment of temporomandibular disorders and facial pain.[26] It might therefore be difficult for OMS programs to dedicate large amounts of time to PI education and training. On the other hand, periodontology specialty is a 3-year program, which focuses on the treatment of patients with periodontal disease, using non-surgical and surgical approaches, as well as on dental implant therapy and the management of implant complications.[15] Periodontal residents receive extensive training about the non-surgical management of periodontal diseases, which includes but is not limited to biofilm control and mechanical debridement.[15] Besides the educational background, the specialty-specific culture might play a role in attitudes toward PI. For example, some clinicians are advocates of the theory that PI is a foreign body disease, therefore downplaying the microbial basis of the disease.[35] Consequently, these clinicians are less likely to use biofilm control and mechanical debridement for the treatment of PI.

Other adjunctive measures such as antibiotics and lasers were considered as less important and were relatively less frequently used by both groups. This is in accordance with the recent EFP guidelines on the prevention and treatment of peri-implant diseases, which recommended against the use of these adjunctive measures since the existing evidence regarding their benefits is low.[7] The less frequent application of lasers could also be related to the limited postgraduate education and clinical training on laser applications.[36] The use of systemic antibiotics in particular has recently raised concerns about antibiotic resistance and alterations of the individual patient microbiome, making activities that monitor the appropriate use of systemic antibiotics in dentistry (antibiotic stewardship) a top priority.[37] Interestingly, the more recently the participants graduated from graduate school and the better their PI-related education had been, the less likely they were to use antibiotics for the management of PI.

Concerning surgical treatment, both groups considered regenerative approaches as "moderately important" to "important" and resective approaches including implantoplasty as "slightly important" to "moderately important." This reflects the therapeutic complexity of PI and the lack of evidence demonstrating superiority of any specific surgical technique.[25] It is worth mentioning that periodontists considered regenerative approaches and especially the use of allograft and GTR, as well as resective surgery and implantoplasty as more important, and used these approaches in their practice more frequently than OMS did. Again, this difference could be explained by the fact that periodontists received extensive clinical and didactic training on the aforementioned surgical techniques for the treatment of periodontitis.[15]

Although both groups agreed that PI is a serious problem and will be a more serious problem in the future, periodontists agreed even more strongly than OMS did. This finding might be related to the fact that these attitudes correlated positively with the number of PI cases treated per month and that periodontists treated more of these patients compared to OMS. In addition, while both groups agreed that there is a need for better education of general practitioners on how to diagnose PI, identifying when referral is indicated, and how to offer maintenance care for implants, periodontists agreed more strongly with these statements than OMS did. While the undergraduate curricular content

about implant dentistry increased since 2008,[38] there is currently no standard method to teach dental students how to diagnose and manage peri-implant diseases.[13] This gap in dental education may result in delays in the referral of PI cases to specialists and in difficulties in communication between general dentists and specialists.

This research had some limitations. First, it only considered that the respondents were members of the AAP and AAOMS and did not assess whether the respondents were board certified. Future research should explore if board certified professionals differ from non-board certified professionals in their PI-related responses. Second, a survey consists of a limited number of questions. The fact that the respondents named some additional risk factors in their open-ended responses is important information for future research. Third, providing specific clinical scenarios with clinical and radiographic images could have offered a more detail-oriented view of considerations related to the effectiveness of specific treatment strategies. Finally, this study specifically compared the responses of periodontists and OMS. However, implant dentistry has been an integral part of prosthodontics. Prosthodontists are trained both in restorative and in surgical aspects of implant dentistry.[10,39] In that sense, they should also receive training in diagnosing and treating peri-implant diseases. It would be interesting in future research to compare the PI-related responses of all specialties that are dealing with implant dentistry, for example, periodontists, OMS, and prosthodontists.

5 | CONCLUSIONS

Based on these findings, it can be concluded that while OMS place more dental implants, periodontists are more likely to treat patients with PI. The more recently the participants graduate from graduate programs, the better educated they are about PI-related risk factors, diagnostic criteria, and treatment approaches. Overall, the responses of both groups concerning risk factors, diagnostic criteria, and management of PI are evidence based and in line with the current literature.

Differences in the responses of periodontists versus OMS concerning the management of PI can be explained by considering their educational background. The results of the present study highlight the lack of standardization in the specialty training of periodontists and OMS. A set of standard criteria, which direct the learning objectives, as well as the targeted skills and competencies concerning the diagnosis and management of peri-implant diseases, should be introduced not only into dental graduate program curricula, but also into predoctoral dental curricula. This will create a common competency standard for specialists who place dental implants and are dealing with peri-implant diseases, and will enhance the educational experiences of dental students in terms of identifying cases of PI and referring them as needed.

The fact that the existing treatment protocols for PI such as providing oral hygiene instruction, plaque control, mechanical debridement, and surgical techniques such as GTR and resective surgery are based on the treatment of periodontitis might explain why periodontists consider these approaches as more important and use them more frequently than OMS do. Adjunctive measures such as antibiotics and lasers are considered as less important and are less frequently used by both groups. The more recently the participants graduated from their residency program and the better PI education they report having received, the less likely they are to use antibiotics for the management of PI. Finally, the more PI cases they treat per month, the more they consider PI to be a serious problem, and the more they recognize the need for better education of general dentists.

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