Cues used by dentists in the early detection of oral cancer and oral potentially malignant lesions: findings from the National Dental Practice-Based Research Network

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Objective. The aim of this study was to assess the influence of clinical cues on risk assessment of cancer-associated mucosal abnormalities.

Study Design. We differentiated lesions with a low risk from those with a high risk for premalignancy or malignancy by using 4 cues: (1) color, (2) location, (3) induration, and (4) pain on exploration. Combinations of color and location were presented through 8 photographs, with induration and pain status variably presented in the standardized history and physical findings. This created 16 clinical scenarios (vignettes) that were permutations of the 4 cues. Three questions assessed the extent to which each cue was used in obtaining a clinical impression as to whether a lesion was benign, premalignant, or malignant.

Results. Completed vignette questionnaires were obtained from 130 of 228 invited dentists, (two-thirds males; 79% white; mean age 52 years; average weekly hours of practice 33 hours). Only 40% of the responding dentists had statistically significant decision policies to assign a clinical diagnosis of a lesion as benign, premalignant, or malignant. Lesion location and color were the 2 dominant cues. As a cue, induration was used as a cue by more of the respondents in determining a clinical diagnosis of malignancy, and pain was infrequently used as a cue.

Conclusions. Many dentists do not to have a decision strategy for the clinical diagnosis and risk stratification of oral potentially malignant lesions. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;130:264−272)

In the United States, during the period 2012−2016, the age-adjusted incidence rate for oral and pharyngeal cancers was approximately 11.3 of 100,000 (when standardized to the standard population in 2000), with cancers of the oral cavity accounting for approximately 54% of the total rate.[1] Some clinically detected oral epithelial lesions have malignant potential and are classified as oral potentially malignant lesions (OPMLs). Most OPMLs are leukoplakias. Tissue biopsy and histopathologic evaluation of OPMLs may reveal a spectrum of diagnoses, including malignancy, epithelial dysplasia, or a benign lesion. Dysplastic lesions and even some nondysplastic lesions have a variable risk of becoming malignant over time. Estimates for the global prevalence of leukoplakia ranges from 2% to 7%,[2] and their annual risk for malignant transformation is 2% to 3%.[3]

Oral mucosal lesions are relatively commonly encountered in dental practice,[4] and dental students understand that a diagnosis begins with synthesis of data from the history and clinical findings, followed by the generation of one or more candidate clinical diagnoses and ending with appropriate diagnostic testing (i.e., biopsy and histopathologic evaluation) to yield a definitive diagnosis.[5] Oral cancer and OPMLs have a wide range of clinical

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Statement of Clinical Relevance

The findings of this investigation highlight the challenges dentists encounter in making risk assessment decisions about oral potentially malignant lesions and suggest that oral health care providers might benefit from standardized training based on the relative contribution of important signs and symptoms.

presentations, and a clinician's first diagnostic clue may be based on symptoms (e.g., a patient presenting with pain) and/or signs (i.e., abnormal findings detected incidentally during a conventional visual and tactile oral examination). Because these variable presentations overlap with those of other benign states, it can be challenging for the clinician to make a "risk assessment" for a lesion, that is, to decide whether or not a lesion meets a threshold of "suspicion" for malignancy or the potential for malignant transformation. Oral cancers and OPMLs may present as *leukoplakia* (defined as "white plaques of questionable risk having excluded [other] known diseases or disorders that carry no increased risk for cancer") or *erythroplakia* (defined as "a fiery red patch that cannot be characterized clinically or pathologically as any other definable disease").[6] Leukoplakias may be subcategorized as homogeneous or nonhomogeneous. Homogeneous leukoplakias are typically only white, flat, well-demarcated plaques, whereas nonhomogeneous leukoplakias may present as a number of clinical phenotypes, including mixed red−white lesions, often referred to as *erythroleukoplakias*, or lesions with a nonhomogeneous surface texture. Nonhomogeneous leukoplakias are at a higher risk for malignant transformation compared with the homogeneous type.[7] Oral cancers and OPMLs may occur on any oral mucosal site, although in the United States, the highest risk locations are the lateral border of the tongue and floor of mouth.[8] Other clinical features of malignant lesions may include ulceration, an exophytic component, palpable induration, and pain. *Induration* is a term used to describe the palpable firmness of a lesion, which results from replacement of normal tissue by the infiltration of abnormal tissue and is highly suggestive of malignancy.

Labeling a lesion as "suspicious" for oral cancer or as an OPML can be a rather uncertain process because the threshold for determining whether a lesion meets the criteria for an oral cancer or an OPML depends on a number of factors, including variability in the clinical presentations of oral cancers/OPMLs (explained by the heterogeneous mutational landscape across lesions); overlapping clinical presentations of mucosal abnormalities with no malignant potential; and the wide variations in the training and experience of clinicians in the diagnosis of mucosal diseases. The decisions that lead to delays in diagnosis or to overdiagnosis are linked to a clinician's ability to perform risk assessment of a lesion and have the potential to negatively impact patient care.[9] Epidemiologic studies of OPML cohorts have demonstrated that a number of clinical variables are associated with malignancy or to the risk for malignant transformation, including high-risk sites (i.e., floor of mouth, ventrolateral tongue); color/surface texture (i.e., nonhomogeneous leukoplakia may have a red component or a nonhomogeneous surface texture); and size (i.e., > 200 mm^2).[7] Malignant lesions differ from dysplastic lesions in that they represent invasive disease, and as such, they may have one or more features, including palpable induration, deep ulceration, exophytic component, and/or pain.

The purpose of this study was to explore whether clinical cues influence decisions in a cohort of general dentists participating in the National Dental Practice-Based Research Network (PBRN; hereafter referred to as "Network") in the risk assessment of mucosal abnormalities for oral cancer or OPMLs.

MATERIALS AND METHODS

The current investigation is part of a larger study exploring how dentists regard and utilize oral cancer examinations (OCEs).[10] Both the parent and current phases of the study were performed under the auspices of the Network. The Network is a consortium of dental practices and dental organizations established to answer questions raised by dental practitioners in everyday clinical practice and to evaluate the effectiveness of strategies to prevent, manage, and treat oral diseases and conditions. The Network includes oral health care providers (general dentists, dental specialists, and hygienists).[11,12]

Dental practitioners eligible to be included in the study were all U.S. licensed, clinically active, general practice (GP) dentists and current members of the Network. Two thousand GPs were invited to join the parent study via e-mail invitations, which included a link to an online questionnaire (available at http://nationaldentalpbrn.org/study-results/the-common-practices-of-head-and-neck-examinations-in-us-dental-offices-old.htm).

The "vignette" study was designed to evaluate the usefulness of cues that dentists might use in assessing oral lesions for their malignant potential. The analytic approach and sample size estimates were based on the Lens analytic practice to maintain consistency.[13] The a priori target sample size was 110 participants and assumed an alpha of 0.10 and power of 80% to detect a statistically meaningful R^2 difference between using and not using a cue. To achieve the necessary sample size, every other participant completing the random sampled parent online questionnaire was invited to join the vignette study until a sample size of 110 to 140 was met. Invitations were sent via e-mail and included a link to the vignette study questionnaire. Individuals not completing the questionnaire within 2 weeks of the e-mailed invitation were considered nonresponders.

Development and design of online vignette questionnaire

Three expert clinician–researchers reviewed the literature and found consensus on 3 "cues" for decision making with regard to clinically assessing a lesion as being benign, at high risk for premalignancy, or at high risk for malignancy. To differentiate lesions at low risk versus high risk for malignancy or having the propensity for malignant transformation, we initially chose 3 cues: (1) color (red vs white); (2) location (high risk: e.g., floor of mouth/lateral tongue versus lower risk: i.e., other sites); and (3) induration (present vs absent). A fourth cue, pain (yes vs no), was included in the investigation to explore whether and how dentists use pain as a cue (i.e., both as a symptom reported by the patient and as a sign elicited when the lesion is palpated by the clinician). There were 16 permutations of the 4 dichotomous cues—that is, 16 clinical scenarios (vignettes) of signs (and, in the case of pain, a symptom) (Figure 1). The 16 vignettes were randomized in presentation order for each participant's questionnaire.

In the vignette scenarios, cues for induration and pain were presented in the form of text, whereas clinical photographs were used to present cues for color and location. Eight photographs were provided as possible choices by an oral medicine specialist to represent the combinations of location and color and were reviewed by 2 clinicians.

Validation of the photograph of the lesion

Five oral medicine and oral pathology practitioners served as the panel for photograph validation. Panel members were individually presented with the 8 candidate photographs and asked to (1) rate the acceptability of each in terms of lesion location and color using a scale of 1 (low) to 5 (high); and (2) provide an overall quality score on a scale of 0 (low) to 100 (high). The 4 photographs subsequently used in the vignette questionnaire (see Figure 1) had an average acceptability score of 4.75 and a quality score of 90.6, thereby validating the selected photographs for use in the study. The 16 vignette scenarios are presented in Figure 1.

Questions to assess the cues for decision making

For each of the 16 vignettes, 3 questions were used to evaluate whether specific cues are useful in providing a clinical impression as to whether a lesion is benign, premalignant, or malignant. A "benign" lesion was defined as one with no malignant potential. A "premalignant" lesion was defined as one that was not malignant but had malignant potential. A "malignant" lesion was defined as one with a high suspicion for oral squamous cell carcinoma (OSCC). Specific questions used in the vignettes were as follows:

Questions 1–3 for each of the 16 vignettes.

1 How would you rate the probability that the lesion is:
  a Benign?
  b Premalignant?
  c Malignant?

The three questions selected for use in the analysis used a slider to measure probabilities from "0%" through "100%" (Figure 2). All vignettes were introduced with a brief standard history (i.e., symptoms), followed by the image and a standard description of the examination findings (i.e., signs).

Standard history. The following standard history was provided for all vignettes:

"Description/History: The patient presented with the following lesion (see photo) reported by the patient to be of approximately 1 month duration. The medical,

Permutation	Cues	Case 1	Case 2	Case 3	Case 4
	Color	White	White	Red	Red
	Lesion Location	Low Risk	High Risk	Low Risk	High Risk
A	Pain	Pain present (+)	Pain present (+)	Pain present (+)	Pain present (+)
	Induration	Induration present (+)	Induration present (+)	Induration present (+)	Induration present (+)
B	Pain	Pain present (+)	Pain present (+)	Pain present (+)	Pain present (+)
	Induration	Induration absent (-)	Induration absent (-)	Induration absent (-)	Induration absent (-)
C	Pain	Pain absent (-)	Pain absent (-)	Pain absent (-)	Pain absent (-)
	Induration	Induration present (+)	Induration present (+)	Induration present (+)	Induration present (+)
D	Pain	Pain absent (-)	Pain absent (-)	Pain absent (-)	Pain absent (-)
	Induration	Induration absent (-)	Induration absent (-)	Induration absent (-)	Induration absent (-)

Fig. 1. Sixteen combinations of 4 lesion assessment cues: color, location, pain, and induration.

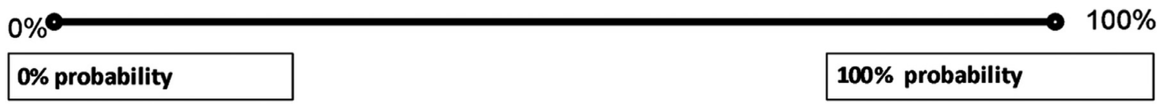

Fig. 2. Oral cancer examination (OCE) vignettes questionnaire scoring slider.

social and dental histories, as well as the physical examination of intraoral soft and hard tissues, were unremarkable, with any exceptions noted below."

Included at the end of the history was an additional sentence, the wording of which varied, depending on the presence or absence of pain:

Either: "The patient does not recall traumatizing the area but *does report mild discomfort* in the area of the lesion while eating or when touching the area."

Or: "The patient does not recall traumatizing the area but *reports no discomfort* in the area of the lesion while eating or when touching the area."

Included at the end of the examination findings was an additional sentence, with wording that varied, depending on the 2 cues of "pain" (i.e., pain versus no pain) and "induration" (i.e., induration versus no induration):

Pain cue. Either: "Palpation of the lesion elicited *mild discomfort.*"

Or: "Palpation of the lesion elicited *no pain or discomfort.*"

(Note that these two possible signs mapped to the history of pain (discomfort) as described above)

Induration cue. Either ". . . and revealed *some firmness/induration.*"

Or: ". . . and revealed *no firmness/induration.*"

The clinical signs varied, depending on the 2 cues of "color" (i.e., red vs white) and "location" (high risk vs low risk) corresponding to the images provided (i.e., 2 white lesions vs 2 red lesions; 2 lower risk sites [buccal mucosa and gingivae] vs 2 higher risk sites [lateral tongue and floor of mouth]).

Review of questionnaire. Before initiation of the study, all questionnaire items were reviewed and evaluated by Westat Instrument Design, Evaluation, and Analysis Services and by key members of the Network Coordinating Center. In addition, 10 Network dentists and dental hygienists, who were selected to be representative of the 6 PBRN regions and who completed the vignette questionnaire, were individually interviewed to determine their understanding of each question, and modifications were made, as appropriate. Furthermore, 2 additional clinician–researchers and an expert in the methods and analyses used in this study reviewed and approved the completed vignette questionnaire. Last, 6 study researchers conducted a pretest of the online vignette questionnaire.

Statistical analysis

We used the LENS model to test the impact of individual cues on the dentists' clinical decision making regarding oral lesions. The LENS model is an analog method to study how individuals use information (cues) to make decisions (see example in Makhija et al.[13]). Equations for individual dentists' decisions were developed and then summarized at the group level. For these analyses, the 4 cues were analyzed to determine their influence on dentists' decisions regarding the likelihood of a lesion in the vignette being benign, premalignant, or malignant. This design allowed for the analysis of the dentists' decisions at the individual level and at the overall sample level. This approach was different from the usual methods that permit only group analyses of the overall sample. Because group analyses average out the data across patients, they do not permit examination of individual differences in each particular dentist's use of cues. Group analyses provide information only about the extent to which the dentists, on average, made different decisions about OPMLs with different clinical features. As such, this information is meaningful but incomplete (i.e., some of the dentists may only use the color cue in making decisions, whereas others may make their decisions on the basis of other cues or combinations of cues). Only individual-level analyses provide this specific information. Cue ratings were linear regressed separately on benign, premalignant, or malignant status (yes/no). Statistical significance was assessed at $P < .1$, and the magnitude of the variance explained by R^2. The cues color (red), location (high risk), induration (present), and pain (present) were each assigned a score of 1; and the cues color (white), location (low risk), induration (absent), and pain (absent) were each assigned a score of 0. If the overall regression model was not statistically significant, then it indicated that no decision strategy used these cues, and these cases were dropped from the cue-use-for-decision analyses.

If a dentist had a significant negative beta weight for 1 of the 4 cues on Q1 (Benign category), it meant that he or she used that cue to predict that the lesion was "less likely to be benign" (i.e., in the direction of worsening disease). A significant positive beta weight meant that the cue was used to predict the lesion was "more likely to be benign" (i.e., in the direction of less disease). Conversely, if a dentist had a significant negative beta weight for 1 of the 4 cues on Q2 or Q3 (Premalignant or Malignant categories), it meant that he or she used that cue to predict that the lesion was "less likely to be premalignant or malignant" (i.e., in the direction of less disease). A significant positive beta weight meant that the cue was used to predict the lesion was "more likely to be premalignant or malignant" (i.e., in the direction of worsening disease). The R^2 and beta weights from these individual regressions were then summarized with descriptive statistics (number of dentists with statistically significant decisions, and significant cues). Each dentist's R^2 value also was used as a dependent variable to assess potential explanatory variables for the strength of decision strategies across dentists.

Study data were imported into SAS, Stata, and SPSS statistical software packages, cleaned, and subsequently analyzed.

RESULTS

A total of 130 dentists (66% male, 34% female) completed the questions pertaining to the 16 case vignettes. The dentists were predominantly white (79%), with the remainder comprising 13% Asian, 5% African American, 1% Native American, and 2% "other," and 98% were non-Hispanic. The mean age of the dentists was 52 years (standard deviation [SD] ± 12 years), and the mean number of hours in practice per week was 33 hours (SD ± 9 hours).

Overall, fewer than 40% of dentists had statistically significant decision policies (i.e., a consistent thought process) at the level of $P < .1$ (and results were also similar at $P < .05$) to assign a clinical diagnosis to the cases in the benign, premalignant, or malignant vignettes. Across these 3 diagnostic categories, lesion location and color were the 2 dominant cues, and pain was the most infrequently used cue (Table I). Induration was used as a cue by more of the dentists in determining a clinical diagnosis of malignancy than in determining benign and premalignant states.

Exploring the beta weights provided some additional insight (see Table I). The majority of dentists who used lesion location as a cue (26 of 30) had significant negative beta weights, suggesting that they used high-risk location to predict that a lesion was less likely to be benign. The majority of dentists (i.e., 23 of 26 and 24 of 27) had significant positive beta weights showing that they used high-risk location to predict that a lesion was more likely to be premalignant or malignant, respectively.

The majority of dentists who used color as a cue (15 of 22) had significant negative beta weights, indicating that they used the red coloration of a lesion to predict that a lesion was less likely to be benign. For the premalignant diagnostic category, the majority of dentists (20 of 27) had significant negative beta weights, suggesting that they used the red coloration of a lesion to predict that a lesion was less likely to be premalignant. Conversely, for the malignant diagnostic category, 17 of 25 dentists had significant positive beta weights, suggesting that they used the red coloration of the lesion to predict that a lesion was more likely to be malignant.

Almost all dentists who used the presence of induration as a cue had significant negative beta weights to predict that a lesion was less likely to be benign or had significant positive beta weights to predict that a lesion was more likely to be premalignant or malignant.

When pain was used as a cue, our results were variable for how the dentists used the symptom of pain to make decisions. For the benign classification, 9 of 14 dentists had significant negative beta weights, suggesting that they used the presence of pain to predict that a lesion was less likely to be benign, and 5 of 14 dentists had significant positive beta weights showing that they used the presence of pain to predict that a lesion was more likely to be benign. Two and 7 dentists (of a total 8 and 12, respectively) had significant negative beta weights showing that they used the presence of pain to predict that a lesion was less likely to be premalignant or malignant, respectively, whereas the remaining 6 and 5 dentists had a significant positive beta weight showing that they used presence of pain to predict that a lesion was more likely to be premalignant or malignant, respectively.

Table I. Frequencies of cue use by dentists with a decision-making policy for assigning a clinical diagnosis to an oral lesion, and frequencies of significant negative and positive beta weights*

Diagnostic category	*Number of dentists*	*Lesion location*	*Color*	*Induration*	*Pain*
Benign	48	30	22	14	14
# Negative beta		26	15	14	9
# Positive beta		4	7	0	5
Premalignant	46	26	27	12	8
# Negative beta		3	20	1	2
# Positive beta		23	7	11	6
Malignant	49	27	25	21	12
# Negative beta		3	8	0	7
# Positive beta		24	17	21	5
Total		83	74	47	34

*Includes findings for dentists with a statistically significant regression model. Initially, patients with overall models ≥ 0.01 (i.e., decisions not incorporating the 4 presented cues) were excluded from further analyses of their cue use. Modeling at the $P \geq .05$ level of exclusion produced essentially identical results. Therefore, we chose to present the $P \geq .05$ level, thus providing a more statistically confident estimate than envisioned. Positive beta weight meant that the cue was used to predict the lesion was in the direction of less disease. Negative beta weight meant that the cue to predict that the lesion was in the direction of worsening disease.

There was a wide range of different cues, cue combinations, and numbers of cues used by the dentists in assigning a clinical diagnosis across the 3 diagnostic categories, and no discernable decision-making pattern emerged. The majority of dentists used only 1 or 2 cues (Tables II and III).

Subanalysis of the data to explore the effect of correlation factors provided no additional insight. There were no statistically reliable differences between male and female dentists in the strength of their decision-making policies, with the exception that a higher proportion of female dentists (50% vs 20%; $\chi^2 = 3.9$; $P = .048$) made statistically reliable decisions in assigning a premalignant diagnosis. Because of the small cell sizes for race/ethnicity, this variable was collapsed to include white versus any minority category, and there were no statistically significant differences between white and minority categories on the R^2 or any of the diagnostic categories. We calculated correlations between decision policy R^2 and the percentage of patients with private insurance, public insurance, reduced fee scales, and uninsured status for each of the 3 diagnostic categories. Results indicated that only the percentage covered by public insurance was correlated with R^2 of likelihood of a lesion being malignant ($r = 0.20$; $P < .05$). The other comparisons between decision policy R^2 (i.e., cue beta weights) across insurance status, geographic regions, hours of practice, and residency training all were nonsignificant.

DISCUSSION

To our knowledge, this is the first study to explore how general dentists make diagnostic decisions when they encounter a patient with an oral epithelial abnormality. Clinical decision making, as taught in dental courses, has long been based on an analytical approach involving the synthesis of data collected through careful history taking and physical examination. Yet, for seasoned clinicians, decision making can be done through an intuitive and heuristic approach, which is a faster process than the analytical approach and in which a clinician uses experience and pattern recognition to guide diagnostic decisions. The overlapping of these 2 approaches has been coined the "dual process theory" of decision making,[14] and both approaches are prone to a number of biases.

The Lens model has been tested in medicine across a number of settings, largely in the area of pain, and these include the study of clinicians' ability to detect pain intensity in patients experiencing pain,[15,16] cancer pain in Chinese patients,[17] and the hemodynamic status in the critically ill.[18] The only known use of the LENS model in dentistry was in a study exploring the decision strategy to diagnose occlusal caries without the need for dental radiography.[13] Given the importance of the clinical diagnosis of oral cancer and OPMLs, we hypothesized that the use of this model would offer insights into how dentists make these clinical decisions. In this study, we provided dentists with clinical cases linked to a detailed set of historical and examination data. These data were tested by experts and a focus group and, thus, provided a highly structured framework that we hoped would help elucidate the analytical diagnostic approach of dentists. Yet, the results reported here reveal that fewer than 40% of the 130 dentists had a significant decision-making policy, as indicated by their responses to the 16 vignette permutations, suggesting that most dentists did not have a consistent decision-making approach to the vignettes. A strength of this study's findings is that the lack of a strategy to use cues was determined for an R^2 change at an alpha value less than 0.05, with almost no difference versus the planned exploratory analyses with less than 0.1 power, providing a more statistically confident estimate than envisioned. Moreover, within the minority group of dentists with a decision-making policy, fewer than half of the four cues incorporated into the vignette design were used.

There are a number of possible explanations for these results: (1) It is likely that a wide variation exists across general dentists in terms of base knowledge or clinical experience; and this may reduce their appreciation of the importance or relevance of all 4 cues in the diagnosis of OPMLs, thus abrogating both an analytical or intuitive approach. (2) The methodology we used had limitations in the assessment of decision making among dentists. It is important to note that the statistical significance of a dentist's decision strategy was based on a P value of .05.

Table II. The numbers of dentists with a decision-making policy using the various cues for predicting a diagnosis (i.e., benign/premalignant/malignant) for an oral lesion

Diagnostic category	*Lesion location*	*Color*	*Induration*	*Pain*	*2 cues*	*3 cues*	*4 cues*	*0 cues*	*Total number of dentists*
Benign	15	3	1	2	20*	5†	1	1	48
Premalignant	13	9	1	1	18*	3‡	1	0	46
Malignant	8	5	5	0	26*	5†	0	0	49

*6 combinations of 2 cues.
†4 combinations of 3 cues.
‡2 combinations of 3 cues.

Table III. Average number of cues used by dentists with a decision-making policy for predicting a diagnosis (i.e., benign/premalignant/malignant) for an oral lesion

	1 cue used	2 cues used	> 2 cues used	Total used	Average
Benign	21	20	6	89	1.9
Premalignant	24	18	4	70	1.5
Malignant	18	26	5	85	1.8

With 16 vignettes and a small sample size, the study had relatively low statistical power for the detection of a decision strategy. Less stringent statistical criteria, a greater number of participants, or more vignettes could have yielded a higher number of dentists with statistically significant strategies and individual cues. At this stage of the inquiry, we opted for a conservative statistical criterion and a number of vignettes that was logistically feasible. (3) For some practitioners, other cues, such as history and physical findings, which were not explored in this study, might be important for assigning a lesion's risk level.

There is evidence that there are variations, across the respondents in the study, in possible knowledge regarding the relevance and importance of the 4 cues. The most frequently used cue was lesion location, and among those dentists who demonstrated a significant decision-making policy, most used this cue correctly in that lesions detected at high-risk sites (lateral tongue and floor of mouth) were more likely to be associated with premalignant and malignant lesions and less likely to be associated with benign lesions. The manner in which lesion color as a cue was integrated into the decision-making process in this group of dentists was not as clear. Although the majority of participating dentists used this cue correctly (i.e., that an OPML with a red component was a more concerning sign compared with only-white lesion), 32% and 74% of the subset of dentists who had significant decision policies used redness to predict that a lesion was either more likely to be benign or less likely to be premalignant, respectively. This suggests that perhaps they were associating redness with inflammation secondary to a benign process, such as infection (erythema, or "rubor," is one of the cardinal signs of inflammation). In the case of a malignant diagnosis, 32% of these dentists did not associate redness with a malignant diagnosis, suggesting that there may be a lack of knowledge regarding redness that is typically associated with OSCC (i.e., related to neoangiogenesis and/or cancer-related inflammation).

Evaluation for induration by using digital palpation of an OPML is critical. Induration associated with malignancy is associated with depth of invasion, which is a prognostic marker that has recently been integrated into the updated 8th edition of the American Joint Commission on Cancer (AJCC) TNM staging classification.[19] Typically, benign and premalignant lesions do not demonstrate induration, and in the subset of dentists with significant decision-making policies, it was reassuring to note that the presence of induration was correctly associated with a lesion being less likely to be benign or more likely to be malignant. The finding that 11 of 12 dentists used the presence of induration to predict a premalignant lesion, however, does demonstrate some confusion about the distinction between premalignant and malignant lesions. The term *premalignant* as defined in this study (i.e., the condition of a lesion that is not currently malignant but has malignant potential) would not typically be associated with induration.

Of all the cues we explored in this study, the presence of pain was the least frequently used cue, and those dentists who used pain as a cue used it in a variable manner. The transition from premalignant lesion to OSCC is often associated with pain, typically manifesting as a mechanical allodynia.[20] Furthermore, pain is not only associated with advanced OSCC but may also be experienced by patients in all stages of cancer,[21] including small lesions similar to those featured in the vignettes. The finding that 58% of the participating dentists did not equate the presence of pain with malignancy is evidence of this misperception.

One other possible, albeit simplistic, explanation for these results is that many general dentists prefer not to engage in diagnostic thinking and prefer to refer all patients with abnormal mucosal findings not associated with trauma or other common mucosal lesions with simple clinical diagnoses (e.g., recurrent aphthous stomatitis) to specialists.

In 2010, the Commission on Dental Accreditation, the body that oversees dental school curricular content, approved a mandatory new standard (Standard 2.24 b): "At a minimum, graduates must be competent in providing oral health care within the scope of general dentistry, as defined by the school, including screening and risk assessment for head and neck cancer."[22] This educational program standard was included in addition to Standard 2.24 k: "At a minimum, graduates must be competent in providing oral health care within the scope of general dentistry, as defined by the school, including oral mucosal and osseous disorders." Yet, these 2 standards provide no assurance that dental students have learned an evidence-based analytical decision-making approach for the assessment of patients with epithelial lesions that meet the clinical criteria for OPMLs. After graduation, dentists have no universal mandate to take continuing education courses in this area. The mean age of dentists in this study was 52 years, with the mean graduation year being 1992. This may give rise to the question: "How many hours of continuing education on the diagnosis of oral lesions would a dentist need to take over an average of 26 years?" Furthermore, the low prevalence of OPMLs encountered in clinical practice does not facilitate acquiring the level of experience required to develop the ability for pattern recognition that underlies an intuitive approach.

In this regard, Hassona et al. have noted, in 2 reports,[23,24] that "significant positive correlation was found between knowledge scores and early detection practice scores," and that "students contact with patients who have oral lesions, including oral cancer will help to improve their future diagnostic ability and early detection practices." We have previously reported identical findings from a qualitative study of dental practitioners.[25] Taken together, these and other reports are clear on the importance of high-quality oral cancer screening and continuing education.

This study has some limitations. The sample size was relatively small, and all participants were PBRN members. The LENS model has been used previously among dentists for diagnosing occlusal caries, and it has been found that almost 90% of dentists have a decision strategy that is based on the 4 cues.[13] Yet, occlusal caries is a very common diagnosis compared with that of OPMLs, and one wonders if the LENS approach for diagnosing OPMLs requires a higher level of baseline knowledge to fully comprehend and engage in this modeling. The fact that greater than 60% of dentists had no statistically significant decision-making policies supports this notion. Examination of digital images is not a perfect substitute for examining a patient in person, and the process of working through the 4 permutations of the 4 cases, each linked to 3 questions (i.e., in the context of benign, premalignant, and malignant types of lesions), may have led to some questionnaire fatigue. This study could have been enriched by surveying the dentists about their baseline knowledge of the signs and symptoms of oral cancer/OPMLs and then correlating these findings to the vignette results presented here. In retrospect, the group of 10 dentists and dental hygienists who piloted the questionnaire and who confirmed that they understood the vignette design might have provided greater insight into the performance of the assessment in a focus group setting. More studies are needed to further explore the decision-making process of dentists. A risk stratification algorithm for the assessment and diagnosis of oral cancer and OPMLs has been suggested by Speight et al.,[7] and the testing of such algorithms in a dental setting could help generate a standardized and evidence-based clinical guideline.

CONCLUSIONS

The findings of the current study suggest that there is variability in the way dentists use cues for the clinical diagnosis and risk stratification of OPMLs. Two lines of research inquiry have emerged from these findings: (1) What are the best educational and training models for general dentists and hygienists in terms of the examination and lesion assessment of oral cancer/OPMLs? (2) What are the individual and conjoint probabilities of each history and examination element that would aid in the development of a clinical "decision" tree for the diagnosis of oral cancer/OPMLs?

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