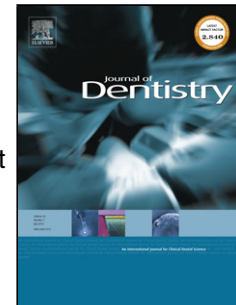


Journal Pre-proof

Dentists Clinical Decision-Making for Erosive Tooth Wear: An Online Pilot Study

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PII: S0300-5712(20)30170-6
DOI: <https://doi.org/10.1016/j.jdent.2020.103424>
Reference: JJOD 103424

To appear in: *Journal of Dentistry*

Received Date: 21 December 2019
Revised Date: 26 June 2020
Accepted Date: 29 June 2020

Please cite this article as: { doi: <https://doi.org/>

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TITLE

Dentists Clinical Decision-Making for Erosive Tooth Wear: An Online Pilot Study

SHORT TITLE

Clinical Decision-Making for Erosive Tooth Wear

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ABSTRACT

Objective: Erosive tooth wear (ETW) is an irreversible loss of dental hard tissue. This pilot study examined dentists' ability to diagnose and manage ETW relative to sound and caries-affected teeth. **Methods:** Dentists recruited through the Indiana Dental Association (N=36) participated in an internet-based survey, containing twenty-two standardized images of buccal and occlusal surfaces of teeth (sound, ETW, or caries). For each image, they provided diagnosis (presence and differentiation) of dental condition, confidence in their judgment, management need, and likelihood to recommend specific management strategies. Dentists made these judgments for teeth with no, initial, moderate, or severe ETW/caries. **Results:** Dentists demonstrated poor detection of ETW compared to sound teeth and caries at each level of severity. The dentists were less confident, less able to correctly diagnose and manage ETW, and less likely to recommend most management strategies for ETW than caries at each level of severity. **Conclusions:** Dentists had difficulty correctly diagnosing (both detection and differentiation) and managing ETW, across all severity levels and particularly in early stages. These difficulties were particularly apparent when compared to caries. The current results are clinically relevant given the importance of early diagnosis for ETW management.

KEYWORDS

Erosive tooth wear, dental caries, diagnostics, management decisions.

CLINICAL SIGNIFICANCE

The internet-based tool created for this study can be used to assess dentists' ability to diagnose and manage cases of ETW. Efforts to raise dentist awareness of early stages of ETW is important to preventing or delaying its progression, avoiding future restorative interventions.

INTRODUCTION

Clinical data suggest that erosive tooth wear (ETW) leads to substantial and irreversible loss of tooth structure, affecting dental form, function and esthetics [1-5]. ETW encompasses dental erosion, abrasion, and attrition processes. Some authors have observed that increased consumption of acidic soft drinks and high acidic diets have increased the prevalence of ETW [6, 7]. The high level of importance ascribed to ETW in the eyes of dental professionals in Europe and South America contrasts sharply with the low salience of ETW in the U.S. Considerable data has shown ETW prevalence in children and adolescents to vary between 7 and 51% in Brazil; 17 and 59% in the U.K.; 24 and 44% in The Netherlands; 11 and 32% in Germany; and 15 and 30% in Iceland [8]. While studies in adults are not as common, Bartlett et al. [9], reported 100% of ETW prevalence in the U.K. for 1,010 young adults (18-30 years old), with high severity (dentin exposure) in 8% of the ETW lesions [9]. Although sparse, available data for the U.S. showed high ETW prevalence among teenagers (46%) [10] and adults (80%) [11]. These figures suggest that ETW in the U.S. is a common problem, worsening with older age. However, diagnosis of ETW by dental professionals appears to be mismatched with the epidemiological and clinical impacts of ETW, raising the possibility that American dentists have limited ETW training.

To the best of our knowledge, there is no research assessing ETW awareness among U.S. dentists. The limited available data in the literature suggest that awareness of ETW can be low even in countries where ETW receives relatively more attention. One study found that 36% of dentists correctly diagnosed ETW among 12-year-olds in the U.K., and 7% reported having never seen it in this age group [12]. That study also showed that 68% of dentists underestimated the prevalence of ETW in children. These findings support the mismatch between dentists' diagnosis ability and the epidemiological and clinical impacts of ETW. If that is indeed the case, it would be concerning because dentists' diagnosis may not only drive the identification of a dental condition but also influence the salience of ETW as a clinical issue to be addressed through professional care. Given the low levels of awareness observed among U.K. dentists, it is reasonable to assume that U.S. dentists may also have difficulty identifying ETW. Empirical research is needed to test this assumption.

The purpose of the present pilot study was to examine a convenience sample of U.S. dentists' ability to diagnose and manage ETW, particularly compared to sound and caries-affected teeth.

We created an internet-based survey that presented standardized images of dental conditions in order to assess dentists' visual perceptions of these conditions absent other clinical information. While we acknowledge the limitations of this approach, given the central role of visual inspection in dental care, we were particularly interested in isolating this aspect of the dental decision-making process [13, 14]. We hypothesized that dentists would demonstrate poor ability to detect ETW – on its own and in contrast with dental caries at different levels of severity – and that dentists would be less confident, make more incorrect diagnoses and management decisions, and would be less likely to recommend management strategies when judging ETW compared to caries.

METHODS

Study design and participants

The study design was a web-case-based survey. We developed a protected website in partnership with Indiana University Network Science Institute that hosted the current study. We recruited dentists through the Indiana Dental Association (IDA) by posting on the IDA Newsletter and on its Facebook page an invitation to members to participate in the survey. We posted exclusively in the newsletter for three months before expanding to Facebook. The first 40 dentists who contacted the research team were given account access to complete the survey in exchange for a gift card. We conducted the survey after receiving institutional review board approval from Indiana University Purdue University Indianapolis (#1808766451).

Survey development

We selected images of sound teeth, teeth with ETW, and teeth with dental caries from a catalogue maintained by a member of our research team (JCC). We used the Basic Erosive Wear Examination (BEWE) to determine severity of teeth with ETW [15]. The BEWE grades ETW on a 0-3 ordinal scale: sound (BEWE 0: no wear), initial (BEWE 1: early surface loss), moderate (BEWE 2: surface loss < 50%), and severe (BEWE 3: surface loss > 50%). While the BEWE is typically a clinical examination, the metrics to determine the severity is determined based on the visual perception of dental surface changes, thus making it appropriate for the current study. The dental caries lesions were classified in similar severity levels to allow a direct comparison

between the two conditions as follows: sound (absence of any sign), initial (visual changes in enamel), moderate (localized enamel breakdown with visual signs of small dentinal involvement), and severe (distinctive cavity with extensive dentin involvement). Initial testing of 77 images was completed wherein three experienced dentists (JCC, GM, & ATH) scored the buccal and occlusal surfaces of selected teeth and reached consensus in cases of disagreement. Finally, 22 images considered representative of all conditions under study were selected and a benchmark established. As the primary goal was to assess dentists' ability to judge dental conditions, we prioritized high quality images of clear conditions. This resulted in an uneven distribution of the numbers of buccal and occlusal surfaces across the images; however, both surfaces were represented in the images for all of the condition categories (sound, initial, moderate, and severe). Next, twelve experienced dentists in a focus group completed a beta version of the online survey. Based on their feedback, we adjusted images and procedures to simplify the methods and decrease participant burden.

Survey materials and administration

Upon accessing the website, participants viewed the twenty-two standardized images of buccal and occlusal surfaces of anterior and posterior teeth, respectively, depicting sound, ETW, and carious surfaces. There were three images per level of severity for ETW and dental caries (initial, moderate, and severe), and four images with no condition (sound). One specific tooth was circled in each image. For each image, we assessed dentists' ability to detect the presence of a dental condition, confidence in their judgment, ability to make correct diagnoses, and ability to make correct management decisions.

The first question assessed dentists' ability to detect the general presence of a dental condition. For each image, dentists responded "yes" or "no" to the question, "Is there a dental condition for the circled tooth?" Responses were correct when they matched the expert-determined clinical diagnosis. The second question assessed dentists' confidence in these judgments. For each image, participants used a Likert-type scale (ranging from *Not at all confident*: 1 to *Extremely confident*: 5) to respond to the question, "How confident are you with your judgment of whether or not there is a dental condition for the circled tooth in the image above?" The third question assessed dentists' ability to make correct diagnoses for specific dental problems. For each image, dentists selected the condition they would diagnose from six possible options (sound, cracking,

dental erosion, fluorosis, caries, or other). The term “dental erosion” was used in this specific survey because our focus group study showed that dentists were more familiar with this term than the more appropriate term “erosive tooth wear”. The next question assessed dentists’ treatment decisions of whether a tooth required management. For each image, dentists responded “yes” or “no” to the question, “Would you recommend clinical management for the patient’s circled tooth?” Responses were scored correct when they matched the expert-determined clinical management recommendations. The final question assessed how likely dentists would be to recommend various management strategies. For each tooth assessed as requiring management (indicated by a “yes” response to the previous item), dentists used a Likert-type scale (ranging from *Extremely unlikely*: 1 to *Extremely likely*: 4) to indicate how likely they are to recommend the following options: patient education, anti-erosion/anti-cavity at home products, anti-erosion/anti-cavity professional application, sealant, and restorative treatment. Acknowledging the limited evidence that exists to support the various treatment options to address ETW - in particular in the early stages - we are not making a definitive set of recommendations for treatment. Our intent was instead to illustrate the diversity and scope of management avenues recommended by this sample of dental practitioners when presented with standardized images of dental conditions.

Analyses

Cochran-Mantel-Haenszel chi-square tests for stratified categorical data were used to compare the percentage of correct responses for presence of a dental condition (sound, ETW, or caries) and the percentage of correct responses for whether or not management was required between dental conditions and between condition severity-level combinations. Generalized linear mixed effects models for binary data with a logit link and random effects for tooth and participant were used to compare between dental conditions and between condition severity-level combinations for differences in the percentage of correct responses for diagnosis and for treatment decisions when determining whether the tooth required management. Linear mixed effects models with random effects for tooth and participant were used to compare between dental conditions and between condition-level combinations for differences in the confidence ratings for presence of a dental condition and in the likelihood of using each management strategy. All analyses considered a significance level of 5%. In a post-hoc power analysis, based on the actual sample size and within-cluster correlation of 0.3, the study had 80% power to detect a difference of 17%

to 25% between dental condition-severity level combinations, assuming two-sided tests each conducted at a 5% significance level. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Demographics

The study included 40 consecutively-enrolled participants, however, four participants were excluded for not completing the survey. In the final sample, which included 19 men and 17 women, ranging in age from 27-74 ($M = 34.6$; $SD = 9.2$), 19 (53%) reported less than 5 years of professional experience, 13 (36%) reported 5-10 years of experience, and 4 (11%) reported greater than 10 years of experience.

Detection

We examined the percentage of dentists who correctly detected whether a dental condition was present. Eighty-eight percent of sound teeth were correctly identified as not having a dental condition present. Dentists had significantly poorer detection of the presence of a dental condition when viewing images of initial ETW (14% correct) than when viewing images of initial caries (94%, $p < .001$), poorer detection for moderate ETW (57%) than moderate caries (100%, $p < .001$), and poorer detection for severe ETW (69%) than severe caries (100%, $p < .001$; see Figure 1).

Confidence

We examined how confident the dentists were that they correctly detected whether a dental condition was present. When examining sound teeth, dentists were somewhat confident in their judgments ($M = 3.46$, $SE = .07$). Dentists were significantly less confident in their judgments for teeth with moderate ETW ($M = 3.42$, $SE = .10$) than moderate caries ($M = 4.35$, $SE = .07$, $p = .001$), and less confident for severe ETW ($M = 3.84$, $SE = .10$) than severe caries ($M = 4.48$, $SE = .06$, $p = .013$); the difference for teeth with initial ETW ($M = 3.62$, $SE = .09$) and initial caries ($M = 4.08$, $SE = .08$) was marginally significant ($p = .06$) and in the same direction as the other levels. Although lower than for caries, ETW mean confidence ratings were still significantly

above the midpoint of the scale for initial ETW ($p = .001$), moderate ETW ($p = .009$), and severe ETW ($p < .001$; see Figure 2).

Diagnoses

We examined dentists' ability to diagnose the circled tooth. Ninety-two percent of sound teeth were correctly diagnosed as being sound. Dentists made significantly fewer correct diagnoses for initial ETW (3% correct) than initial caries (60%, $p = .01$), fewer correct diagnoses for moderate ETW (19%) than moderate caries (87%, $p < .01$), and marginally fewer correct diagnoses for severe ETW (48%) than severe caries (87%, $p = .07$) which was in the same direction as the other levels. Across all stages of severity, dentists correctly diagnosed only 24% of the cases of ETW compared to 78% of the cases of caries (see Figure 3).

Management

We examined the percentage of dentists who correctly determined whether a tooth required management. Sixty-seven percent of sound teeth were correctly identified as not requiring management. Dentists made significantly fewer correct management decisions for initial ETW (30% correct) than initial caries (94%, $p < .001$), fewer correct decisions for moderate ETW (69%) than moderate caries (98%, $p < .001$), and fewer correct decisions for severe ETW (77%) than severe caries (100%, $p < .001$; see Figure 4).

Management strategies

A consistent pattern indicated that dentists were more likely to recommend most management strategies for caries than ETW at each level of severity. There were a few non-significant findings for recommending sealants at both moderate and severe levels of ETW and caries (see Figure 5).

DISCUSSION

Our findings suggest that dentists' ability to diagnose dental conditions using visual information differ for ETW and caries. Dentists demonstrated poor ability to detect ETW, especially compared to sound teeth and teeth with caries at each level of severity. Dentists were less confident in their judgments of teeth with ETW than caries-affected teeth at each level of severity. Consistent with the detection findings, relative to the other conditions, dentists

demonstrated poorer diagnostic ability for ETW, were less able to correctly determine if ETW-affected teeth required management, and were less likely to recommend most management strategies for ETW compared to caries at each level of severity - all of these compared to a benchmark.

The poor ability for dentists to detect the presence of a dental condition when viewing teeth with ETW (47% correct, collapsing across each level of severity) and to differentially diagnose ETW (24% correct, collapsing across severities) can be problematic given that ETW prevalence has been reported to be as high as 80% among adults in the U.S [11]. Meanwhile, dentists demonstrated better ability to make a differential diagnosis for caries, which may be due to the high prevalence (94% of U.S. adults) [16] and widespread awareness of this condition [17]. The detection and diagnosis disparities between ETW and caries observed in the current study were especially marked at early stages (14% [detection] and 3% [differential diagnosis] correct for ETW vs. 94% [detection] and 60% [differential diagnosis] correct for caries). These findings are supported by the inherent difficulty in the identification and differentiation of the clinical aspects of the ETW lesion, especially at its initial stages [18].

Similar to the differences in detection and differential diagnostic for ETW and caries, dentists' confidence in their judgments differed per dental condition. Dentists were more confident when detecting caries than ETW at each level of severity. This pattern is consistent with their detection ratings for caries vs. ETW. However, given their poor performance on the detection tasks, dentists were surprisingly confident in their judgments of teeth with ETW. Indeed, their average confidence ratings for these teeth were above the midpoint of the scale at each level of severity despite the fact that their detection ability was relatively poor. A great deal of research highlights the disconnect between confidence and ability in many domains including among physicians when estimating values related to right-heart catheterizations [19], and among dentists when diagnosing pathoses in radiographs [20, 21]. Our findings suggest that dentists' ability to diagnose ETW align with this broader literature.

Dentists' management decisions also differed across conditions. Dentists made fewer accurate management determinations for ETW-affected teeth than caries-affected teeth at each level of severity. Dentists were also less likely to recommend management strategies for teeth with ETW compared to teeth with caries. This pattern of effects held constant for nearly all management

strategies including education, at home products, professional applications, sealants (at initial ETW), and restorations. These differences were especially pronounced at early stages of ETW, which can be problematic given the importance of the early implementation of preventive measures [22].

Perceptions of the physical appearance of the tooth may contribute to these differences in detection, differential diagnosis, and management decisions. In the early stages of ETW, the enamel surface is lightly abraded and polished, eliminating or reducing superficial defects (e.g. light fluorosis or uneven coloring/staining), and appears shinier [23], yielding a more visually attractive tooth [24]. The current findings suggest a need for education to enhance dentists' understanding of the pathophysiology of ETW, especially in the early stages, and the manifest visual changes to the tooth so as to improve early detection and management of this highly prevalent condition.

Another possible factor leading to dentists' relatively poor detection, differential diagnosis, and management decisions of ETW has to do with insufficient and inconsistent training [25,26]. Insufficient training is especially problematic given that it is the primary means of establishing professional competence in diagnosing and monitoring of ETW [22]. U.S. dental schools spend less than one hour a year on ETW and less than half of the schools include tooth wear indices in their curriculum [27]. Given this situation, it is unsurprising that only 15.3% of sampled dental students correctly identified clinical signs of ETW [27]. Taken together with the results of the current study, the limited training on ETW is incongruent with the epidemiological and clinical impacts of ETW.

The present pilot study is innovative in that it has shed light on dentists' ability to diagnose ETW, both on its own and in contrast to dental caries. The present research also has some limitations, including the limited sample size and restriction of recruitment to Indiana dentists. Our research plan posited that obtaining clinical criteria from the Indiana Dental Association members would accrue good quality and sufficient spread of perspectives to render our preliminary study well situated in the clinical context. Although we have no reason to believe that Indiana dentists are fundamentally different from dentists in other geographical regions, confidence in the current findings would be strengthened by future research on diagnosis of ETW among dentists from across the U.S. Another limitation is that only dental images were

used, absent other potentially-relevant clinical information. However, because visual inspection remains the centerpiece for most restorative dental care decisions [13, 14], these results likely have direct clinical implications. Moreover, this pilot study lays the groundwork for future studies that are both larger and more clinically representative of how dentists assess and treat ETW in the United States and beyond. The current sample also lacked variability in dental specialty areas, which prevented us from exploring differences in diagnosis of ETW across specialties. Future research should focus not only on the study of a more representative U.S. dentist population, but also on the identification of optimal ways to improve dentists' perceptions and management of ETW.

CONCLUSION

Dentists had difficulty correctly diagnosing (both detection and differentiation) and managing ETW, across all severity levels and particularly in early stages. These difficulties were particularly evident when compared to caries at similar severity levels. The current results are clinically relevant given the importance of visual detection to the diagnosis and management of ETW, especially at early stages. These findings will inform a subsequent, larger study of dentists across the United States.

CREDIT AUTHOR STATEMENT

- Micah B. Goldfarb: Data curation; Investigation; Methodology; Project administration; Resources; Writing - original draft
- Gerardo Maupomé: Conceptualization; Funding acquisition; Methodology; Project administration; Resources; Supervision; Writing - original draft
- Adam T. Hirsh: Conceptualization; Methodology; Writing - review & editing
- Joana C. Carvalho: Methodology; Resources; Writing - review & editing
- George J. Eckert: Formal analysis; Writing - review & editing
- Anderson T. Hara: Conceptualization; Funding acquisition; Methodology; Project administration; Resources; Supervision; Writing - original draft

ACKNOWLEDGEMENTS

We would like to thank the Indiana Dental Association (IDA) and the Indiana University Network Institute (IUNI) for their assistance in this project. The IDA was extremely helpful recruiting dentists to participate in our study. The IUNI was responsible for implementing our survey onto a website, which we used for this study. This project was funded by GlaxoSmithKline Consumer Healthcare in a public domain, investigator initiated Investigator-Sponsored Study (ISS #8730).

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FIGURES

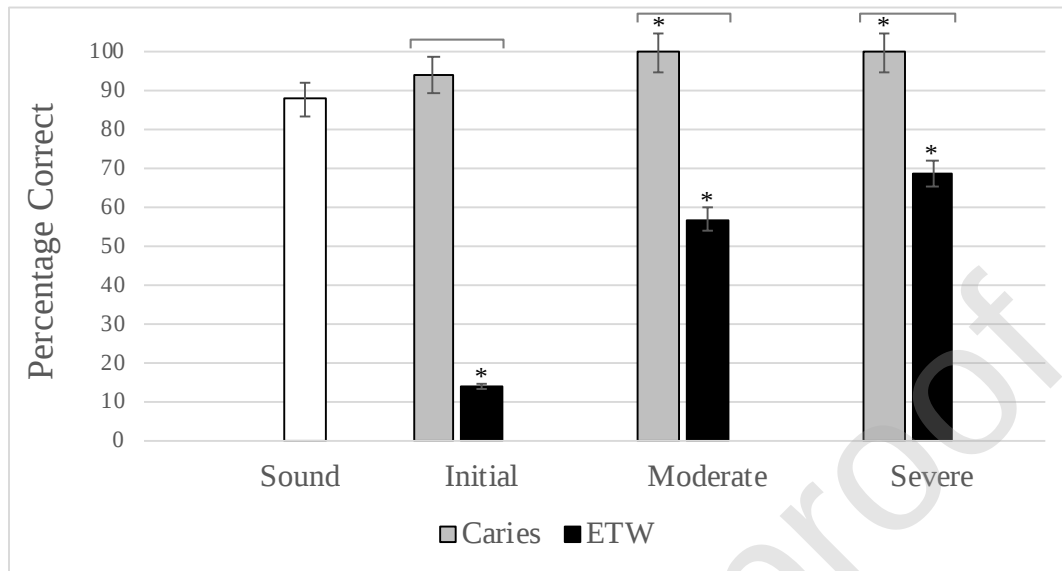


Figure 1. Dentist recognition of different severities (initial, moderate and severe) of erosive tooth wear (ETW) and caries, as well as sound teeth. Bars connected by brackets differ significantly from each other ($p < 0.05$); bars marked with asterisks differ significantly from sound ($p < 0.05$).

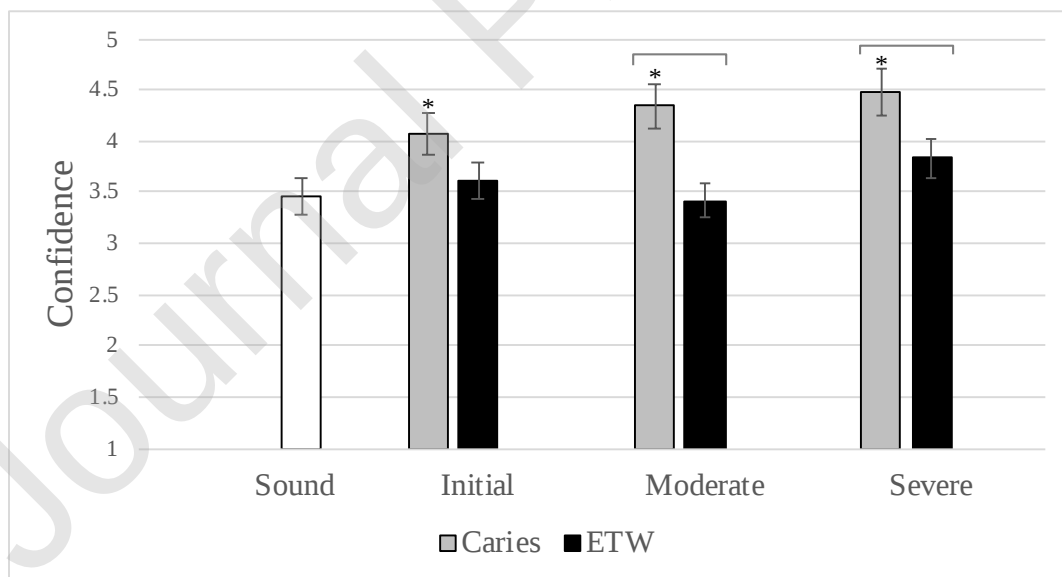


Figure 2. Mean ratings of dentists' confidence recognizing different severities (initial, moderate and severe) of erosive tooth wear (ETW) and caries, as well as sound teeth. Bars connected by brackets differ significantly from each other ($p < 0.05$); bars marked with asterisks differ significantly from sound ($p < 0.05$).

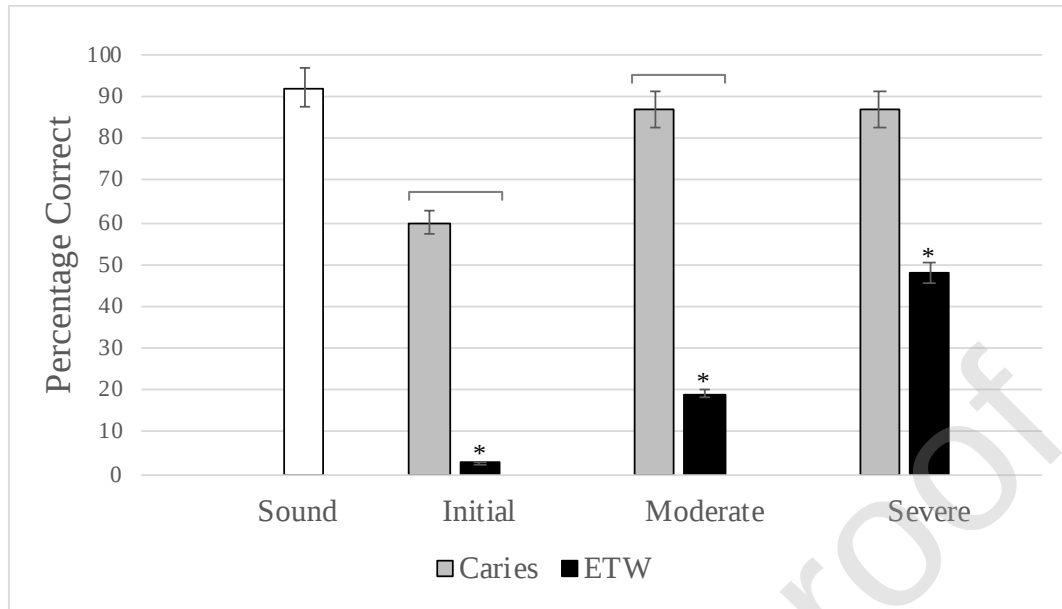


Figure 3. Dentists' diagnoses of different severities (initial, moderate and severe) of erosive tooth wear (ETW) and caries, as well as sound teeth. Bars connected by brackets differ significantly from each other ($p < 0.05$); bars marked with asterisks differ significantly from sound ($p < 0.05$).

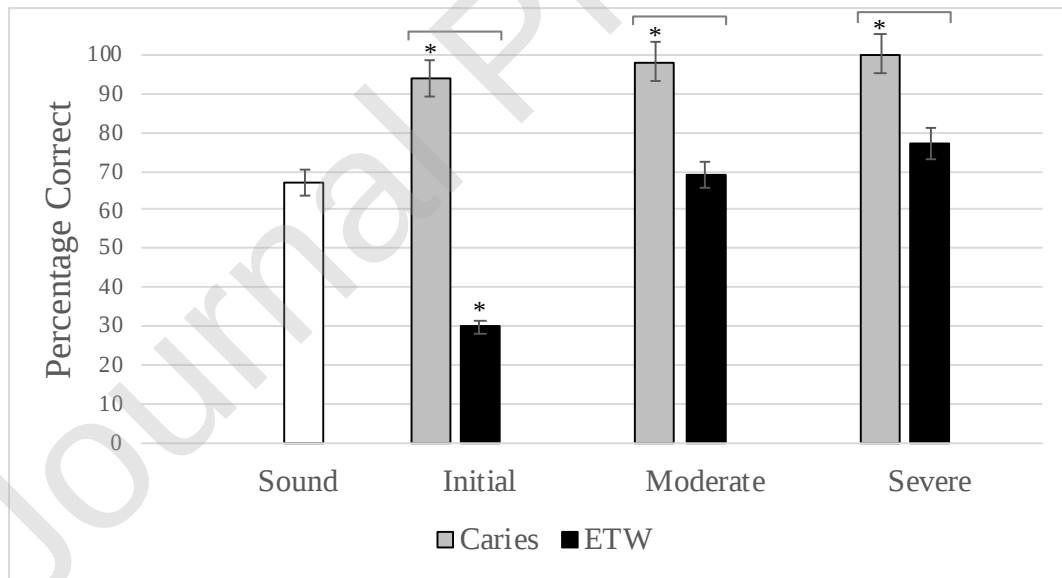


Figure 4. Dentists' management of different severities (initial, moderate and severe) of erosive tooth wear (ETW) and caries, as well as sound teeth. Bars connected by brackets differ significantly from each other ($p < 0.05$); bars marked with asterisks differ significantly from sound ($p < 0.05$).

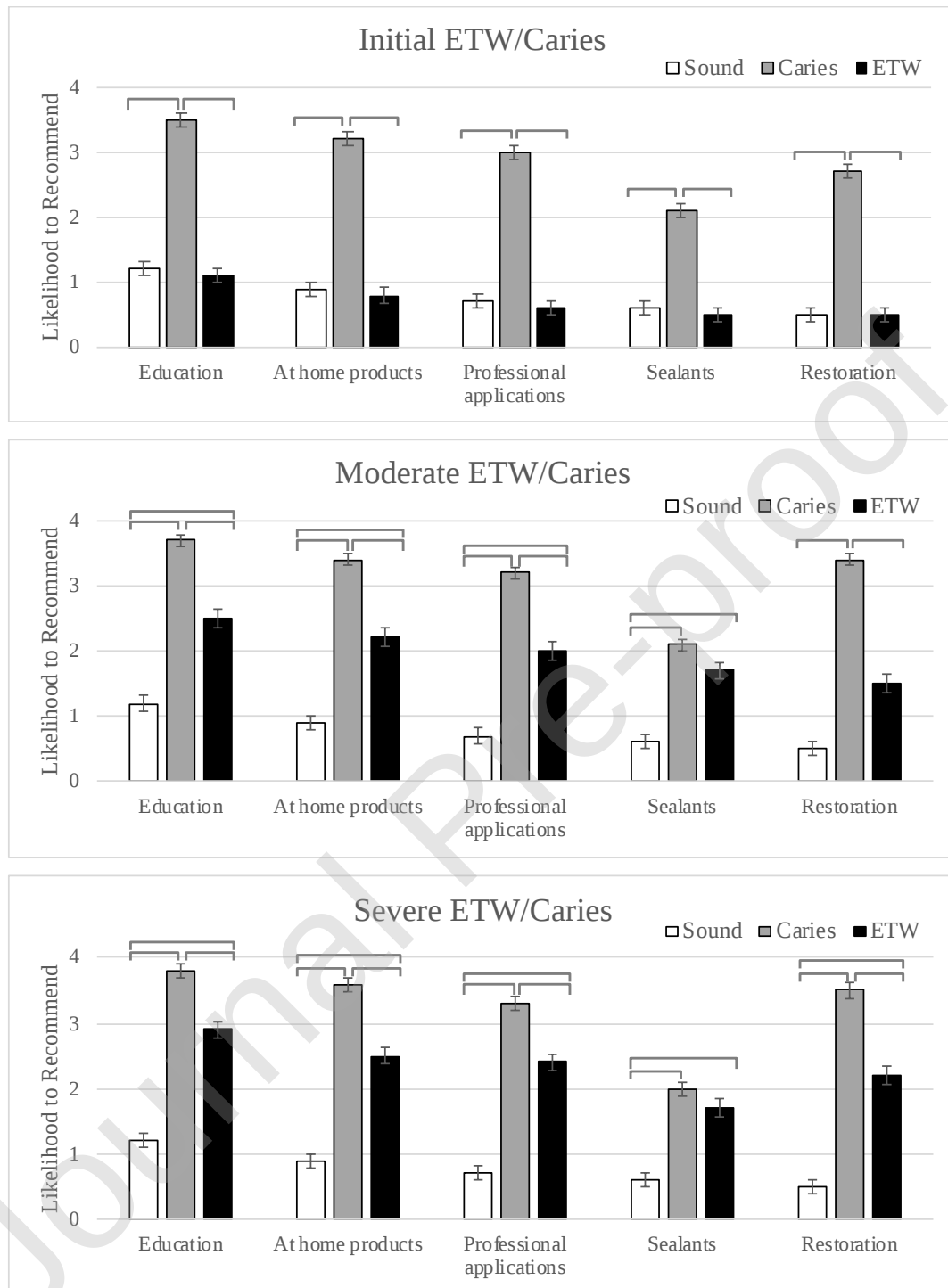


Figure 5. Mean ratings of dentists' likelihood to recommend treatments for erosive tooth wear (ETW), caries, and sound teeth. Bars connected by brackets differ significantly from each other ($p < 0.05$).