Short Communication

Comparison of Visual-Tactile, Radiographic, and Histologic Diagnoses of Subgingival Crown Margin Caries—An In Vitro Study

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The purpose of this study was to investigate the accuracy of diagnosing interproximal subgingival caries at crown margins. A total of 32 subgingival interproximal crown margin areas were examined by 10 clinicians (n = 320) using conventional diagnostic methods on extracted, crowned teeth mounted in a specially designed cast. Crown margins were located 1.5 mm below the level of the artificial gingiva. Clinical and radiographic diagnoses were compared to the histopathologic findings for each site. Both visual-tactile and radiographic evaluations revealed a weak diagnostic accuracy for interproximal subgingival crown margin caries. *Int J Prosthodont 2009;22:561–565.*

Secondary caries at crown margins has been identified as the most frequent biologic complication for teeth with fixed dental prostheses (FDPs).[1–4] In a systematic review, Pjetursson et al[5] found 5-year rates of secondary caries of 1.8% for all-ceramic and 3.2% for metal-ceramic single crowns. Sharma[6] calculated a 10-year risk for caries of 9.5% for FDPs in a meta-analysis. An accurate diagnosis can be difficult, especially for subgingival and interproximal crown margin locations.[2,7]

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Material and Methods

An in vitro cast was fabricated containing 8 extracted premolars and 8 molars, each restored with a full coverage crown, as well as 12 nonrestored teeth (Figs 1a and 1b). Silicone putty (Xantropren, Heraeus Kulzer) mixed with sawdust was used to imitate the appearance of bone in the radiographs. Gingival contours were created leaving crown margins of approximately 1.5 mm subgingivally. Periapical radiographs (3 × 4 mm; Agfa Dentus, Heraeus Kulzer) were obtained with a conventional unit (Heliodent, Siemens) using a parallel technique (Fig 2).

Ten dentists examined the mesial and distal surfaces of 16 crowned teeth in a phantom head (KaVo) (Fig 3) using the customary visual-tactile method (explorer and dental mirror, Hu-Friedy) and periapical radiographs in a random order (n = 320 surfaces). No loupes were used. The presence or absence of caries was noted. Teeth were embedded in methyl methacrylate (Technovit 9100, Heraeus Kulzer) under vacuum pressure and sectioned longitudinally. A histologic evaluation was conducted subsequently under a polarization microscope (DMRM, Leitz). Three teeth were not sectioned; two teeth were caries-free, as evaluated visually by two examiners, and one tooth had deeply progressed caries (caries profunda).

Table 1 Number and Percentage Distribution of Visual-Tactile, Radiographic, and Histologic Caries Diagnoses on Mesial Tooth Surfaces

	Radiograph (n = 160)	Tactile (n = 160)	Type I (n = 160)	Type II (n = 160)	Type III (n = 130)
Total no. of lesions (%)	59 (37)	55 (34)	40 (25)	20 (13)	110 (85)
Experiment order					
Radiograph–tactile (n = 80)	31	31	–	–	–
Tactile–radiograph (n = 80)	28	24	–	–	–
Tooth* (10 evaluations each)					
17	9	4	Lesion	–	Lesion
16	0	1	–	–	–
15	1	4	Lesion	–	Lesion
14	2	2	–	–	Lesion
27	5	5	–	–	Lesion
26	1	1	–	–	–
25	2	5	–	–	Lesion
24	4	5	–	–	Lesion
37	6	1	–	–	Lesion
36	10	7	Lesion	Lesion	NA
35	1	0	–	–	NA
34	0	1	–	–	Lesion
47	3	6	–	–	Lesion
46	4	2	–	–	Lesion
45	3	2	–	–	NA
44	8	9	Lesion	Lesion	Lesion

NA = not available.
*FDI tooth-numbering system.

Table 2 Number and Percentage Distribution of Visual-Tactile, Radiographic, and Histologic Caries Diagnoses on Distal Tooth Surfaces

	Radiograph (n = 160)	Tactile (n = 160)	Type I (n = 160)	Type II (n = 160)	Type III (n = 130)
Total no. of lesions (%)	43 (27)	53 (33)	70 (44)	10 (6)	120 (92)
Order of evaluation					
Radiograph-tactile (n = 80)	22	31	–	–	–
Tactile-radiograph (n = 80)	21	22	–	–	–
Tooth* (10 evaluations each)					
17	10	2	–	–	Lesion
16	0	1	Lesion	–	–
15	1	4	Lesion	–	Lesion
14	1	4	–	–	Lesion
27	2	2	–	–	Lesion
26	0	1	Lesion	–	Lesion
25	0	3	–	–	Lesion
24	3	4	Lesion	–	Lesion
37	6	5	Lesion	–	Lesion
36	5	5	Lesion	Lesion	NA
35	5	1	–	–	NA
34	2	3	Lesion	–	Lesion
47	4	6	–	–	Lesion
46	0	6	–	–	Lesion
45	2	3	–	–	NA
44	2	3	–	–	Lesion

NA = not available.
*FDI tooth-numbering system.

Lesions were classified as being either with or without cavitation based on their vertical and horizontal extension (Figs 4 and 5). The horizontal marginal gap of the crown was measured in μm (Fig 5).

Statistical Analysis

Histologic findings were grouped into three types: caries lesion without cavitation (Type I), caries lesion with cavitation (Type II), and presence of a crown margin gap ≥ 100 μm with or without caries (Type III).

Table 3 Performance Criteria for Type I to Type III Lesions

	Radiograph		Tactile	
	Distal	Mesial	Distal	Mesial
Type I				
Sensitivity (%)	24	79	33	60
Specificity (%)	71	74	67	74
PPV (%)	40	47	43	44
NPV (%)	55	88	56	85
Type II				
Sensitivity (%)	50	90	50	80
Specificity (%)	75	71	68	72
PPV (%)	12	31	9	29
NPV (%)	96	98	95	96
Type III				
Sensitivity (%)	26	40	36	40
Specificity (%)	100	95	90	90
PPV (%)	100	98	98	96
NPV (%)	10	22	10	21

PPV = positive predictive value; NPV = negative predictive value.

Table 4 Kappa and ROC Analysis

	Radiograph		Tactile	
	Distal	Mesial	Distal	Mesial
Type I				
Kappa	−0.0481	0.3813	−0.0049	0.3037
ROC	0.4712	0.6779	0.4974	0.6420
Type II				
Kappa	0.0971	0.3307	0.0599	0.2980
ROC	0.5368	0.6426	0.5238	0.6264
Type III				
Kappa	0.0509	0.1502	0.0576	0.1299
ROC	0.5505	0.6007	0.5410	0.5854

ROC = receiving operating characteristics.

Table 5 Logistic Regression Analysis

Logistic regression	OR	*P*	95% CI	
Site (mesial/distal)	1.60	.000	1.37	1.96
Type II (presence of cavitation)	0.63	.003	0.47	0.86
Type III (marginal gap)	2.50	.000	1.59	3.92
Radiologic evaluation	0.93	.127	0.84	1.02
Clinical experience > 3 y	1.03	.627	0.91	1.17
Order of evaluation	10.2	.677	0.90	1.18

OR = odds ratio; CI = confidence interval.

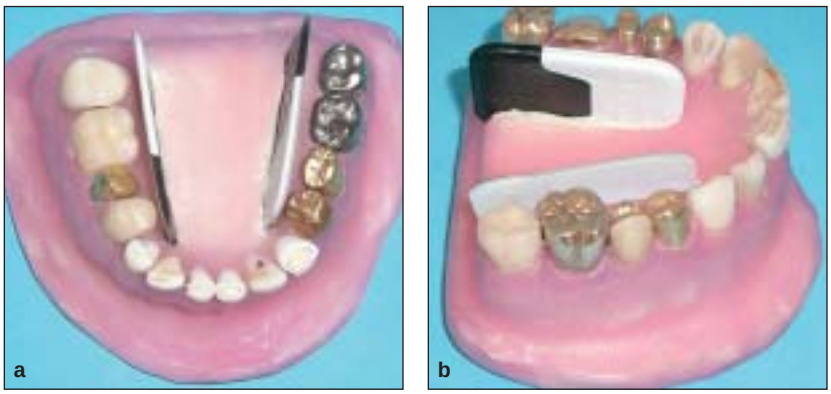

Fig 1 Mandibular **(a)** and maxillary **(b)** in vitro wax-ups before embedding the ginigva mask.

Fig 2 Periapical radiograph of the mandibular left second premolar, first molar, and second molar. Note the cavitated lesion on the mesial side of the first molar.

The statistical validation included sensitivity, specificity, positive (PPV) and negative predictive values (NPV), receiver operating characteristics (ROC), Cohen kappa, and logistic regression.

Results

The total number of examined sites was 320; 102 were diagnosed with the presence of a caries lesion based on the radiographic evaluation and 108 based on the clinical examination. Tables 1 and 2 summarize the visual-tactile, radiographic, and histologic findings in three types of lesions as previously defined. A correlation was found between the presence of a horizontal crown margin gap and the examiner's diagnosis (specificity: 90% to 100%, PPV: 96% to 100%). NPV data demonstrated greater diagnostic accuracy for caries lesions with cavitation (95% to 98%) (Table 3).

The agreement between diagnostic methods tested with the Cohen kappa coefficient was fair for mesial (0.29 to 0.38) and low for distal surfaces (−0.04 to 0.09) (Table 4). Overall, lesions on distal tooth surfaces were more often inaccurately diagnosed (sensitivity: 24% to 50%, ROC: 0.47 to 0.55, logistic regression: $P < .05$) (Tables 3 to 5).

Fig 3 Cast for simulation of clinical condition.

Fig 4 Polarized light micrograph of a secondary caries lesion on the mesial side of the mandibular right first premolar with cavitation into the enamel and dentin and cementum at the crown margin. The presence of demineralized and translucent hypermineralized dentin as well as dead tracts are noted.

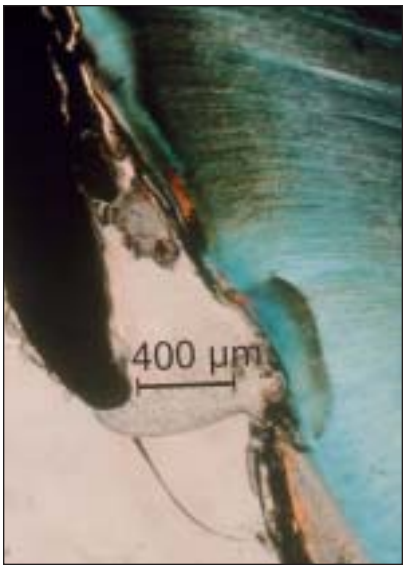

Fig 5 Polarized light micrograph of an arrested secondary caries lesion on the distal side of the maxillary left first molar without cavitation at the crown margin. A horizontal crown margin > 400 µm is distinguishable.

Logistic regression was used to describe factors promoting a false diagnosis. Site location (distal > mesial), absence of cavitation, and presence of a crown margin gap significantly affected the odds ratio for a false positive or negative diagnosis ($P < .05$), while diagnostic method, clinical experience, and order of diagnostic evaluation did not (Table 5).

Discussion

This study confirms the deficiency of conventional diagnostic methods for interproximal subgingival crown margin caries.

Interproximal areas of crowned teeth have a higher risk of developing secondary caries since adequate oral hygiene procedures are more challenging in this area. Consequently, higher plaque scores tend to be found, which negatively influence the demineralization and remineralization process.[2]

Severe pathologic changes of the endodontium due to primary caries and trauma from previous dental treatment (eg, thermal injury, transsection of the odontoblastic process, vibration, desiccation of dentin, smear layer, remaining dentin thickness, materials, and temporization) underline the importance of an adequate evaluation for secondary caries at the crown margin.[8]

In addition, the contour and proximal contacts of a crown, as well as the quality and location of the crown margin, play an important role for the efficacy of oral hygiene measures and thus, in preventing secondary caries in the approximal area.

Mach effects can cause false positive diagnoses on radiographs while marginal overhangs may hide caries lesions, resulting in false negatives. The results confirm the findings of Zoellner et al,[2,7] that clinical examination is more reliable than radiographic for the diagnosis of interproximal caries on crowned teeth, and that radiographs alone are not sufficient.

The results of this study indicate the weakness of conventional diagnostic accuracy for subgingivally located interproximal crown margin caries.

The distal surfaces especially were less confidently diagnosed compared to the mesial surfaces. The influence of the location (mesial or distal) on diagnostic accuracy was statistically significant. This can be explained by the fact that distal surfaces are clinically more difficult to assess. The research design succeeded in simulating the challenge of an intraoral examination with a limited mouth opening. Furthermore, face masks and gloves were worn by the examiners.

However, it is admitted that a limitation of this investigation lies in its in vitro design, in which saliva, tongue and cheek, and patient behavior were nonfactors. Thus, it would appear that the outcome in the true clinical situation would have to be even more concerning. The in vitro design was chosen to simulate the currently used caries diagnostic procedures, to enable the histologic evaluation of the respective lesions, and thus, to determine the true presence and extent of secondary caries lesions.

Conclusions

From this in vitro study it may be concluded that:

- Caries on mesial surfaces can be more accurately diagnosed than on distal.
- The presence of a cavitation improves the diagnostic accuracy for caries.
- The clinician's diagnostic ability is negatively influenced by the presence of a horizontal crown margin gap.
- There is no significant difference in diagnostic accuracy between tactile and radiographic examination, the order in which the examination occurs, and the clinician's experience.
- False positive and false negative diagnoses may result from the commonly used diagnostic techniques for dental caries located at crown margins.

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Literature Abstract

Effect of implant support on distal-extension removable partial dentures: In vivo assessment

This study evaluated the effectiveness of implant-supported removable partial dentures (ISRPDs) compared to conventional ones (CRPDs) by means of measuring masticatory movement, occlusal force, and area contact points. Comfort, chewing, retention, and stability were also evaluated. Five partially edentulous patients with Kennedy Class I or II were involved. One implant was placed in each posterior edentulous mandibular region. Autopolymerizing acrylic resin was fit to the healing abutments of the ISRPD group. By changing the healing abutment to a healing cap, the connection between the implant and the RPD was eliminated in the CRPD group. There were no significant differences in masticatory movements. Nonetheless, ISRPDs had greater force and greater area than CRPDs. All patients preferred the ISRPD in terms of comfort, chewing, retention, and stability. According to this study, a simple attachment technique will improve the stability and the satisfaction with distal-extension RPDs. Patients may experience a greater satisfaction with a resilient attachment system, which yields more stability (ie, locator or ball attachments).

Ohkubo C, Kobayashi M, Suzuki Y, Hosoi T. *Int J Oral Maxillofac Implants* 2008;23:1095–1101. **References:** 29. **Reprints:** Dr Chikahiro Ohkudo, Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine, 2-1-3 Tsurumi Tsurumi-ku, Yokohama 230-8501, Japan. Fax: +81455739599. Email: okubo-c@tsurumi-u.ac.jp—*Majd Al Mardini, Hamilton, Ontario, Canada*