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Restorative Treatment Decision Making with Unaided Visual Examination, Intraoral Camera and Operating Microscope

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Clinical Relevance

The use of an intraoral camera aided in the treatment of occlusal surfaces of molars.

SUMMARY

This study assessed the restorative treatment options of the occlusal surfaces of teeth examined with unaided visual assistance, an intraoral camera and an operating microscope. Sixty-eight extracted human molars were mounted to perform mouth models with a premolar in contact on both sides. Four observers examined the models in a phantom head, which simulated clinical conditions, using three techniques: unaided visual examination, intraoral camera and operating microscope. The observers were asked to assess the occlusal surface of each tooth and make a treatment decision based on the following scale: 1) the occlusal surface being sound and "not needing a restoration," 2) the occlusal surface having a subsurface or enamel lesion. No operative treatment was needed at this visit, but special attention was given to this surface at recall visits: "preventive care-defer treatment" and 3) the surface had a carious lesion and "needed a restoration." The teeth were then sectioned in the mesio-distal direction and examined under a stereomicroscope with 10x magnification to determine the true extent of caries. Statistical analysis was conducted by calculating percentages and kappa values of the restorative treatment scores based on examinations by four observers. According to all the observers' treatment decisions, the kappa values were found to be 0.341 (*p*<0.001), 0.471 (*p*<0.001) and 0.345 (*p*<0.001) for unaided visual examination, intra-

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oral camera and operating microscope, respectively. There was a statistically significant difference between the intraoral camera and the other two methods (*p*<0.05), while there was no significant difference between the unaided visual examination and operating microscope (*p*>0.05).

As a result of a comparison between the unaided visual examination and operating microscope, the use of an intraoral camera improved the restorative treatment decisions of the occlusal surfaces on posterior teeth.

INTRODUCTION

Caries diagnosis is considered to be an important factor in the treatment decisions of occlusal surfaces. Incorrect diagnosis can result in an incorrect treatment decision. Surfaces having an arrested, uncavited lesion may be treated operatively, and surfaces having extensive caries may be left unrestored (Verdonschot & others, 1999; Pitts & Longbottom, 1995). In addition, diagnosis of subsurface and enamel lesions is very important, as the lesions could be arrested or even remineralized with preventive measures.

The combination of visual inspection with light, probe and a dental mirror has been accepted as a standard examination procedure in occlusal caries diagnosis (Lussi, 1991); however, researchers have shown that forceful probing may result in damage to fissures, and microorganisms may progress into the deeper parts of underlying tooth substance (Ekstrand, Qvist & Thylstrup, 1987). Therefore, alternative diagnostic methods have been developed.

One promising new method is the use of magnifying visual aids. Magnification is applicable to all tooth surfaces, and several authors have reported its use for caries diagnosis and restorative treatment decision-making (Simonsen, 1985; Whitehead & Wilson, 1992; Forgie & others, 1999). Magnification loops (Forgie, Pine & Pitts, 2002), intraoral camera (Forgie, Pine & Pitts, 2003) and operating microscope (Haak & others, 2002) are methods that provide magnification. While their use in caries detection is discussed, there still is the need for research on how they affect the treatment decisions of occlusal surfaces.

This study assessed dentists' treatment decisions of occlusal surfaces of molars when using unaided visual examination, intraoral camera and operating microscope.

METHODS AND MATERIALS

Out of a stock of extracted human teeth kept in a 10% buffered formalin solution, teeth with no signs of demineralization and those with demineralization on the central fossa were selected after an examination with a stereomicroscope. The teeth were cleaned with a toothbrush and rinsed under running water. Mouth models were manufactured with 68 molars and one premolar on each side to simulate anatomical contacts. The models were fixed in a phantom head that was adjusted to a dental unit during examination periods.

The occlusal surfaces of each tooth were examined by four dentists, including one associate professor, one assistant professor and one research assistant in the Operative Dentistry and Endodontics Department, each having 13, 10 and 4 years of experience, respectively, and a research assistant in the Oral Diagnosis, Oral Medicine and Radiology Department, who had four years of experience. All the observers had been calibrated for occlusal caries detection in epidemiological studies, and they participated in a previous study where the efficiency of the three techniques at occlusal caries detection was assessed. None of the observers used the operating microscope and intraoral camera routinely for treatment planning during dental examinations. The routine method used by all the observers was unaided visual examination.

The observers were told that all the teeth were asymptomatic and in acceptable occlusion from healthy, non-medicated, young individuals with a reasonably good oral hygiene status and a DMFT score of six (Maupome, 2000).

The first examination was unaided visual examination, with the assistance of a dental unit light, compressed air and water from the unit air-water syringe and a standard dental mirror without magnification. Twenty seconds was the maximum allowed for the examination of one tooth. The observers were asked to assess the central fossa of each tooth according to the scale shown in Table 1.

Two weeks after the unaided visual examination, the four observers assessed the teeth with an intraoral camera with normal magnification, macro setting with a resolution of 752 x 582 at true color range using a halogen light (Rydalmere NSW 2116, Australia). The images were displayed on a 14-inch computer monitor. The camera was placed over the examined teeth with a 90-degree angle between the occlusal surface of the teeth and the camera. A maximum of 20 seconds was allowed to examine one tooth, and the observers were asked to assess the occlusal surfaces according to the

Table 1: *Criteria for Observers Scoring the Occlusal Surfaces of the Teeth*

1-The occlusal surface was sound and "did not need a restoration"
2-The occlusal surface had a subsurface or enamel lesion. No operative treatment is needed at this visit but special attention should be paid to this surface at recall visits "preventive care, defer treatment"
3-The surface had a carious lesion which "needed a restoration"

same criteria used during the first examination. Pictures captured with the intraoral camera were stored in the computer for re-examination.

Approximately one week later, the four observers independently examined the same teeth using an operating microscope at 16x magnification (Moller-Wedel, Dento 300, Germany) according to the criteria used in both the first and second examinations. This time, 20 seconds was the maximum allowed for examination of one tooth. Pictures captured on the computer monitor were recorded using a video recorder.

Approximately three weeks later, all observers repeated their examinations, starting with unaided visual examination. Two weeks later, the teeth were examined with the intraoral camera, and one week later, they were examined with the operating microscope, as in the first round. The occlusal surfaces of the teeth were kept wet during each individual examination.

The mouth models were randomized throughout each examination, so that observers did not see the teeth in the same order each time.

Upon completion of the second examination, the teeth were removed from the mouth models and hemisectioned in mesio-distal direction through the selected investigation side using a diamond saw (Hp:915S/220, Risa Dental, Germany) to allow for histologic validation of each surface. Two observers viewed the sections under a stereomicroscope (SZ PT Olympus, Japan) using 10x magnification according to the following scale:

0—No signs of demineralization

1—Demineralization in enamel

2—Demineralization in dentin

The observers had experience in determining sound surfaces and caries depth under a stereomicroscope. The depth of enamel demineralization was assessed as the area showing the greatest extension of demineralization along the direction of the rods. The depth of dentin demineralization was assessed where the color changed from brownish/yellow to gray along a line at right angles to the dentoenamel junction towards the pulp (Kidd & others, 2003). Any discrepancies in the histologic scores were corrected by consensus after reviewing the sections.

Statistical analyses were made by calculating the percentages and kappa values of observers' decisions made with unaided visual examination, intraoral camera and operating microscope, as the judgment allowed for the use of kappa analysis. Comparisons of the kappa values were based on the asymptotic normal distribution of correlated kappa values using the SPSS Syntax program that was specifically written based on two recently published articles (Donner & others, 2000; Barnhart & Williamson, 2002).

Table 2: *Kappa Values According to All Observes Correct Treatment Decisions with Unaided Visual Examination (UVE), Intraoral Camera (IOC) and Operating Microscope (OM)*

Methods	Kappa Value
Unaided Visual Examination	0.341
Intraoral Camera	0.471
Operating Microscope	0.345

Note: For all values $p<0.001$

Table 3: *Pairwise Comparisons Between Correlated Kappa Values According to All Observers' Correct Treatment Decisions with Unaided Visual Examination (UVE), Intraoral Camera (IC) and Operating Microscope (OM)*

	Intraoral Camera	Operating Microscope
Unaided Visual Examination	z=-3.170, *p*=0.001*	z=-0.076, *p*=0.470
Intraoral Camera	-	z=2.906, *p*=0.002*

* *Statistically significant at* $p<0.05$

Table 4: *Kappa Values of Each Observer for Unaided Visual Examination, Intraoral Camera and Operating Microscope*

	Unaided Visual Examination	Intraoral Camera	Operating Microscope
1st observer	0.322	0.491	0.250
2nd observer	0.390	0.400	0.257
3rd observer	0.372	0.457	0.456
4th observer	0.281	0.535	0.421

Note: For all values $p<0.001$

RESULTS

Based on the histological evaluation of the tooth sections, 21 teeth were caries free, 28 had lesions confirmed to enamel and 19 had lesions confirmed to dentin. The percentage of correct treatment decisions for all participants was calculated as 0.55, 0.65 and 0.55 for unaided visual examination, intraoral camera and operating microscope, respectively. The percentage of teeth correctly diagnosed has the disadvantage of an inherent possibility that a correct decision could have been achieved only by chance. The kappa statistic is used to calculate the proportion of correctly classified teeth beyond chance (Fleiss, 1981). Therefore, the kappa statistic was also used for statistical analysis. The kappa values for unaided visual examination, intraoral camera and operating microscope were found to be 0.341 ($p<0.001$), 0.471 ($p<0.001$) and 0.345 ($p<0.001$), respectively (Table 2), and there was a statistically significant difference between intraoral camera and the other two methods ($p<0.05$), while there was no significant difference between both unaided visual examination and operating microscope ($p>0.05$) (Table 3).

Landis and Koch (1977) reported that the strength of agreement could be evaluated as the kappa value being <0.00 as poor, between 0.00-0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial and 0.81-1.00 as almost perfect; therefore, being fair, moderate and fair for unaided visual examination, intraoral camera and operating microscope, respectively.

The kappa values obtained from the observers' restorative treatment decisions ranged between 0.281-0.390 for unaided visual examination, 0.400-0.535 for intraoral camera and 0.250-0.456 for operating microscope ($p<0.001$). From these results, it could be seen that, with the operating microscope, the first two examiners' kappa values decreased compared to the unaided visual examination, while the third and fourth observers' kappa values increased. The lowest kappa value for unaided visual examination was calculated for the fourth observer. In contrast to this finding, the highest value for intraoral camera was obtained by this observer also. It was found that all of the observers made the most accurate decisions with the intraoral camera. Details are shown in Table 4.

DISCUSSION

From these results, it can be seen that correct treatment decisions were low with all techniques, but by using an intraoral camera, compared to unaided visual examination and operating microscope, the proportion of correct treatment diagnosis could be improved. Magnification achieved with the operating microscope in this study was higher than magnification achieved with the intraoral camera. Therefore, the authors of this study think that lower correct restorative treatment decisions could be related to an increased magnification level.

The percentage of correct diagnosis achieved with unaided visual examination and operating microscope were the same, but the percentage of teeth correctly diagnosed had the disadvantage of an inherent possibility that a correct decision could have been achieved only by chance. Therefore, kappa statistics were used to calculate the proportion of correctly classified teeth beyond chance. According to kappa values, by using an operating microscope, there was a slight increase in the proportion of correct diagnosis compared to unaided visual examination, but the difference was not significant.

A previous study (Forgie & others, 2003) reported that use of an intraoral camera in general dental practice is increasing rapidly, and it has been shown to improve occlusal caries detection. As mentioned above, true restorative treatment decisions are related to true diagnosis of the presence or absence of caries. The authors of this study think that more accurate treatment decisions come from the intraoral camera, which helped observers assess the absence, presence and extension of caries more accurately compared to the other methods used. When treatment decisions are looked at, all observers made the highest true decisions with the aid of the intraoral camera, with the difference being significant.

Whitehead and Wilson (1992) found an almost threefold increase in restorative treatment decisions when making diagnosis with a loupe that provided 3x magnification. In their study, extracted posterior teeth with amalgam restorations and unrestored teeth with staining on the occlusal surfaces were evaluated. No attempt was made for histologic evaluation of the true extension of caries, and 3x magnification was used; therefore, one may assume the difference could be related to these factors. On the other hand, Lavonius and others (1997) reported no significant changes in restorative treatment decisions based on visual inspection with magnification when compared to visual inspection only. In their study, magnification was provided with lenses having 1.25x magnification.

From these results, it could be seen that, with the operating microscope used by the first two examiners, kappa values decreased compared to unaided visual examination, while kappa values observed by the third and fourth observers increased. The first and second observers had 13 and 10 years of experience, respectively, while the third and fourth observers each had four years of experience. The lowest kappa value for unaided visual examination was calculated by the observer from the Oral Diagnosis Oral Medicine and Radiology Department. In contrast to this finding, the highest kappa value for the intraoral camera was obtained by this observer as well. Forgie and others (1999) reported that the routine use of magnifying systems is associated with the period after graduation of a dentist, and the benefit depends on experience with these systems. Therefore, a similar investigation could be undertaken, with observers routinely using magnification to provide aid for treatment planning.

In this study, if the surface was sound, it was considered to not need any treatment or prophylactic measure. If a subsurface or an enamel lesion existed, the tooth was considered as not needing a restoration (no operative treatment); however, prophylactic measures such as good oral hygiene status, maintaining controlled dietary habits, fissure sealant and more, should be taken, and the patient should be called for a control visit. The tooth was considered as needing a restoration only when caries extended into dentin (Kay & others, 1988). With new restoration techniques, occlusal lesions could be treated with various materials and methods, for example, preventive resin restoration, amalgam and composite. It was assumed that some lesions that penetrated into dentin may also be treated with preventive resin or glass ionomer restorations instead of amalgam or composite restorations; therefore, no attempt was made to assess the restorative material type. The authors of this study are planning to assess material types in another study.

CONCLUSIONS

Based on this study, it can be concluded that the intraoral camera significantly increased the chance to make correct treatment diagnoses compared to using unaided visual examination and an operating microscope.

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