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Effects of Dental Probing on Occlusal Surfaces – A Scanning Electron Microscopy Evaluation

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Key Words

Dental caries, diagnosis · Dental probing

Abstract

The aim of this clinical-morphological study was to investigate the effects of dental probing on occlusal surfaces by scanning electron microscopy (SEM). Twenty sound occlusal surfaces of third molars and 20 teeth with initial carious lesions of 17- to 26-year-old patients (n = 18) were involved. Ten molars of each group were probed with a sharp dental probe (No. 23) before extraction; the other molars served as negative controls. After extraction of the teeth, the crowns were separated and prepared for the SEM study. Probing-related surface defects, enlargements and break-offs of occlusal pits and fissures were observed on all occlusal surfaces with initial carious lesions and on 2 sound surfaces, respectively. No traumatic defects whatsoever were visible on unprobed occlusal surfaces. This investigation confirms findings of light-microscopic studies that using a sharp dental probe for occlusal caries detection causes enamel defects. Therefore, dental probing should be considered as an inappropriate procedure and should be replaced by a meticulous visual inspection. Critical views of tactile caries detection methods with a sharp dental probe as a diagnostic tool seem to be inevitable in undergraduate and postgraduate dental education programmes.

The past two decades have shown a decline in caries prevalence in general [Marthaler, 2004] and an increase in the number of initial carious lesions on occlusal surfaces of molars in children and adolescents in Western industrial countries [Bjarnason et al., 1992; Steiner et al., 1994; Kühnisch et al., 2001]. This development has been accompanied by an apparent change of occlusal caries lesions, which has led to a more difficult diagnostic process for these lesions [Weerheijm et al., 1992].

As long as carious lesions progressed rampantly and preventive intervention approaches were limited, the traditional examination with a sharp probe and a dental mirror was an integral part of dentistry. Considering the changes in caries pattern as well as the substantial improvements in the fields of caries detection/diagnosis and caries prevention/treatment that became obvious, the

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dental probe is more and more criticized as an inappropriate diagnostic tool.

Major points of criticism were the risk of producing irreversible traumatic enamel defects in demineralized occlusal fissures, converting subsurface lesions into cavities and favouring lesion progression [Bergmann and Linden, 1969; Ekstrand et al., 1987; Imfeld et al., 1990; Yassin, 1995], the possibility of the bacterial contamination from one fissure to another [Loesche et al., 1979] and the lack of accuracy for detection of occlusal lesions [Lussi, 1991; Penning et al., 1992]. According to accuracy aspects, Parfitt [1954] already reported that 20% of all occlusal surfaces examined with a sharp dental probe had a more progressed carious lesion than expected. The conclusion that 'sticking' of the probe tip should not equate with the presence of an occlusal caries lesion was confirmed by Miller and Hobson [1956].

The diagnostic outcome is influenced by the dimension of the probe tip and the subjective probing pressure. Recently published findings demonstrated that probing forces varied widely between dentists [Wagner et al., 2003]. This could be related to hand position, training, experience, age, fatigue, muscle strength, body weight of the dentist and other factors. However, this problem is not a new one; to avoid subjective differences of probing forces, pressure-calibrated probes were recommended [Bodecker, 1952] but not implemented in clinical practice.

Until now the invasive character of dental probing has been assessed in light-microscopic studies [Bergmann and Linden, 1969; Ekstrand et al., 1987] and microradiographic investigations [Yassin, 1995]. Therefore, this study aimed to enlighten traumatic effects by scanning electron microscopy (SEM) as an evaluation method. Furthermore, the frequency of enamel defects and information about the nature of enamel damage were considered.

Material and Methods

Eighteen 17- to 26-year-old patients with third molars indicated for extraction by orthodontic reasons were included in this study. An informed consent of the patients was obtained. Prior to the probing procedure and to the tooth extraction, a separate examination was conducted to allocate the teeth to study groups. The clinical examination was performed by a dentist (R.H.W.) with considerable experience in the clinical assessment of caries lesions. Before the diagnostic investigation all teeth were cleaned with an air-flow device (Cavitron Prophy-Jet, Dentsply De Trey, Constance, Germany). Visual examination of the occlusal pits and fissures was performed using cotton roll isolation and prolonged air drying for >5 s [Ekstrand et al., 1997, 1998, 2001]. Occlusal surfaces without any caries-related signs before and after air drying were scored as sound; occlusal surfaces with whitish opaque and/or brown discolorations were classified as initial carious lesions. Molars with microcavities or frank lesions were excluded from this study. Following the diagnostic decision, the dental assistant flipped a coin to allocate the specimen to one of the groups. The molars were randomly assigned to the following groups: probing of sound pits and fissures (n = 10), probing of initial carious pits and fissures (n = 10). Ten molars with sound and initial carious occlusal surfaces were not probed and served as negative controls.

During an additional appointment, the teeth were probed and/or extracted. The examiner was asked to scan the complete fissure system with a new sharp dental probe (No. 23; Carl Martin, Solingen, Germany) using gentle force; the number of 'sticky' contacts was limited to less than 10 for each occlusal surface. Following the clinical diagnostic procedure, the molars were carefully extracted to avoid any kind of damage of the crown. Between extraction and preparation for the SEM investigation, the teeth were stored in a 0.02% sodium azide solution to prevent any bacterial growth.

After cutting the crowns from the roots of the molars, the crowns were cleaned with a 2% sodium chloride solution for 60 s to remove organic debris. The specimens were subjected to critical point drying and gold sputtering. The scanning electron microscope SEM 515 (Philips, Eindhoven, the Netherlands) at 20 kV with a maximal 1,000-fold magnification was used for morphological evaluation of the occlusal surfaces. The complete pit and fissure system of each specimen was systematically examined with an approximately 200-fold magnification to ensure that no surface alteration or defect would be missed. Areas of special interest were carefully analysed from different directions, and evident defects were registered. Artefacts, e.g. enamel cracks and/or gaps, which may occur ordinarily during the examination process in the high vacuum chamber of the SEM, were not registered. All occlusal surfaces were examined blindly to the clinical diagnosis and independently by two investigators (J.K., W.D.). Neither examiner had information with regard to which group the molars belonged to. Each occlusal surface was classified with respect to the following criteria: (1) distinct probing marks visible as impressed line of the enamel surface with or without discontinuity and exposure of enamel prisms; (2) enlargement of pits and fissures with compressed enamel on side walls; (3) enamel breakoffs representing distinct splintering of the outer enamel surface. In cases of different findings, both investigators judged the occlusal surfaces together until agreement was obtained.

Results

Probing defects were observed on all molars with initial carious lesions, whereas only 2 surfaces visually scored as 'sound' had probing defects (table 1). Comparable defects were not seen on all occlusal surfaces that had not been probed. Further, we could differentiate morphologically between probing marks with and with-

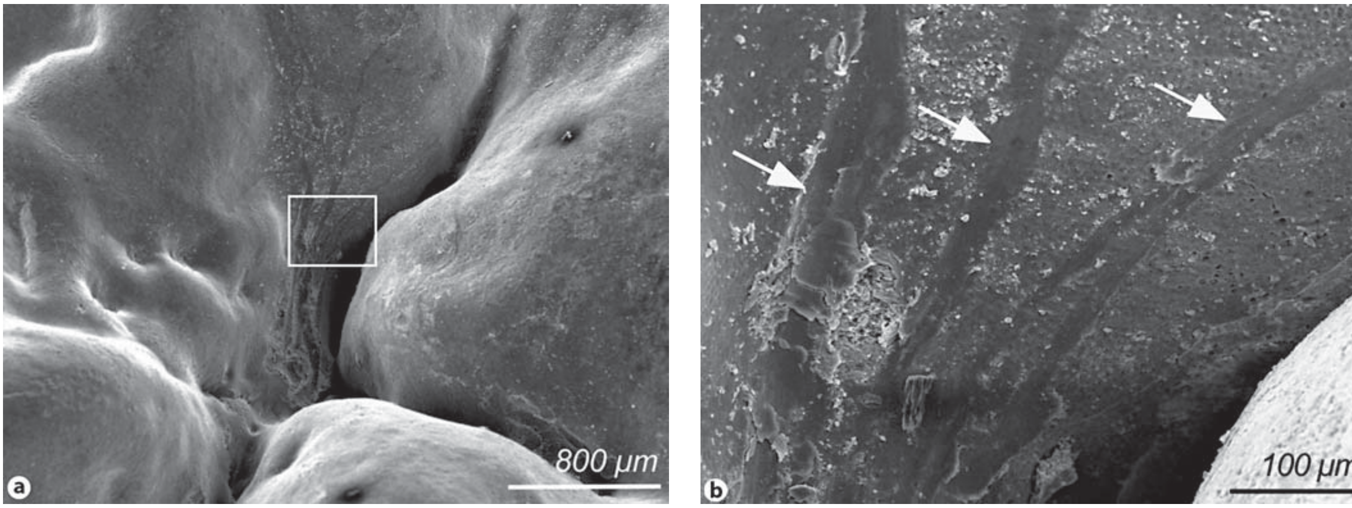


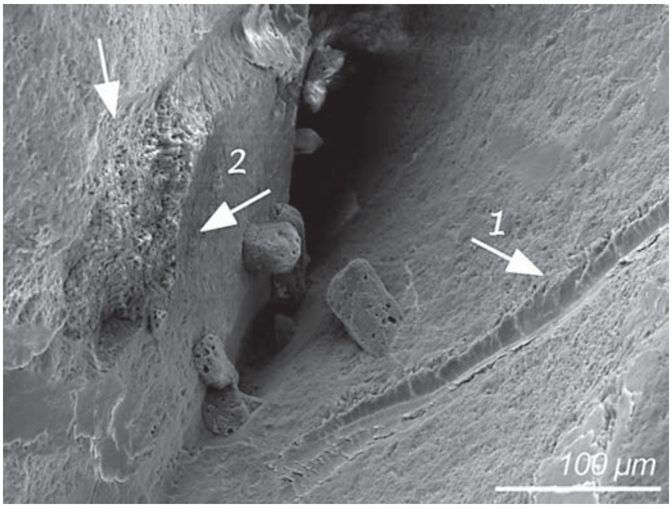
Fig. 1. a Overview of a probed occlusal fissure system with initial carious lesion. **b** Note the distinct probing marks at the fissure wall of the magnified area (arrows).

Table 1. Distribution of defects on probed sound and initial carious occlusal surfaces of third molars

Surface No.	Sound	Initial lesion
1	Probing marks without surface defects (criterion 1)	Probing marks without surface defects and enlargements in an occlusal pit (criteria 1, 2)
2	–	Probing marks with surface defects (criterion 1)
3	–	Probing marks with surface defects, enlargements (criteria 1, 2)
4	Probing marks (criterion 1)	Probing marks without surface defects (criterion 1)
5	–	Enamel break-offs in the fissure floor (criterion 3)
6	–	Probing marks with surface defects, enlargements, enamel splintering (criteria 1, 2, 3)
7	–	Probing marks without surface defects (criterion 1)
8	–	Probing marks with surface defects, enamel break-offs at the fissure floor (criteria 1, 2)
9	–	Probing marks without surface defects (criterion 1)
10	–	Probing marks without surface defects (criterion 1)

No defects were identified on unprobed surfaces, whether sound or carious.

out surface defects (n = 10 specimens), enlargements (n = 4) and enamel break-offs (n = 3). Probing marks were found on cusp slopes (fig. 1) as well as at the bottom of the fissures (fig. 2). Distinct enamel break-offs caused by probing are shown in figures 2–4. A further finding was the enlargement of occlusal pits and fissures congruent with the tip of the dental probe (fig. 5, 6). Probing caused a distinct negative impression in the respective initial carious lesion pit. In addition, compression of enamel was apparent as a result of wedging the probe into the enamel. While the enlargement of occlusal pits and fissures did not usually result in a reduction of the enamel substance,



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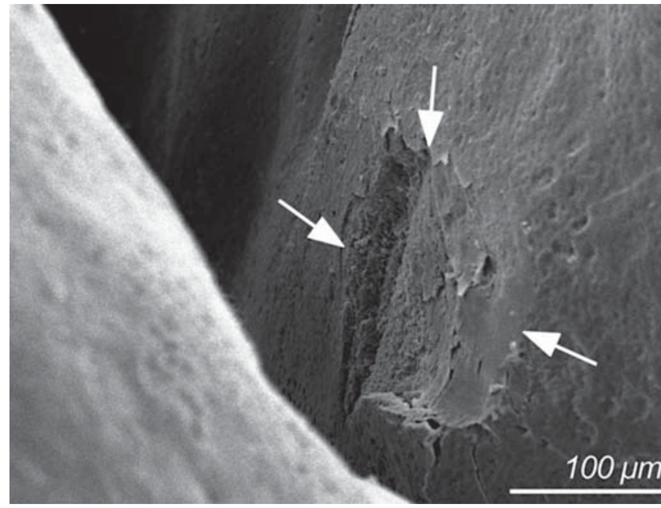

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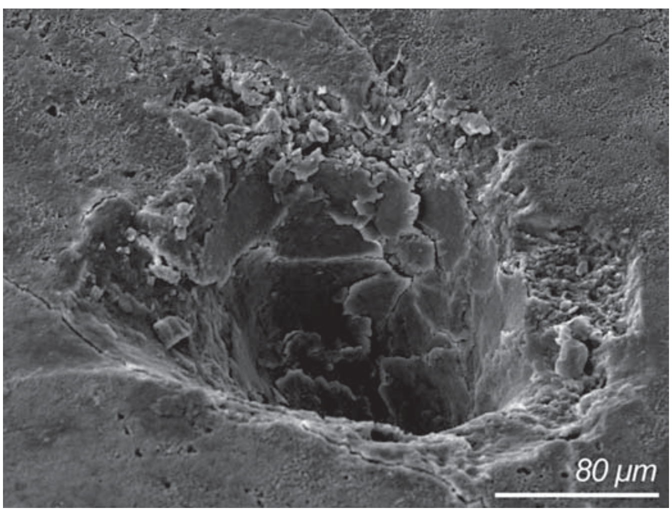

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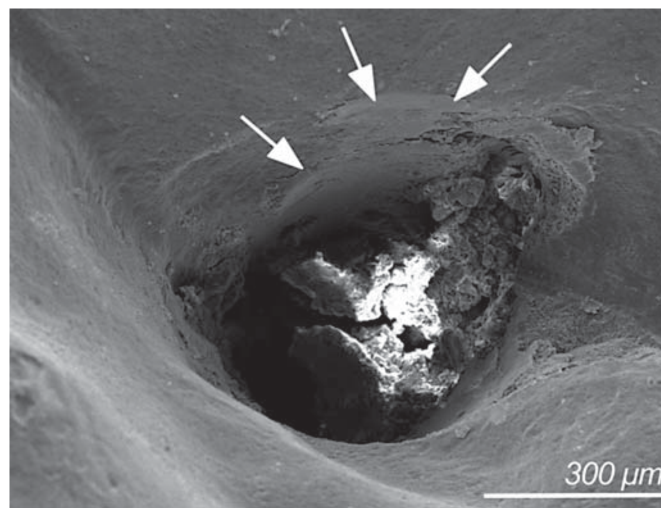

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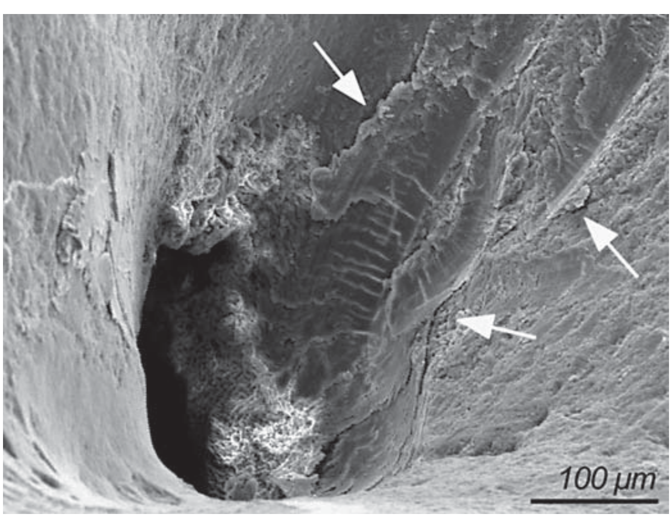

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Fig. 2. Bottom of the fissure system with an initial carious lesion. The probing mark (1) ends in a distinct enamel break-off (2) on the opposite side of the fissure slope (arrows).
Fig. 3. Slope of a deep initial carious fissure with enamel break-offs (arrows).
Fig. 4. Impression with surface defect of the dental probe located in porous, initial carious enamel of a fissure wall.
Fig. 5. Occlusal pit whose sides were compressed congruent with the dental probe (arrows).
Fig. 6. Occlusal pit with probing marks of an initial carious lesion with interruption of the surface continuity (arrows).

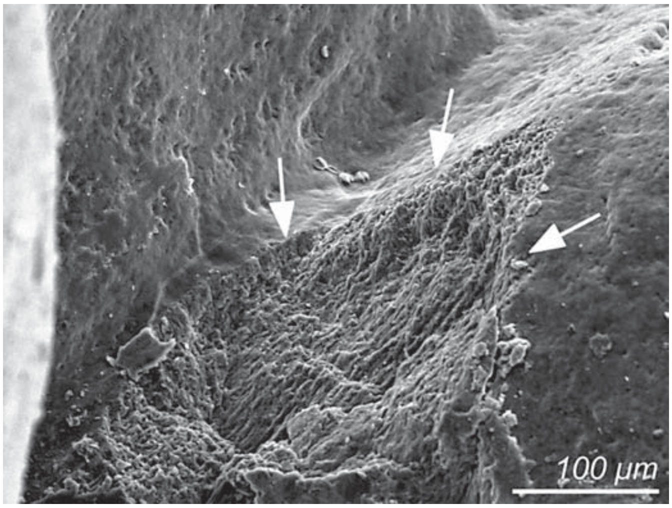

Fig. 7. Initial carious fissure with extensive enamel break-offs (arrows) with exposure of enamel prisms.

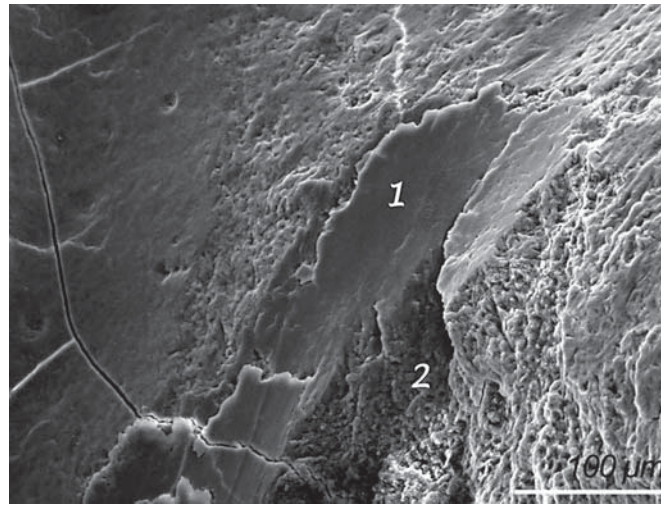

Fig. 8. Probing marks (1) and enamel break-offs (2) in initial carious enamel at the bottom of the fissure.

figures 7 and 8 illustrate widespread break-offs at the bottom of the fissures.

The dimensions of the observed defects were of different magnitudes. Probing marks without surface defects, observed as 'impressed' and 'smeared' lines, were found to be nearly 20–120 µm wide (fig. 1b and 6). In cases of enamel break-offs, defects of up to approximately 500 µm were observed (fig. 2, 3, 7, 8). Probing enlargements in occlusal pits congruent with the tip of the sharp dental probe had diameters of nearly 1 mm wide (fig. 5, 6) and were related to the anatomy of the fissure system.

Discussion

This morphological study aimed to detect and describe possible probing defects on the basis of a combined in vivo and in vitro study design. As in the light-microscopic study of Ekstrand et al. [1987], we did not use a standardized probing pressure which was applied in laboratory studies [Bergmann and Linden, 1969; Yassin, 1995, Wagner et al., 2003]. Therefore, variations in probing pressure cannot be excluded and could influence the degree of surface defects. To simulate probing with a sharp dental probe under clinical conditions, this study failed to set up a valid identification system because of the anatomical difficulties of viewing the complete occlusal surface and the problems of making excellent photographs of wisdom teeth. But such an identification system would allow more detailed and quantitative information, e.g. in how many cases probing contacts of defined areas of the fissure system would cause special enamel defects. For answering these quantitative aspects, an in vitro design seems to be inevitable.

The morphological findings of this SEM study complement previous light-microscopic and microradiographic investigations [Ekstrand et al., 1987; Yassin, 1995]. Considering the extent of traumatic probing defects, our findings are comparable with former reports about damage ranging from 100 µm to 2.0 mm in diameter on initial carious lesions of approximal surfaces [Bergmann and Linden, 1969]. In principle, the SEM results of all probed surfaces with initial lesions confirm the observation that probing can convert an initial carious lesion into a cavity which may promote further lesion development. In cases of probing marks without enamel defects (approx. 20–120 µm), SEM is probably a more sensitive method to visualize such small defects than light microscopy and microradiography.

According to the high prevalence of initial carious lesions in relation to frank occlusal lesions on permanent molars in children and adolescents [Kühnisch et al., 2001], the routinely tactile examination of occlusal surfaces with sharp probes may lead to an unnecessary accumulation of possible traumatic injuries favouring the caries progression at the most caries-susceptible surface [Hannigan et al., 2000]. As the accuracy of subjective probing seems to be questionable [Lussi, 1991, 1993, 1996], the present findings support the demand that the visual inspection of a clean and dry occlusal surface should be the method of first choice in daily dental practice [Ekstrand et al., 1997, 1998; Heinrich-Weltzien et al., 2002]. Thus, the recommendation to replace the probe in the hand of the dentist by something, without which he felt naked [James, 1989], e.g. a multifunctional syringe, blunt probe [Kidd et al., 1993] or ball end CPI probe [WHO, 1997], is still up to date as the tactile examination is the basic method for dental practitioners and reflects the widespread European researcher's opinion that probing is an 'unethical' diagnostic procedure [Pitts, 2001]. Furthermore, non-invasive caries detection with the CPI probe allows the dentist to continue periodontal examination without changing the instrument. In addition to the meticulous visual inspection, bitewing radiographs and laser fluorescence measurements are methods of second or third choice in doubtful cases. As a consequence of this study, dental probing should be critically reviewed in basic and continuing educational programmes.

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