*Original Article*

# Preventive Effect of Ozone on the Development of White Spot Lesions during Multibracket Appliance Therapy

**Otmar Kronenberg[a]; Adrian Lussi[b]; Sabine Ruf[c]**

**ABSTRACT**

**Objective:** To test the null hypotheses: (1) there is no difference in the caries protective effect of ozone and Cervitec/Fluor Protector during multibracket (MB) appliance therapy, and (2) DIAGNOdent and quantitative light-induced fluorescence (QLF) are not superior to a visual evaluation of initial caries lesions.

**Materials and Methods:** Twenty right-handed patients with a very poor oral hygiene who required full MB appliance therapy were analyzed during 26 months. In a split-mouth-design, the four quadrants of each patient were either treated with ozone, a combination of Cervitec and Fluor Protector, or served as untreated controls. The visible plaque index (VPI) and white spot formation were analyzed clinically. DIAGNOdent and QLF were used for a quantitative assessment of white spot formation.

**Results:** The average VPI in all four dental arch quadrants amounted to 55.6% and was independent of the preventive measure undertaken. In the quadrants treated with Cervitec/Fluor Protector, only 0.7% of the areas developed new, clinically visible white spots. This was significantly ($P < .05$) less than in the quadrants treated with ozone (3.2%). The lesions detected with QLF only partially corresponded to the clinically detected white spots, while DIAGNOdent proved to be unable to detect any changes at all.

**Conclusions:** The caries protective effect of Cervitec/Fluor Protector during MB therapy was superior to ozone, and a visual evaluation of initial caries lesions was superior to both DIAGNOdent and QLF. (*Angle Orthod.* 2009;79:64–69.)

**KEY WORDS:** Orthodontics; Demineralization; White spots; Ozone; DIAGNOdent; QLF

## INTRODUCTION

During multibracket (MB) appliance therapy, the prevalence and severity of enamel demineralization increases.[1–3] Preventive procedures are mechanical removal of bacterial plaque or the use of chemical auxiliaries. Mechanical removal procedures are unable to prevent completely white spot formation during MB treatment.[4–8]

It is generally accepted that fluoride ions promote remineralization of tooth substance and reduce the rate of demineralization. However, fluoride treatment has been shown to have a reduced effect under bacterially produced lower pH conditions[9] as they occur in MB patients compared with untreated individuals.[10] Nevertheless, there is evidence that the daily use of a 0.05% fluoride rinse reduces the incidence of caries during MB therapy.[11]

Chlorhexidine inhibits acid production in plaque and thus reduces the pH decline during sucrose challenges.[12] In vitro studies using a chlorhexidine/thymol varnish (Cervitec) have shown mutans streptococci suppression[13–15] and an enhanced prophylactic effect compared with nonprotected teeth.[16–18] When combining Cervitec with a fluoride varnish (Fluor Protector), the cariostatic effect was enhanced even further.[19,20]

Ozone, one of nature's most powerful oxidants, has been shown to kill mutans streptococci efficiently.[21]

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The inhibitory effect of ozone in the caries process is discussed and controversial. Baysan and Lynch[22] found a significant reduction in total microorganisms in ozone-treated caries lesions in vivo after ozone gas application. Ozone arrested the progression of dentinal caries after the removal of the gross part of decayed enamel and dentin.[23] A recent study associated with noncavitated occlusal caries found a nonsignificant reduction of the number of viable bacteria.[24] To our knowledge, ozone has never been tested in orthodontics.

Traditionally, a visual clinical evaluation of white spot lesions is performed, but it would be desirable to have objective measurement tools. DIAGNOdent, a laser-based device, has been successfully tested for the detection of occlusal caries,[25] and quantitative light-induced fluorescence (QLF) has been shown to detect the reduced fluorescence associated with demineralized enamel.[26–28]

Thus, the aims were to assess whether it is possible to avoid demineralization around brackets using ozone, and to evaluate if DIAGNOdent or QLF are useful in detecting initial caries lesions during MB treatment. The null hypotheses were: (1) there is no difference in the caries protective effect of ozone and Cervitec/Fluor Protector during MB therapy, and (2) DIAGNOdent and QLF are not superior to a visual evaluation of initial caries lesions.

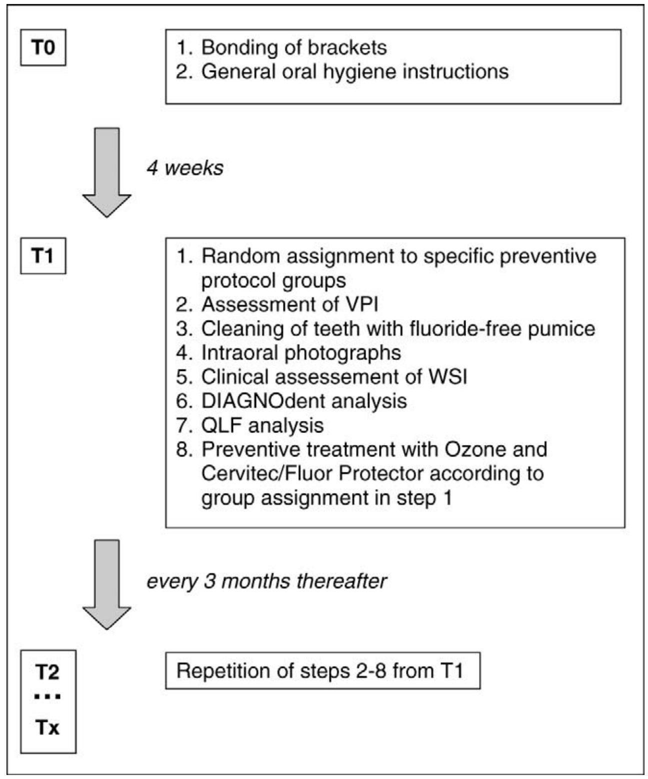


**Figure 1.** Study design showing data collections and preventive measures undertaken during the start of orthodontic treatment (T0), the randomization examination (T1) and the follow-up examinations (T2, . . . , TX). VPI indicates visible plaque index; WSI, white spot index; QLF, quantitative light-induced fluorescence.

## MATERIALS AND METHODS

At the start of the present investigation, the first 20 right-handed patients (12 female, 8 male) were selected/were included with permanent dentition from the Department of Orthodontics, University of Bern, who required full MB appliance therapy and presented a clinically diagnosed very poor oral hygiene (visible plaque index $>$ 40%). Informed consent was obtained from the patients and/or their parents.

The mean pretreatment age was 15.0 years. The patients were followed for at least 16 months, or until the end of their MB treatment. The average observation period was 26 (16–40) months.

All incisors, canines, and premolars with brackets were analyzed. In case of aplasia, tooth retention, or an orthodontic extraction protocol, only the actual present teeth were included in the evaluation.

Examinations were performed at multiple time points, during which specific measures and data collections were undertaken (Figure 1).

### Start of MB Treatment

At TO Mino-Mono® Brackets (FORESTADENT, Pforzheim, Germany) were bonded with Transbond LR (3M Unitek, Monrovia, Calif) after etching for 20 seconds with 35% phosphoric acid. To avoid a protective film around the brackets, no bonding was used.

All patients were instructed to brush their teeth three times per day with a fluoride toothpaste (elmex, GABA, Therwil, Switzerland) and a manual toothbrush (elmex interX medium, GABA) according to the modified Bass technique supplemented by an interdental brush (Paro Interspace, Esro, Kilchberg, Switzerland) and a fluoride rinsing solution (250 ppm, elmex ANTICARIES dental rinse, GABA). The latter was to be used at least at night time after brushing. The patients were supplied with all required oral hygiene utilities for the entire duration of the study. No further preventive measures were undertaken until the first control visit 4 weeks after bonding.

### Randomization Examination

At T1 the 20 subjects were consecutively (in random order of their MB start) assigned to four experimental preventive protocol groups based on a split-mouth-design (Figure 2). The four quadrants of each patient were either treated with ozone (HealOzone, KaVo, Biberach, Germany), a combination of Cervitec and Fluor Protector (Vivadent, Schaan, Lichtenstein), or

| Group | Patient | 1. Quadrant | 2. Quadrant | 3. Quadrant | 4. Quadrant |
|---|---|---|---|---|---|
| 1 | 1-5 | Ozone | Control | Cervitec/Fluor Protector | Control |
| 2 | 6-10 | Control | Ozone | Control | Cervitec/Fluor Protector |
| 3 | 11-15 | Cervitec/Fluor Protector | Control | Ozone | Control |
| 4 | 16-20 | Control | Cervitec/Fluor Protector | Control | Ozone |

**Figure 2.** Random distribution of the 20 patients to the protocol groups. The four quadrants of the patient were either treated with ozone, a combination of Cervitec and Fluor Protector (Cervitec/Fluor Protector) or served as untreated controls.

served as untreated controls. The specific preventive protocol for each patient was maintained until the end of the study. According to the above mentioned procedure a total of 100 ozone-treated teeth, 100 Cervitec/Fluor Protector treated teeth, and 200 control teeth were available.

Prior to the preventive measures, the visible plaque index (VPI) according to Turesky and coworkers[29] was assessed. Plaque was recorded as present or not present (Figure 3). The presence of white spot lesions was evaluated clinically (Figure 3), according to the white spot index (WSI) of Gorelick and coworkers.[1] Pretreatment existing white spots were not considered.

Furthermore, white spot formation or enamel decalcification was quantitatively measured (Figure 3) using a DIAGNOdent device (KaVo), which was calibrated according to the manufacturer's instructions before every use. The changes in the amount of reemitted near-infrared fluorescent light were evaluated relative to the pretreatment value. A deviation greater than 10 units from the initial value was considered as mineralization loss.

The second method used for a quantitative assessment of enamel decay was QLF (Inspektor Research

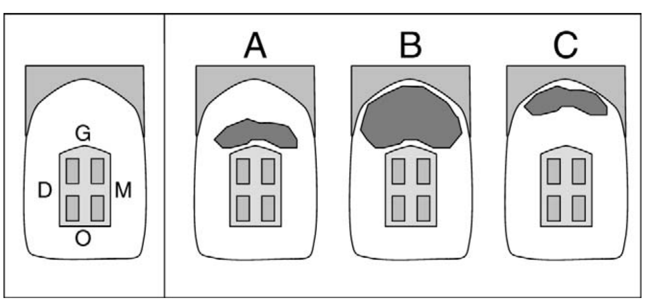


**Figure 3.** Illustration of the gingival (G), mesial (M), distal (D), and occlusal (O) areas surrounding a bracket that were assessed for the visible plaque index and the white spot index, as well as for the quantitative evaluation by means of DIAGNOdent and quantitative light-induced fluorescence. In the gingival area (A-C) any finding was only evaluated as positive if it was located as shown in examples A or B. If the plaque, white spot, or demineralization was exclusively located directly adjacent to the gingiva (C) it was not included because the ozone cup did not cover this area.

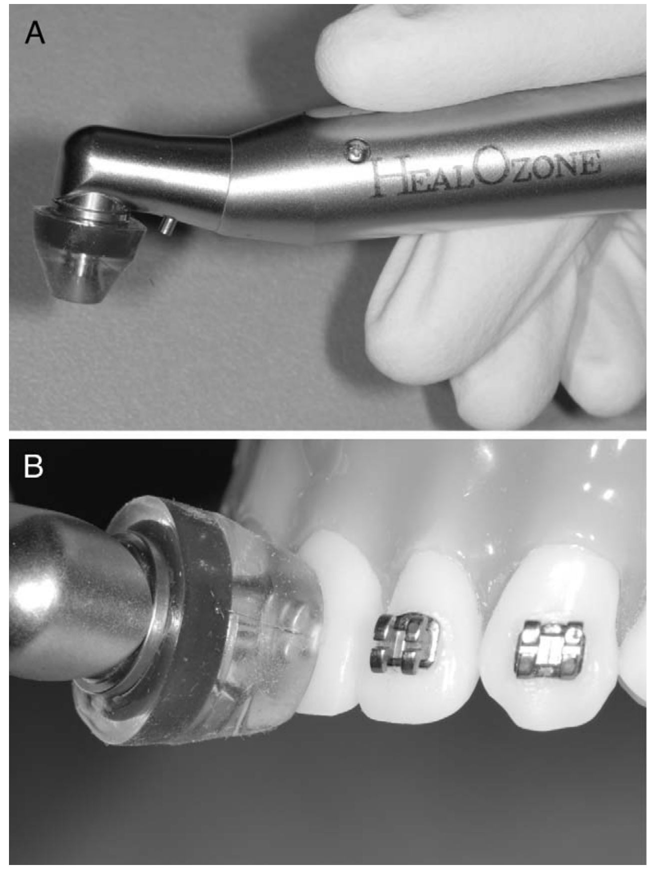


**Figure 4.** The handpiece of the HealOzone device (KaVo, Biberach, Germany) is equipped with a disposable silicone cup (A), which is placed over the bracket and seals the area underneath it completely to prevent any escape of ozone (B).

Systems BV, Amsterdam, Netherlands). A minimum autofluorescence difference ($\Delta$F) of 15%[30] was classified as existent white spot formation.

According to current clinical experience, ozone (2′100 ppm $\pm$ 10%) was delivered for 30 seconds using a HealOzone device (Figure 4).[23,31] The application of Cervitec (1% chlorhexidine + 1% thymol) was followed by Fluor Protector (5% difluorosilane). After the preventive measures, the patients were instructed not to eat or drink during the following 3 hours and not to brush their teeth during the rest of the day.

Data were analyzed with the Fisher exact test using the software program SAS Software 8.2. A level of significance of at least $P < .05$ was considered statistically significant.

## RESULTS

Using DIAGNOdent a trend in the relative change of the amount of reemitted fluorescence light could not be detected in any of the quadrants or at any of the examination times. Therefore, no data of this method are presented.

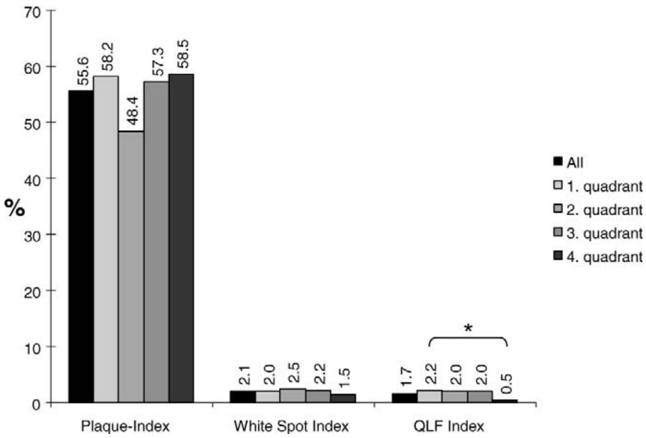


**Figure 5**. Average percentage values for visible plaque index, visual white spot index, and quantitative light-induced fluorescence index of 20 patients in the four different quadrants. (* $P < .05$)

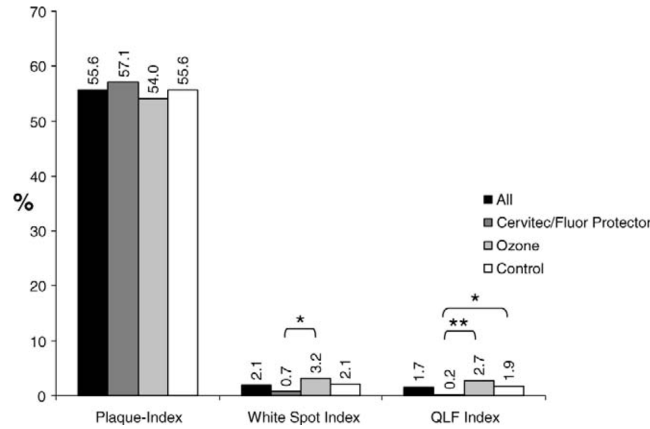


**Figure 6**. Average percentage values for visible plaque index, visual white spot index, and quantitative light-induced fluorescence index in all four quadrants, ie, the quadrants treated with Cervitec/Fluor Protector (Cervitec/Fluor Protector) or ozone and those quadrants serving as untreated controls. (* $P < .05$; ** $P < .01$)

For orthodontic reasons the treatment length, and thus, the number of examinations, differed between the subjects. The average percentage values for the VPI, the WSI, and the QLF index in the different dental arch quadrants and the different preventive quadrants are given in Figures 5 and 6.

The average VPI in all four dental arch quadrants amounted to 55.6%. Although it varied between 48.4% and 58.5% among the quadrants, and between 54.0% and 57.1% depending on the preventive measure undertaken, none of the differences were statistically significant.

In 2.1% of all tooth areas, newly developed white spot lesions were clinically detected. There was a slight, but nonsignificant, variation between the quadrants (1.5%–2.5%). In the quadrants treated with Cervitec/Fluor Protector, only 0.7% of the areas developed new white spots. This was significantly ($P < .05$) less than in the quadrants treated with ozone (3.2%).

Using QLF, newly developed lesions were detected in 1.7% of all tooth areas. There was a significantly ($P < .05$) different degree of detection between the first (2.2%) and the fourth (0.5%) quadrant. The lowest percentage of newly developed lesions was found in the quadrants treated with Cervitec/Fluor Protector (0.2%). That was significantly less than in those treated with ozone (2.7%; $P < .01$), or the untreated controls (1.9%; $P < .05$).

The lesions detected with QLF only partially corresponded to the clinically detected white spots. Of the decalcified areas detected by QLF, 51.8% were clinically visible, while in 48.1%, clinically sound enamel was seen. Of the clinically discernible white spot lesions, 57.6% were undetected by QLF and only 42.4% were identified by both methods.

## DISCUSSION

In concordance with Øgaard and coworkers[32] and Twetmann and coworkers,[14] the VPI in the present study was not influenced by Cervitec/Fluor Protector. The same was found to be the case for ozone.

Despite the relatively high VPI throughout the study and the long observation period, the incidence of new white spot lesions was relatively low (2.1%). This could be due to the general fluoride prevention (fluoride toothpaste, fluoride rinsing solution) undertaken, which has been shown to be an efficient prophylactic measure during orthodontic treatment.[33]

The smallest WSI (0.7%) was seen in teeth treated with Cervitec/Fluor Protector. Even if there are several studies showing that Cervitec reduces the WSI,[34,35] Benson and coworkers[11] concluded in their systematic review that there is only small evidence for the positive effect of varnishes during MB treatment. In ozone-treated teeth, newly formed white spot lesions were more frequent than in teeth treated with Cervitec/Fluor Protector, whether analyzed visually (WSI) or by QLF.

Although in vitro studies[36,37] indicate that DIAGNOdent is able to detect decalcifications around brackets, in the present study, no changes in the DIAGNOdent values could be measured, even in clinically indisputable white spot lesions. Several other studies support this result.[38–41] Therefore, DIAGNOdent does not seem to be a suitable device for the detection of initial caries lesions during MB treatment.

QLF has been shown to detect more lesions than can be visually perceived.[30,38,41,42] When used in vitro around brackets, the specificity was higher compared with clinical rating; sensitivity, however, was higher with visual inspection than with QLF.[40] This corresponds to the present in vivo results.

In contrast to most other studies, the present investigation analyzed white spots during their formation. Such initial lesions may be very superficial and have the potential to remineralize again.[43] A possible explanation why DIAGNOdent was unable and QLF partially unable (42% of the lesions detected) to detect the visually recognizable lesions, may be the fact that such early lesions, as those analyzed, are only scarcely populated with bacteria.[44] The most basic reason why QLF cannot be recommended for screening purposes in MB patients, even though this has been propagated based on in vitro investigations,[37,41] is that the primary goal of orthodontics is to move teeth, which makes it nearly impossible to provide the congruent shots required by the QLF software.

## CONCLUSIONS

- Both null hypotheses have to be rejected.
- The caries protective effect of Cervitec/Fluor Protector during MB therapy was superior to ozone.
- A visual evaluation of initial caries lesions was superior to DIAGNOdent and QLF.

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