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Plaque control effectiveness and handling of interdental brushes during multibracket treatment—a randomized clinical trial

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SUMMARY The aim of this randomized clinical trial was to compare the plaque control effectiveness and handling of an interdental brush with a short curved handle and a triangular cross-section of the brush head (IDB) and an interdental brush with a long straight handle in combination with a monotufted brush head (MTB).

In a split-mouth design, 110 multibracket patients were randomly assigned to group A using the MTB in the first and third quadrants and the IDB in the second and fourth quadrants or to group B who proceeded the other way around. A crossover was performed after 3 months. The plaque index (PI) was scored every 6 weeks for a period of 24 weeks, and handling was evaluated using visual analogue scales (VAS). Wilcoxon tests were used to determine differences in PI and VAS scores between the two brushes and for PI differences between the different observation periods. Differences concerning personal preference and perceived cleaning efficacy were analysed with chi-square tests. The significance levels used were $P < 0.001$ and $P < 0.01$.

The PI decreased significantly, but no statistically significant difference was found between the two brushes. Subjects experienced less pain and reported better access behind the archwire with the IDB. The use of an interdental brush reduced the PI irrespective of the design of the brush head. In direct comparison, adolescent patients preferred the IDB. Further trials are required to investigate the effectiveness of the IDB in reducing decalcification during orthodontic treatment.

Introduction

White spot lesions are an undesired side effect of orthodontic treatment with multibracket (MB) appliances occurring between 2 and 96 per cent of patients (Gorelick *et al.*, 1982; Årtun and Brobakken, 1986; Geiger *et al.*, 1988; Mitchell, 1992; Øgaard, 1989).

It is generally accepted that fluoride reduces the rate of demineralization. However, fluoride treatment has a reduced effect under bacterially produced decreased pH conditions (Øgaard and Rølla, 1993), and these occur in MB patients when compared with untreated individuals (Chatterjee and Kleinberg, 1979). Orthodontic measures, such as the use of fluoride-releasing materials, seem to have minimal or no positive effect (Derks *et al.*, 2004). Nevertheless, the daily use of a fluoride rinse reduces the caries incidence during MB therapy (Benson *et al.*, 2005; Stecksén-Blicks *et al.*, 2007). However, chemical prevention alone does not seem to be able to completely prevent white spot formation during MB treatment.

Some authors have found electric toothbrushes to be more effective than manual toothbrushes as mechanical cleaning aids in MB patients (Wilcoxon *et al.*, 1991; Boyd and Rose, 1994; Clerehugh *et al.*, 1998; Doll *et al.*, 1999), while others could not confirm this superior effect (Jackson, 1991; Thienpont *et al.*, 2001; Kaklamanos and Kalfas, 2008) or found manual toothbrushes to be superior to electric toothbrushes (Trimpeneers *et al.*, 1997). Furthermore, no significant difference in plaque removal effectiveness was found between standard manual toothbrushes and orthodontic toothbrushes (Williams *et al.*, 1987; Kiliçoğlu *et al.*, 1997; Heasman *et al.*, 1998; Hickman *et al.*, 2002; Rafe *et al.*, 2006).

However, all latter studies revealed that the sole use of a toothbrush (manual or electric) does not adequately clean all tooth surfaces. Remaining plaque around the brackets and behind the archwire causes demineralization and subsequently white spots (Gorelick *et al.*, 1982; Mizrahi, 1982; Årtun and Brobakken, 1986; Øgaard, 1989; Mitchell, 1992; Chang *et al.*, 1997; Arici *et al.*, 2007). Therefore, the additional use of interdental cleaning aids is recommended (Jackson, 1991; Heintze *et al.*, 1996; Sudjalim *et al.*, 2006). However, non-randomized controlled trial data are equivocal in supporting the use of interdental cleaning aids in MB patients (Kossack and Jost-Brinkmann, 2005), while the use of floss is often not regularly observed (Djamchidi *et al.*, 2004). According to a recent systematic review (Goh, 2007), there is no actual corresponding evidence so far for recommending the use of interdental brushes for MB patients.

However, an interdental brush with a new type of brush head has recently been introduced by elmex®. It has a triangular cross-section, which is supposed to imitate the shape of the interdental space, offering an alternative way of removing plaque. Concerning resistance to insertion, an experimental set-up demonstrated superior results compared with conventional interdental brushes (Wolff *et al.*, 2006).

However, the clinical situation has not as yet been evaluated in orthodontic patients. Furthermore, the handle, being short and curved, was designed according to ergonomic principles suggesting easier use than conventional handles of other interdental brushes.

Therefore, the aim of this study was to compare plaque control effectiveness and handling of the new elmex® (GABA International, Therwil, Switzerland) interdental brush no. 6 (IDB) and an interdental brush with a long straight handle in combination with a monotufted brush head (MTB)—the TePe® (TePe, Malmö, Sweden) Compact Tuft during 6 months of MB treatment (Figures 1 and 2).

The null hypothesis was that there would be no difference in plaque control effectiveness (primary outcome measure) and handling (secondary outcome measure) between either type of brush.

Subjects and methods

The study protocol was approved by the Ethic Committee of the University of Giessen (no. 110/06).

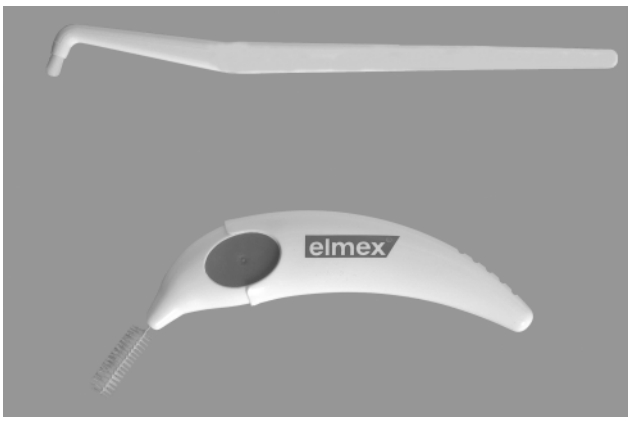

Figure 1 TePe® Compact Tuft with a long straight handle (MTB: top) and elmex® interdental brush no. 6 with a short curved handle (IDB: bottom).

One hundred and ten adolescent MB patients (Tip-Edge®; TP Orthodontics Inc., La Porte, Indiana, USA) treated at the Orthodontic Department, University of Giessen were consecutively enrolled in this prospective, randomized, observer-blind clinical trial between January and May 2007. The inclusion criteria were between 11 and 17 years of age and MB treatment (including at least 10 teeth per arch) scheduled to last for at least a further 6 months. Patients were not included if orthognathic surgery was planned, they refused to follow the instructions given, had oral or systemic diseases, or were mentally or motor disabled. Due to the split-mouth design and the crossover, each patient acted as his/her own control. Thus, no intention-to-treat analysis was performed, but reasons and circumstances of study dropouts were documented.

After written informed consent, the baseline evaluation (T0) was performed by single examiner (MK), who was trained during a pilot study. The plaque index (PI; Figure 3) according to Attin (2005) was calculated using the incisors, canines, and first and second premolars:

$$\text{Index} = \frac{\text{Amount of plaque scores} \times 100}{\text{Number of teeth judged} \times 3}.$$

All subjects underwent professional dental cleaning at T0 and were randomly assigned by an independent person using a die either to group A (MTB first and third and IDB second and fourth quadrants) or to group B (MTB second and fourth and IDB first and third quadrants). The split-mouth design was colour coded (two colours of ligatures on the brackets), and the patients were instructed to use the interdental brushes only as allocated. To exclude bias through left- or right-handed brushing, after week 12, a crossover of the brushes and professional dental cleaning were performed.

In addition, all patients were provided with the same dental hygiene products [anticaries toothpaste, anticaries

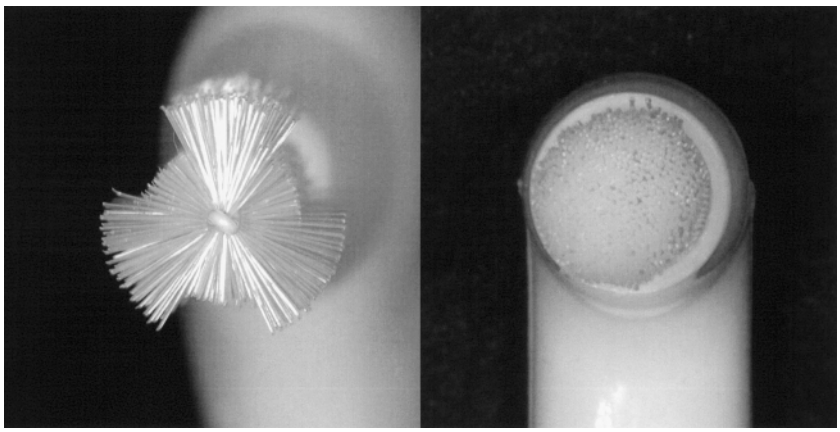

Figure 2 elmex® interdental brush no. 6 with a triangular cross-section of the brush head (IDB: left) and TePe® Compact Tuft with a monotufted brush head (MTB: right).

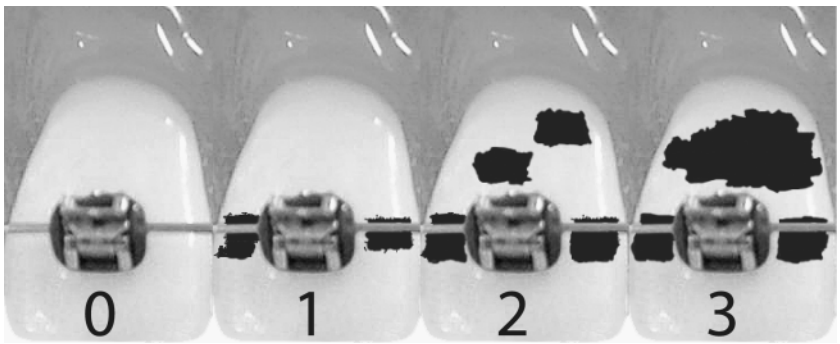

Figure 3 Plaque index (Attin, 2005). The criteria of the different scores are as follows: 0, no plaque visible; 1, moderate accumulation on surfaces lateral to the brackets; 2, moderate accumulation on surfaces lateral and cervical to the brackets; 3, one-third of the surface gingival to the bracket covered with plaque.

mouthrinse, and InterX short head manual toothbrush (elmex®)] and were required to use only these products for the duration of the study. The PI was scored after 6 (T1), 12 (T2), 18 (T3), and 24 (T4) weeks (twice before and twice after the crossover) by one examiner (MK) blinded to the brushes used.

During the first week after the start of the study (T0) and after the crossover (T2), the patients were asked to complete questionnaires using visual analogue scales (VAS) directly after brushing at home. These questionnaires had been developed together with a psychologist and contained questions concerning the subjective plaque removal effectiveness, pain or bleeding during use, and handling. At the follow-up (after 6, 12, 18, and 24 weeks), the same questionnaires, with additional questions considering illnesses requiring antibiotic medication and cross-check questions to ensure correct use of the interdental brushes, were completed. The return rate of the questionnaires was between 92.3 and 100 per cent for the different time points.

Statistical analysis was performed with the Statistical Package for Social Sciences version 12.0 for Windows (SPSS Inc., Chicago, Illinois, USA). The proposed sample size was calculated on the basis of the results of a pilot study. A sample size of 110 subjects would be sufficient to detect a statistically significant difference of 20 per cent (one score of the PI with $\alpha = 5$ per cent and $\beta = 10$ per cent) and therefore giving the study a power of 90 per cent. The sample size reduction due to the crossover design was expected to be the same as the sample size increase due to possible dropouts.

Wilcoxon tests were used to test for differences in PI and VAS scores between the two brushes and for PI differences between the different observation periods. Differences between the two brushes concerning personal preference and perceived cleaning efficacy were analysed with chi-square tests. The significance levels used were $P < 0.001$ and $P < 0.01$.

Results

One hundred and four (65 females and 39 males) of the 110 (group A: 59 and group B: 51) subjects completed the study. The reasons for the dropouts ($n = 6$) were early debonding, severe illness, and missed appointments. The mean age at T0 was 13.5 years (females) and 13.7 years (males).

At baseline (T0), the mean PI was 38 per cent. During T0–T1, the PI decreased by 12 per cent ($P < 0.001$). During the remaining trial period (T1–T4), the changes were not significant. There was no statistically significant difference between the two brushes at any time point.

The percentage of patients with excellent oral hygiene increased from 19 per cent at T0 to 41 per cent at T1 and varied between 40 and 48 per cent thereafter. The percentage of patients showing good oral hygiene increased from 42 per cent at T0 to 53 per cent at T4. While 6 per cent of the patients showed poor oral hygiene at T0, no subject showed poor oral hygiene between T1 and T4 (Figure 4).

On average, patients described a higher resistance ($P < 0.001$) on inserting the MTB (VAS score 65.0) under the archwire than on inserting the IDB (VAS score 43.8) as the ideal value was 50. The use of the IDB was reported to be less painful than that of the MTB (VAS score 90.5 versus 84.3, $P < 0.001$). There was no significant difference concerning bleeding during use (IDB: 86.3 and MTB: 84.5, n.s.).

The insertion of the IDB underneath the archwire was stated to be easier than the insertion of the MTB. This was the case for all regions (upper and lower anterior and posterior teeth), with a significant difference ($P < 0.001$) in favour of the IDB (Figure 5a). Generally, the IDB was found to be more suitable for the removal of food debris ($P < 0.001$). For subjective plaque removal, however, no difference was found between the two brushes (Figure 5b).

Finally, the patients were asked which brush they felt was more effective and which they preferred. Seventy-eight per cent of the patients thought that the IDB cleaned the teeth

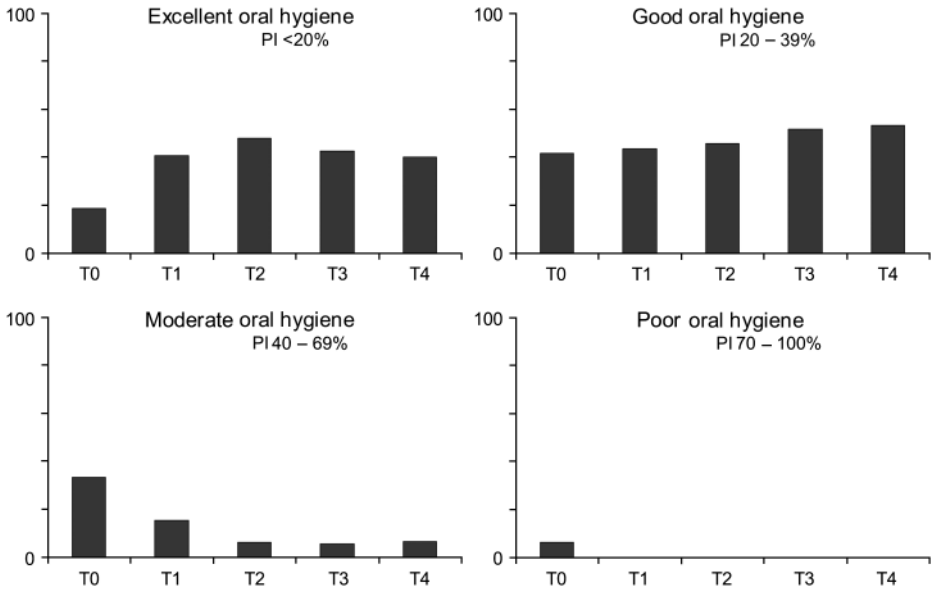

Figure 4 Quality of oral hygiene according to the plaque index (PI). For each category (excellent, good, moderate, and poor), the percentage of subjects is shown for the five occasions T0 (baseline), T1 (6 weeks after start), T2 (crossover), T3 (6 weeks after crossover), and T4 (end of the study).

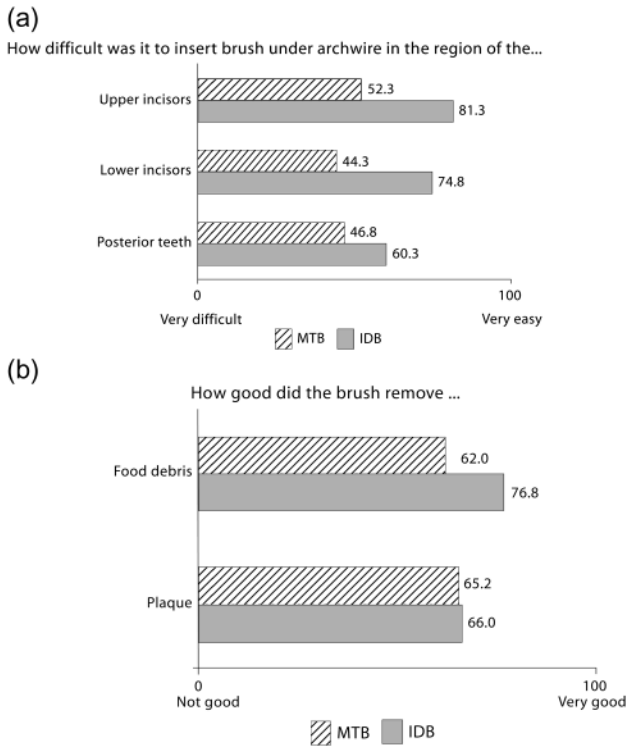

Figure 5 Handling (**a**) and objective cleaning effectiveness (**b**) of the new elmex® interdental brush no. 6 (IDB) and the TePe® Compact Tuft (MTB) as assessed by patients using visual analogue scales.

better, whereas 22 per cent believed that the MTB was more effective ($P < 0.001$). Concerning their preferred brush, 67.5 per cent favoured the IDB compared with 32.3 per cent preferring the MTB ($P < 0.001$).

Discussion

The subjects in this study were homogenous, including only adolescent orthodontic patients treated with the same type of MB appliance. Furthermore, due to the split-mouth design, the significance of variation between individuals was reduced as the subjects represented their own control. The number of dropouts was reasonable, as was the percentage of returned questionnaires. For sample size generation, a pilot study had been performed by the same examiner (MK).

The PI by Attin (2005) was chosen because it scores the high-risk areas around the brackets and behind the wire (Gorelick *et al.*, 1982; Mizrahi, 1982; Årtun and Brobakken, 1986; Øgaard, 1989; Mitchell, 1992; Chang *et al.*, 1997; Arici *et al.*, 2007).

The brushes tested were selected because they represent two basically different types of brushes available on the market. One marked difference is the length and shape of the handle, and the other is the shape of the head. According to a previous investigation, the IDB showed significantly lower resistance to insertion than conventional interdental brushes (Wolff *et al.*, 2006).

The split-mouth design seemed to be appropriate for this investigation as the outcome achieved with one brush could not affect the performance of the other.

The mean PI decreased significantly during the initial observation period (T0–T1) in both groups. No significant difference between the two types of brushes was seen. This result is supported by Wolff *et al.* (2006) who showed, in an experimental study, that the relative cleaning efficacies of the IDB and conventional interdental brushes were equal.

However, due to lower resistance to insertion values, the IDB cleaned more effectively.

Comparing the percentage of patients exhibiting excellent or good oral hygiene at baseline (approximately 60 per cent) to T1 (84 per cent) or thereafter (greater than or equal to 93 per cent) clearly shows the positive effect of the use of interdental brushes. Improved oral hygiene due to the use of specific interdental cleaning aids was also seen by Kossack and Jost-Brinkmann (2005). The present findings are also in agreement with a systematic literature review (Gray and McIntyre, 2008), which found oral health promotion during orthodontic treatment to have a positive effect. On the other hand, the improvement might also be due to the Hawthorne effect (Roethlisberger and Dickson, 1939), with patients using interdental brushes more regularly due to their participation in the trial, despite the fact that they had been instructed to do so directly after insertion of the MB appliance.

When evaluating the effectiveness of different interdental brushes, not only the objective PI reduction has to be considered but also the acceptance of the brush, which might influence oral hygiene long term (Warren and Chater, 1996).

On average, patients described the MTB as having too much resistance (VAS value 65.0) and the IDB (VAS score 43.8) as having too little upon insertion underneath the archwire. Wolff *et al.* (2006) also found a significantly better relationship between resistance on insertion and cleaning effectiveness of the IDB in an experimental study. However, they evaluated the insertion resistance in interdental spaces and not under archwires or between brackets. The amount of resistance on insertion of interdental brushes between brackets depends on the interbracket distance and the bracket thickness (distance between tooth and archwire). Whereas the latter is normally the same for one patient, the interbracket distance varies depending on the individual mesiodistal crown widths of the different teeth. Since it was decided that the use of two or more sizes of interdental brushes for the different regions of the mouth was unrealistic, an experimental pilot study preceded the present research to determine the appropriate brush size. The no. 6 size of the IDB seemed to be best suited for both large (i.e. upper incisors) and small (i.e. lower incisors) interbracket distances. For the MTB, only one size was available.

An important parameter in the use of any type of toothbrush is discomfort or pain since patients are unlikely to frequently use a brush if it hurts. The use of the IDB was reported to be less painful than the MTB, probably due to the lower resistance upon insertion. Bleeding on use was not a problem with either brush.

Besides pain, it also seems important that the brush is good to handle and easily reaches all regions of the mouth. Stüdeli (2004) evaluated the ergonomic aspects of different interdental brush designs and found that in general their use is challenging (high demand on hand–eye co-ordination). That author proposed that the handle should be made for two- and three-finger grasping to optimize intuitive handling. In the present study, the insertion of the IDB underneath the archwire was stated to be easier than the insertion of the MTB. It seems likely that preferred scoring was due to the curved handle of the IDB. Furthermore, the shape of the IDB was designed to resemble the triangular interdental anatomy, where resistance upon insertion is reduced through the adapted shape of the brush (Wolff *et al.*, 2006). The area around the brackets or underneath the archwire is, however, not triangular. It thus, remains unclear, if the easier handling of the IDB is due to its more ergonomic handle, the triangular cross-section, or its smaller more flexible head.

The perceived improved removal of food debris is probably due to the fact that patients generally found it easier to reach all areas underneath the archwire with the IDB. The plaque-removing efficacy of the two brushes was, however, not felt to be different by the patients. This, of course, is difficult for patients to judge but corresponds with the clinical PI measurements.

Concerning their personal preference and the perceived cleaning efficacy, the IDB was preferred by the adolescent patients in the present study, which seems to be due to the easier handling and the less painful use.

Conclusions

Use of interdental brushes significantly reduced the PI. However, neither brush (IDB/MTB) was found to be superior. Since, however, adolescent patients significantly preferred the use of the IDB over the MTB and thus might use it more often, the use of the IDB can be recommended during MB therapy. Further trials are required to investigate the effectiveness of the IDB in reducing decalcification during orthodontic treatment.

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References

Arici S, Alkan A, Arici N 2007 Comparison of different toothbrushing protocols in poor-toothbrushing orthodontic patients. European Journal of Orthodontics 29: 488–492

Årtun J, Brobakken B O 1986 Prevalence of carious white spots after orthodontic treatment with multi-bonded appliances. European Journal of Orthodontics 8: 229–234

Attin R 2005 Introduction of a new plaque index designed for control and motivation of orthodontic patients. Informationen aus Orthodontie und Kieferorthopädie 37: 271–273

Benson P E, Shah A A, Millett D T, Dyer F, Parkin N, Vine R S 2005 Fluorides, orthodontics and demineralization: a systematic review. Journal of Orthodontics 32: 102–114

Boyd R L, Rose C M 1994 Effect of rotary electric toothbrush versus manual toothbrush on decalcification during orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 105: 450–456

Chang H S, Walsh L J, Freer T J 1997 Enamel demineralization during orthodontic treatment. Aetiology and prevention. Australian Dental Journal 42: 322–327

Chatterjee R, Kleinberg I 1979 Effect of orthodontic band placement on the chemical composition of human incisor tooth plaque. Archives of Oral Biology 24: 97–100

Clerehugh V, Williams P, Shaw W C, Worthington H V, Warren P 1998 A practice-based randomised controlled trial of the efficacy of an electric and a manual toothbrush on gingival health in patients with fixed orthodontic appliances. Journal of Dentistry 26: 633–639

Derks A, Katsaros C, Frencken J E, van't Hof M A, Kuijpers-Jagtman A M 2004 Caries-inhibiting effect of preventive measures during orthodontic treatment with fixed appliances. Caries Research 38: 413–420

Djamchidi C, Hartung C, Jost-Brinkmann P-G 2004 Cleaning efficacy of superfloss, Special-floss and satinfloss/megafloss in patients with brackets. Orthodontics 1: 33–41

Doll G M, Typolt A, Sergl H 1999 The efficiency of different orthodontic toothbrushes in patients with fixed orthodontic appliances. European Journal of Orthodontics 21: 581

Geiger A M, Gorelick L, Gwinnett A J, Griswold G 1988 The effect of a fluoride program on white spot formation during orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 93: 29–37

Goh H H 2007 Interspace/interdental brushes for oral hygiene in orthodontic patients with fixed appliances. Cochrane Database of Systematic Reviews 3: CD005410

Gorelick L, Geiger A M, Gwinnett A J 1982 Incidence of white spot formation after bonding and banding. American Journal of Orthodontics 81: 93–98

Gray D, McIntyre G 2008 Does oral health promotion influence the oral hygiene and gingival health of patients undergoing fixed appliance orthodontic treatment? A systematic literature review. Journal of Orthodontics 35: 262–269

Heasman P, Wilson Z, Macgregor I, Kelly P 1998 Comparative study of electric and manual toothbrushes in patients with fixed orthodontic appliances. American Journal of Orthodontics and Dentofacial Orthopedics 114: 45–49

Heintze S D, Jost-Brinkmann P-G, Loundos J 1996 Effectiveness of three different types of electric toothbrushes compared with a manual technique in orthodontic patients. American Journal of Orthodontics and Dentofacial Orthopedics 110: 630–638

Hickman J, Millett D T, Sander L, Brown E, Love J 2002 Powered vs manual tooth brushing in fixed appliance patients: a short randomized clinical trial. Angle Orthodontist 72: 135–140

Jackson C L 1991 Comparison between electric toothbrushing and manual toothbrushing with and without oral irrigation, for oral hygiene of orthodontic patients. American Journal of Orthodontics and Dentofacial Orthopedics 99: 15–20

Kaklamanos E G, Kalfas S 2008 Meta-analysis on the effectiveness of powered toothbrushes for orthodontic patients. American Journal of Orthodontics and Dentofacial Orthopedics 133: 187.e1–187.e14

Kiliçoğlu H, Yildirim M, Polater H 1997 Comparison of the effectiveness of two types of toothbrushes on the oral hygiene of patients undergoing orthodontic treatment with fixed appliances. American Journal of Orthodontics and Dentofacial Orthopedics 111: 591–594

Kossack C, Jost-Brinkmann P G 2005 Plaque and gingivitis reduction in patients undergoing orthodontic treatment with fixed appliances—comparison of toothbrushes and interdental cleaning aids. A 6-month clinical single-blind trial. Journal of Orofacial Orthopedics 66: 20–38

Mitchell L 1992 Decalcification during orthodontic treatment with fixed appliances—an overview. British Journal of Orthodontics 19: 199–205

Mizrahi E 1982 Enamel demineralization following orthodontic treatment. American Journal of Orthodontics 82: 62–67

Øgaard B 1989 Prevalence of white spot lesions in 19-year-olds: a study on untreated and orthodontically treated persons 5 years after treatment. American Journal of Orthodontics and Dentofacial Orthopedics 96: 423–427

Øgaard B, Rølla G 1993 Cardiological aspects of treatment with fixed orthodontic appliances. New concept on cariostatic mechanism of topical fluoride. Kieferorthopädische Mitteilungen 6: 45–51

Rafe Z, Vardimon A, Ashkenazi M 2006 Comparative study of 3 types of toothbrushes in patients with fixed orthodontic appliances. American Journal of Orthodontics and Dentofacial Orthopedics 130: 92–95

Roethlisberger F J, Dickson W J 1939 Management of the worker. Harvard University Press, Cambridge

Stecksén-Blicks C, Renfors G, Oscarson N D, Bergstrand F, Twetman S 2007 Caries-preventive effectiveness of a fluoride varnish: a randomized controlled trial in adolescents with fixed orthodontic appliances. Caries Research 41: 455–459

Stüdeli T 2004 Ergonomische Gestaltungsprinzipien bei Interdentalbürsten. Gfa-Press, Dortmund, pp. 619–622.

Sudjalim T R, Woods M G, Manton D J 2006 Prevention of white spot lesions in orthodontic practice: a contemporary review. Australian Dental Journal 51: 284–289

Thienpont V, Dermaut L R, Van Maele G 2001 Comparative study of 2 electric and 2 manual toothbrushes in patients with fixed orthodontic appliances. American Journal of Orthodontics and Dentofacial Orthopedics 120: 353–360

Trimpeneers L, Wijgaerts I A, Grognard N A, Dermaut L R, Adriaens P A 1997 Effect of electric toothbrushes versus manual toothbrushes on removal of plaque and periodontal status during orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 111: 492–497

Warren P R, Chater B V 1996 An overview of established interdental cleaning methods. Journal of Clinical Dentistry 7: 65–69

Wilcoxon D B, Ackerman R J, Killoy W J, Love J W, Sakumura J S, Tira D E 1991 The effectiveness of a counterrotational-action power toothbrush on plaque control in orthodontic patients. American Journal of Orthodontics and Dentofacial Orthopedics 99: 7–14

Williams P, Fenwick A, Schou L, Adams W 1987 A clinical trial of an orthodontic toothbrush. European Journal of Orthodontics 9: 295–304

Wolff D, Joers D, Rau P, Dörfer C E 2006 *In vitro* cleaning efficacy and resistance to insertion test of interdental brushes. Clinical Oral Investigations 10: 297–304