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The effectiveness of different toothbrushes for people with special needs

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Abstract

Aim: To investigate the type of toothbrush that enables patients with special needs and/or their carers to carry out effective tooth brushing. **Study Design:** Three-way cross-over with 36 subjects with physical and/or mental impairments, who used the brushes, on their own ('Self-Brushers') or with assistance, either in part ('Assisted Brushers') or total ('Other Brushers') from their guardian or carer. Subjects used the three-headed toothbrush Superbrush® and the Teledyne® Waterpik Sonic Speed Plaque Remover as well as a simple manual toothbrush, the Oral-B 35®. The subjects were divided into three groups according to the severity of their disability. After professional cleaning, the 14-day test phases began followed by the 14-day wash-out phase. The following indices were used by one blinded, experienced examiner for each test phase: Quigley-Hein Index (QHI), approximal plaque index according to Lange (API) as well as the papilla bleeding index according to Saxer and Muhlemann (PBI). **Results:** The three-headed toothbrush removed plaque more effectively from the smooth surfaces in two of the subject groups (Other Brusher and Assisted Brusher). For those able to brush for themselves, the powered toothbrush performed better in removing plaque from vestibular surfaces. **Conclusion:** Although the study groups are small, differences were observed in the plaque removing efficacy of the brushes with the three-headed brush performing better for those adults who required help, some or total, to brush their teeth. The Superbrush® can thus be recommended for brushing in these groups on the basis of the results from this blind, cross-over study.

Key words: Toothbrushes, electric toothbrush, manual toothbrush, special needs, oral hygiene

Introduction

Tooth brushing is, for patients with special needs, the simplest and most effective method for removing plaque and thus for prevention of caries as well as periodontal diseases. However, impairments of the motor or intellectual skills frequently result in ineffective or no tooth cleaning.

According to Axelsson and Lindhe (1978) and Axelson *et al.* (1991), continuous mechanical removal of the biofilm together with regular application of fluoride results in a reduction in the prevalence of caries and periodontal disease. Cichon and Grimm (1999) confirm that such a prophylaxis and follow-up programme is also successful with patients with special needs. In particular, they refer to the significance of the motivation of parents and carers for daily dental care, nutritional guidance, fluoride therapy as well as professional tooth cleaning. As part of this, it is necessary to be able to recommend a suitable toothbrush to the patient and his or her guardian or carer, for which the effectiveness has been scientifically tested, as well as the corresponding cleaning technique.

In 1967, Bay *et al.* investigated seven different toothbrushes. The study team concluded that a U-shaped toothbrush with two brush heads, applied with a scrubbing motion, removed plaque most effectively, as assessed using the modified Quigley Hein Index. In contrast, in studies with young people by Horowitz and Suomi (1974), the double-headed toothbrush performed no better than a conventional toothbrush. Didner (1996) and Bloch-Zupan and Maniere (1996) reported on the use of the Superbrush®, a toothbrush with three heads, in a study on the efficiency of these toothbrushes with children, young and elderly adults. The Superbrush® was found to be superior to conventional toothbrushes and to an electric toothbrush. In contrast, Sauvetre *et al.* (1995) found no greater effectiveness in plaque reduction with the use of the Superbrush® in a group of people with special needs. Shaw *et al.* (1983) demonstrated that electric toothbrushes are not superior to manual toothbrushes in a group of children with special needs while Bartel und Berggren (1991), came to the same conclusion with a group of adults with special needs. However, Carr *et al.* (1997) were able to provide evidence for a greater cleaning effectiveness of the Interplaque in comparison to a manual toothbrush in the course of a twelve-month comparative

Figure 1. Young woman (Group 1 - Other Brusher) during tooth brushing by her guardian

study with people with intellectual difficulties. For those using manual toothbrushes, Wetzel (1999) formulated characteristics appropriate for use by people with special needs and proposed suitable products based on the results.

This study thus aimed to test the clinical effectiveness of a variety of toothbrushes, conventional manual (Oral-B 35®), modified manual (Superbrush®) and powered (Teledyne® Waterpik Sonic Speed). The study departs from previous work in that the study population are different from those groups already reported in the literature, since they required modifications to be made to the examination conditions. These modifications relate to the limited cooperation of severely disabled people, for whom there are few, scientifically validated recommendations on suitable toothbrushes.

Materials and method

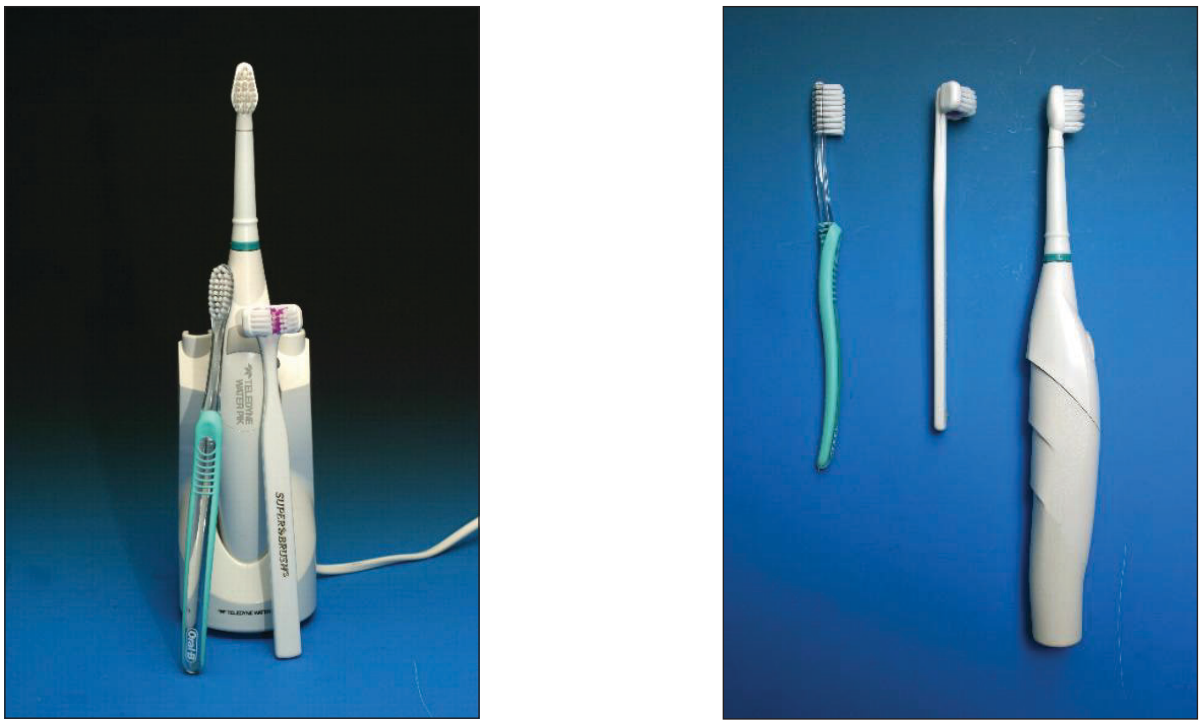
This study was approved by the Ethics Committee of the Charité University Clinic in Berlin.

Thirty six patients with varying degrees of intellectual and/or physical impairments, between the ages of 18 and 45 years, participated in this cross-over study (*Figure 1*). They were assigned to three groups of twelve participants, each according to their capability of implementing oral hygiene procedures. The Oral-B 35® manual toothbrush, the Superbrush® three-headed toothbrush and the Teledyne® Waterpik sonic toothbrush were investigated in this study for effectiveness of plaque removal (*Figures 2a, 2b, 3*). The clinical evaluation was carried out by one experienced clinician who was blind to the toothbrush group of the subject.

Due to the differences between the three tested toothbrushes, each required specific cleaning techniques. Therefore, all subjects and their guardians or carers received verbal and written oral cleaning directions at the beginning of the study. All participants applied the same cleaning techniques with each toothbrush type. Fluoridated MERIDOL® toothpaste (GABA GmbH, Lörrach, Germany) was used exclusively. The method of sampling was comparable to those of past studies (Zimmer, 1999), and described as sufficient.

The study was set up as a blind study with a three-way, cross-over design. In order to avoid differences due to sequence, the subjects used the toothbrushes in a prescribed sequence that guaranteed that each of the brushes under investigation was as equally frequent in first, second and third settings. Each of the three groups, A, B, and C, was composed of four subjects from each of the person subgroups: one (Other Brusher), two (Assisted Brusher) and three (Self-Brusher). Thus each subject group consisted of 12 subjects, whereby each group possessed an approximately equal average ability for carrying out oral hygiene. The classification into the three groups was based on the responses of the caregivers with regard to the individual tooth brushing abilities of the subjects.

Prior to the start of the study, semi-professional tooth cleaning was performed on each patient to obtain plaque-free base conditions. In this case, semi-professional cleaning means that the examiner cleaned the subject's teeth with a uniform standard manual toothbrush and toothpaste. The reason for this was that all examinations were performed on location in the patient's home without access to a dental office. Interdental cleaning by means of dental floss or interdental brushes, was not uniformly possible. The goal of the initial tooth cleaning was to determine how well plaque was removed and gingivitis was eliminated with each tested toothbrush following the 14-day test phase. A baseline examination with ascertainment of the oral hygiene indices was not made prior to the test phase. Following completion of the first two-week cleaning cycle, the oral hygiene status and the gingival index of each participant was determined by means of the plaque index (Quigley-Hein-Index, API according to Lange) and a bleeding index



A *B*

Figure 2a and 2b. Investigated toothbrushes (Oral-B 35® manual toothbrush, Superbrush® three-headed toothbrush and Teledyne® Waterpik sonic toothbrush)

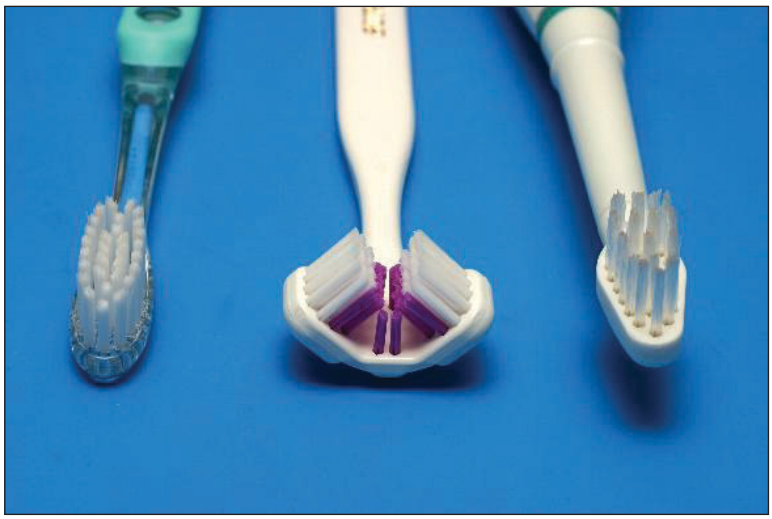


Figure 3. Heads of the investigated toothbrushes (Oral-B 35® manual toothbrush, Superbrush® three-headed toothbrush and Teledyne® Waterpik sonic toothbrush)

(PBI according to Saxer and Mühlemann) on six Ramfjord teeth (Ramfjord, 1959). Due to the extent of the subjects' disabilities, it was not possible to use reduction of plaque as the outcome measure. For the same reason, neither was it possible to include pre-brushing plaque scores as covariants in the statistical analysis.

The limitation of the examination to the Ramfjord teeth is not ideal but does correspond to the guidelines of the American Dental Association for oral hygiene studies. The evaluation of all teeth was not possible due to the poor cooperation of the subjects and taking into account that the assessment was undertaken in the subject's home. Because the duration of the examination had to be kept as short as possible, the Quigley-Hein-Index was applied as follows: All Ramfjord teeth were evaluated in the oral (QHO) and vestibular (QHV) regions on a scale from 0 (no plaque) to 5 (plaque covers more than two thirds of the tooth surface) and separately analysed.

After a two week interval with subjects using their normal oral hygiene methods, the participants switched to the next toothbrush, depending on their group. The duration of the entire study was twelve weeks. All examinations of the oral hygiene status were conducted by one examiner who had no knowledge about the toothbrush used by each subject. In order to undertake the statistical analysis, the individual results from each tooth of each patient were

totalled (sum of the values of the six Ramfjord teeth). The same applies to the papilla bleeding index. This approach is different from that adopted for the assessment using the approximal plaque index according to Lange and for the plaque index according to Quigley-Hein, for which percentages were calculated in both instances.

Data analysis

The data were collected on a survey sheet and analysed using SPSS 9.0 for Windows. Within the scope of the descriptive statistics, a sum of all collected indices was calculated for each patient. The arithmetical average and the standard deviation were recorded for the characterisation of the distribution. Additionally, the median value was provided.

In the concluding statistics, the Friedman test was used for more than two connected nonparametric test series in order to compare the indices for the three toothbrushes. For the comparison of two toothbrushes, the Wilcoxon test with α-adjustment was used. In doing so, consideration was given to the fact that that the data were not distributed normally. Therefore, calculations were made with a distribution-independent method. The probability of error was set at ≤0.05 and 0.01.

Results

Comparative representation of the collected indices of the three toothbrushes for all patients

In the comparison of the indices for the three test toothbrushes, the median of the PI, QH, QHO, QHV and PBI for the Superbrush® lies below that of the other two toothbrushes. However, the differences are for the most part not significant; only the QHV and the QH index show significant differences. The QHV for the Superbrush® (median 19.0) is significantly (p<0.05) lower than for the manual toothbrush (median 20.0). The differences in the QHV of the electric sonic toothbrush (median 19.5) and the manual toothbrush (median 20.0) do not quite reach significance (p= 0.069). The powered sonic toothbrush and the Superbrush® do not differ significantly in the QHV. The QH behaves similarly. For the oral and vestibular tooth surfaces summarised in the plaque index according to Quigley and Hein, the median values for the Superbrush® (median 35.5) and for the electric sonic toothbrush (median 36.0) were significantly lower (p<0.05) than the median value for the manual toothbrush (median 38.0). By contrast, the powered sonic toothbrush and the Superbrush® did not differ significantly from each other (*Figures 4.1, 4.2, 4.3*).

No significant differences were found within the examined indices API and PBI in any of the study groups (Self-Brusher, Assisted Brusher, and Other Brusher). Significant differences were only found in the statistical analysis of the Quigley-Hein Index, which is presented separately below, according to the groups of Other, Assisted and Self-Brushers.

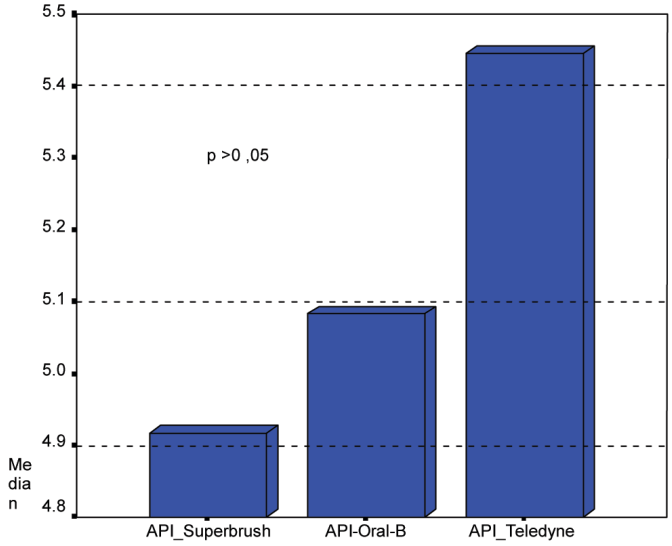


Figure 4.1. Approximal-Plaque-Index (API) for all patients (n=36)

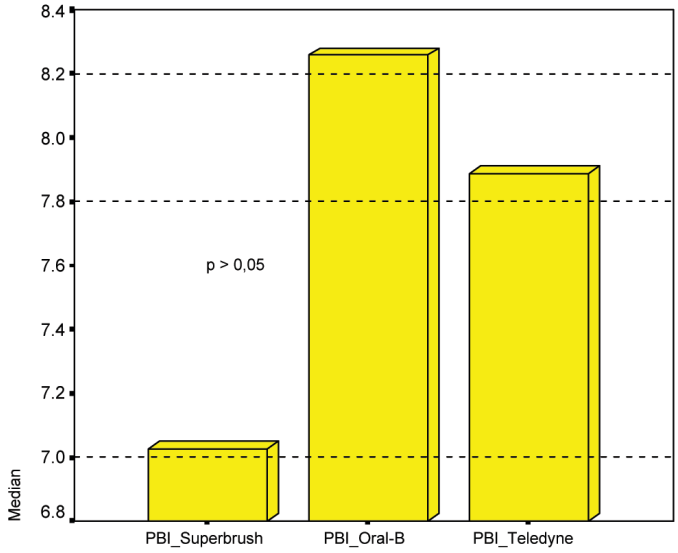


Figure 4.2. Papilla–Bleeding-Index (PBI) for all patients (n=36)

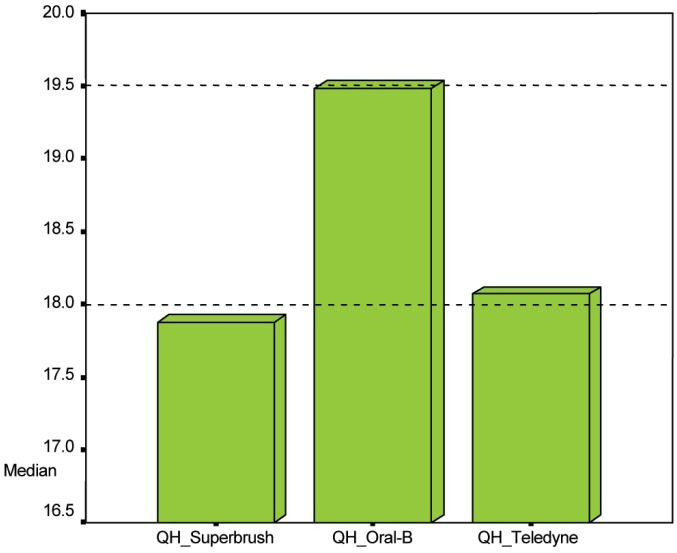


Figure 4.3. Plaque-Index (QH) for all patients (n=36)

Results of plaque removal from the smooth surfaces (QH) of the teeth by group (corresponding to the severity of the disability)

Modified QH Group 1: Other Brusher

In the group of 'Other Brushers', the Superbrush® removed plaque most effectively (*Figure 5.1*). Statistically, differences were established for both the vestibular and the oral tooth surfaces. Observed separately, however, no significant differences were found in the maxillary teeth between the three test toothbrushes for any of the indices. By contrast, in the mandible, the Superbrush® showed significantly better cleaning results in the vestibular and oral regions and in the QH index by comparison with the manual toothbrush. The Superbrush® also performed significantly ($p<0.05$) better than Teledyne® in the QHV and QH. In comparing Teledyne® and Oral-B®, no significant differences were detected.

With regard to the QH values, the Superbrush® appeared to be superior to the manual toothbrush Oral-B® ($p=0.012$) and the powered sonic toothbrush ($p=0.045$). The sonic toothbrush and the manual toothbrush did not differ significantly.

Modified QH Group 2: Assisted Brusher

In the group of Assisted Brushers, the Superbrush® attained significantly better results in both the vestibular area of maxillary teeth and the oral surfaces of mandibular teeth (*Figure 5.2*). In the vestibular region, the median for the Superbrush® was 17.0, in contrast to the Oral-B® manual toothbrush (median 19.0) and Waterpik® (median 19.5). The differences were not statistically significant. The QH values of the oral and vestibular surfaces combined showed significant differences ($p<0.05$) in the comparison of all three toothbrushes. The Superbrush proved to be superior. The comparison of two toothbrushes resulted in highly significant differences ($p<0.01$) between Superbrush® and Oral-B®, and between Waterpik® and Oral-B®. Waterpik® and Superbrush® did not differ significantly.

The comparison of the three toothbrushes for the maxillary teeth generated significantly better values ($p<0.05$) for the QH and the QHV with the Superbrush® in contrast to the Oral-B® manual toothbrush.

List of Abbreviations

API Approximal plaque index according to Lange,
API = API of the teeth 16, 21, 24, 36, 41, 44
QH Plaque index Quigley - Hein, QH = QHO + QHV
QHO Plaque index Quigley - Hein oral,
QHO = QHO of the teeth 16, 21, 24, 36, 41, 44
QHV Plaque index Quigley - Hein vestibular,
QHV = QHV of the teeth 16, 21, 24, 36, 41, 44
PBI Papilla bleeding index according to Saxer and Mühlemann
PBI = PBI of the teeth 16, 21, 24, 36, 41, 44
S Superbrush® three-headed toothbrush
O Oral-B 35® manual toothbrush
T Teledyne® Waterpik sonic toothbrush

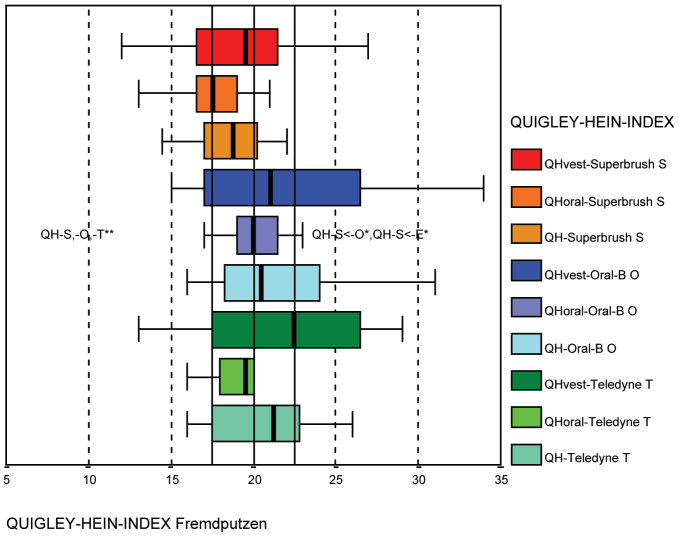


Figure 5.1. Boxplot-diagram for the QH-Index, QH-Index vestibular and QH-Index oral in the group 'Other Brusher'

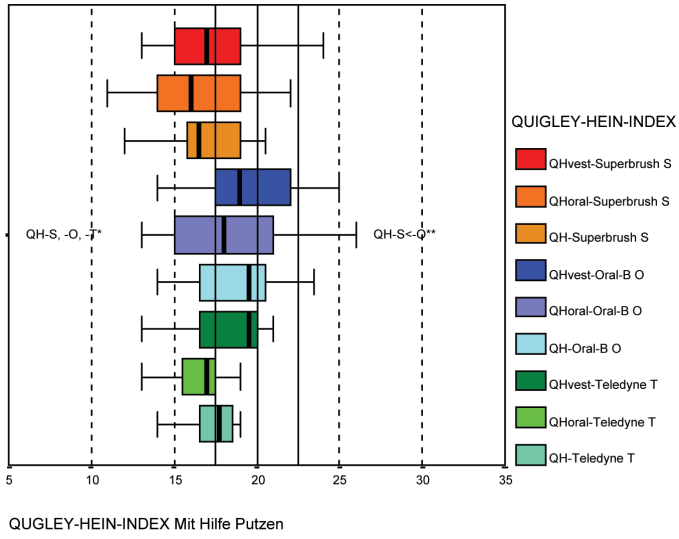


Figure 5.2. Boxplot-diagram for the QH-Index, QH-Index vestibular and QH-Index oral in the group 'Assistant-Brusher'

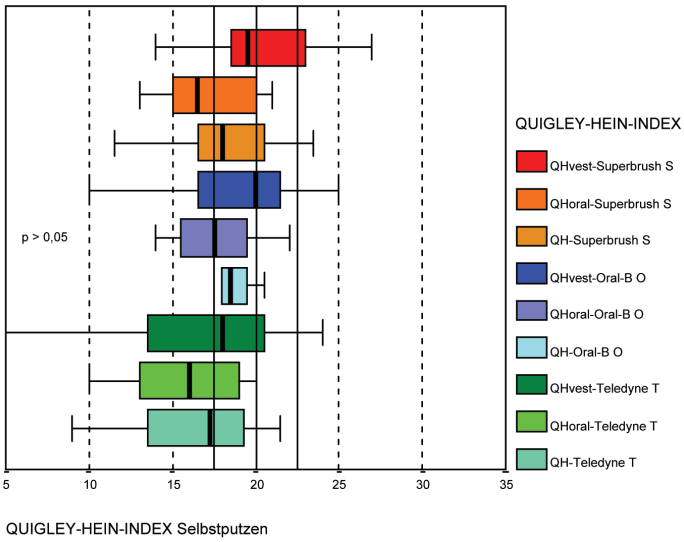


Figure 5.3. Boxplot-diagram for the QH-Index, QH-Index vestibular and QH-Index oral in the group 'Self- Brusher'

Modified QH Group 3: Self-Brushers

In the Self-Brusher group, the Waterpik® sonic toothbrush proved to be the most effective in the area of vestibular tooth surfaces in the maxilla and mandible (*Figure 5.3*). The subjects removed significantly ($p<0.05$) more plaque in the vestibular region with the sonic toothbrush (median 18.0) than with the Superbrush® (median 19.5) or the manual toothbrush (median 20.0). In the comparison of two toothbrushes, the electric sonic toothbrush and the Superbrush® differed significantly ($p=0.013$). When comparing the maxilla and mandible separately, statistically proven differences were apparent, favouring the Waterpik® in particular, for the vestibular tooth surfaces of the maxilla.

Discussion

Whilst some of these results appear to be statistically significant, there is always the danger that, taking into account the small group sizes when analysed by brush type, assistance or not and different tooth surfaces, differences may become apparent that are not real nor clinically significant.

The problem of comparability of the study results with those of other studies is evident. Very different toothbrush designs, various experiment methodologies, various indices for assessment of the effectiveness of the toothbrushes and different test durations lead to results that are difficult to compare. This study was of a cross-over design to test the effectiveness of various toothbrushes (Listgarten, 1992; Saxer and Yankel, 1997a; Stoltze and Bay, 1994). However, it differs in that the study population were all intellectually and/or physically disabled people. Different abilities and skill in daily oral hygiene were represented in the three groups of the study population. Furthermore, comparisons are difficult due to the non-uniform experimental methodology in testing toothbrush effectiveness. Saxer and Yankel (1997b) believe such comparisons to be impossible. Only the comparison with the reference toothbrushes seems sensible to the authors. Nonetheless, studies with identical toothbrushes, similar toothbrush design and similar aims will be included in the following discussion. The results presented here thus allow only limited comparison.

In addition, the conduct of the study in the subjects' homes conferred yet another variable. Despite this, they nonetheless offer a means of testing the effectiveness of various toothbrushes (Saxer and Yankel, 1997a).

All test persons combined

The three toothbrushes investigated are appropriate for use by disabled people due to their differing construction features. The average plaque removal amounted to 35.1% with the conventional manual toothbrush, 39.8% with the powered sonic toothbrush and 40.4% with the three-headed toothbrush. When the study group are considered as a whole, significant differences were revealed for the test toothbrushes Superbrush® and Teledyne® WaterPik Sonic Speed® in comparison to the Oral-B 35® toothbrush. The Superbrush® removed more plaque in the vestibular surfaces in both the maxilla and mandible than the normal manual toothbrush. In addition, the manual toothbrush was less effective at removing plaque in the mandible than for the other two test toothbrushes. No differences were found for the API and PBI. In contrast, O'Beirne *et al.* (1996) found an improvement of clinical and biochemical parameters in patients with moderate periodontitis following an eight-week use of a sonic toothbrush (Sonicare), in comparison to a manual toothbrush. The fact that these results could not be confirmed in this study could be either due to the short, two-week duration of the test and/or to the fact that the flow effect of the sonic toothbrush (Stanford *et al.*, 1997) was not fully employed by the disabled subjects in this study.

Discussion of the results in the three test groups corresponding to the severity of the disability

The primary aim of the study was to test the effectiveness of different toothbrushes subject to various levels of oral hygiene skills in a group of disabled patients. The main focus of the discussion is therefore the consideration of the results in the different subject groups.

In the group of Self-Brushers, the Waterpik® achieved the best results, while the Superbrush® attained the worst results. Significant differences were found in the plaque values on the vestibular tooth surfaces. API and PBI showed no significant differences. In a study by Horowitz and Suomi (1974) a double-headed toothbrush was not found to be superior to a single-headed toothbrush in tooth cleaning by a dental hygienist. However, it must be borne in mind that a double-headed toothbrush is not comparable with the Superbrush®, because the former does not guarantee the correct vertical positioning of the oral and vestibular brush areas due to the lack of the 'occlusal' brush area. It must also be mentioned that the compact handle of the Superbrush® could prove to be an advantage, in particular for the Self-Brushers.

However, the electric sonic toothbrush was not able to fulfil the expectations for plaque reduction in the approximal areas based on other studies (Zimmer *et al.*, 1999). One possible reason for this could be a reduction of the flow effect in the fluid environment around the brush end due to the patient's flexed cheek muscles, as was observed during use.

The Assisted Brusher group was best able to perform tooth cleaning in cooperation with the guardian or career using the Superbrush®. Significant differences were found in the vestibular surfaces in the maxilla and in the oral surfaces in the mandible, by comparison with the manual toothbrush. The API as well as the PBI showed no differences. Similar results were shown by a study that was conducted in the USA in 1988. In patients with intellectual disabilities, a multi-headed toothbrush cleaned as well as a conventional manual toothbrush – in half the time (Williams and Schuman, 1988). In addition, this toothbrush was

proven to be particularly effective when it was used by trained nursing staff (Kambu and Levy, 1993).

In the group of Other Brushers, significantly more plaque was removed when using the Superbrush® in comparison to the simple manual toothbrush, in particular in the oral and vestibular surfaces of mandibular teeth. The sonic toothbrush did not clean any better than the normal manual toothbrush in this group. This is contradictory to the findings of Day *et al.* 1998, who investigated a group of disabled patients whose teeth were cleaned by the nursing staff. In their study, the sonic toothbrush Sonicare clearly performed better than a simple manual toothbrush with a 32% higher rate of plaque removal. On the other hand, in a study to test the effectiveness of an electric toothbrush in comparison to a manual toothbrush, used by intellectually disabled patients over 16 months, Bartel and Berggren (1991) found that both toothbrushes proved to be similarly effective. However, the authors also emphasised that motivation incorporated into a prophylaxis programme for patients and guardians or carers is more important than the type of toothbrush used.

In the Assisted Brusher and Other Brusher groups, the Superbrush® showed better results than the Oral-B® manual toothbrush and the Teledyne® sonic toothbrush. These results are consistent with the observations made by Didner (1996) and Bloch-Zupan and Maniere (1996). A factor to be considered in the assessment of these brushes is the lack of feedback from the client in terms of the pressure applied by the person undertaking the assisted brushing. However, it is acknowledged that the correct amount of pressure is very important for the proper use of the sonic toothbrushes.

Conclusions

Notwithstanding the point about small groups and the issue of what may be statistically may not be clinically significant, the three toothbrushes appear to be suitable for carrying out oral hygiene in disabled people. The three-headed toothbrush Superbrush® removed plaque most effectively from the smooth surfaces in the subject groups, Other Brusher and Assisted Brusher and can thus be recommended for these patients. In the Self-Brusher group, better cleaning was achieved in the vestibular region with the powered Teledyne Waterpik®. However, it remains unclear at this point to what extent the various characteristics of the brushes, in particular the handle design, influenced the effectiveness of cleaning. Whether these results can be sustained merits further research.

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