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ORIGINAL ARTICLE

Adoption of a toothbrushing technique: a controlled, randomised clinical trial

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Abstract The aim of this study was to evaluate the implementation of the modified Bass technique (MBT) and a brushing sequence using different instruction methods. Ninety-nine participants, aged 19–42, were randomly assigned to one of three groups (control group: no instruction; leaflet instruction group: verbal instruction using a leaflet; and demonstration group: verbal instruction supported by demonstration with a model, no leaflet). Participants were instructed twice with an interval of 2 weeks. To evaluate the implementation of the technique and brushing sequence, participants were filmed during toothbrushing at baseline and 2 weeks after the first and second instruction, respectively. The duration of brushing was measured. After the first instruction, 19% in the leaflet instruction group and 41% in the demonstration group fully performed the MBT, and 36% in both instruction groups fully adopted the brushing sequence. After the second instruction, 25% of patients in the leaflet instruction group and 62% in the demonstration group had adopted the technique completely. The brushing sequence was adopted by 63% in the leaflet instruction group and by 48% in the demonstration group. Only 16% in the leaflet group and 38% in the demonstration group adopted both the technique and brushing sequence after the second instruction. The results indicate the need to improve instructional strategies.

Keywords Clinical trial · Learning effect · Instruction · Toothbrushing technique · Patient education

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Introduction

As dental plaque is implicated in the aetiology of dental caries, gingivitis, and periodontitis, regular toothbrushing plays a key role in the prevention of these oral diseases [4]. In western societies, toothbrushing is performed with manual or electrically powered toothbrushes. With both manual and electrical-powered brushing, accurate technique is necessary to achieve optimal results. Many people have deficient dental hygiene [19] and brushing techniques [13, 17] which makes oral hygiene instruction necessary.

For manual toothbrushing, the modified Bass technique (MBT) is often recommended in order to achieve optimal plaque reduction with a concomitant protection of the oral tissues against mechanical irritation [11]. One major problem with this brushing technique is that it consists of complex motion sequences. First, the toothbrush should be positioned at a 45° angle to the gingival margin. Second, the brush should be moved with small horizontal agitations, back and forth. Third, with a vertical movement, the brush should be moved out in the occlusal direction, which means upwards in the lower jaw and downwards in the upper jaw, to wipe out debris. These motion sequences require dexterity and attention to technique. In addition, a special brushing sequence [14] is advised to ensure that all surfaces of the teeth are cleaned. This brushing sequence is also complex and seems to be difficult to adopt.

To the authors' knowledge, only a few studies have investigated the learnability of diverse brushing techniques [1, 12, 15, 23]; no study has taken the brushing sequence into account. However, several of those studies had methodological shortcomings, such as using a reduction in the plaque score as an index instead of showing whether the technique was really implemented [12, 23] or failing to include a non-instructed control group [1, 12, 15], ignoring

the possibility of a Hawthorne effect [6, 16]. In addition, studies dealing with toothbrushing efficacy and behaviour have often been performed with participants who are familiar with the medical or dental profession, which can lead to a bias within the study [10].

The aim of the present study was therefore to investigate by means of video recording how well a brushing technique (MBT) and a brushing sequence can be learned. Two different instructional methods were compared: (1) verbal instruction by using a leaflet and (2) verbal instruction supported by demonstration of the technique with a model but without a leaflet. Both instructional methods were compared with a non-instructed control group. Students who were not familiar with the medical or dental profession were selected as subjects and went through an instructional and motivational programme lasting 4 weeks. The null hypothesis was that there was no difference between the different instructional methods with regard to the adoption of (1) the brushing technique, (2) the brushing sequence, and (3) the brushing duration.

Participants, materials, and methods

Participants

The study was conducted in the dental clinic at the Department of Conservative and Preventive Dentistry of the Justus Liebig University of Giessen. The study conformed to the Declaration of Helsinki and was performed according to the guidelines of Good Clinical Practise. It was approved by the local ethics committee (Ethik-Kommission des Fachbereiches Medizin der Justus-Liebig-Universität Giessen).

The trial was planned as a prospective, single centre, single-blind, and three-cell study with an overall observation period of 5 weeks in accordance with the Consolidated Standards of Reporting Trials guidelines. Participants were students of the Justus Liebig University in Giessen without relationship to the fields of dentistry or medicine. After sample size calculation and considering dropouts or withdrawals, a sample size of $n=33$ for each group (99 in total) was targeted. Participants were recruited by announcements in the local press and by notices on news boards. All participants were given oral and written information about the products and the purpose of the study. All participants gave their informed consent.

The inclusion criteria were adult age, dentition with a minimum of 24 teeth, and the regular use of a manual toothbrush. Exclusion criteria were serious diseases, active periodontitis or history of periodontitis, multiple recessions with an extent greater than 1/3 of the root length, oral prostheses or orthodontic appliances, allergies to dental materials, physical disability with the potential to influence oral hygiene, and habitual toothbrushing with MBT.

Materials

For the study, the clinic provided each participant with an elmex® interX toothbrush (GABA International AG, Münchenstein, Switzerland); subjects continued with their habitually used toothpaste. Professional tooth cleaning was performed with scalers (S204S7, SH6/77, Hu-Friedy Mfg. Co., Inc., Leimen, Germany), a rubber cup (Pro-Cup, art. no. 991/30, KerrHawe, Bioggio, Switzerland) and fluoridated polishing paste (Tri Fluor O Clean, art. no. 984, KerrHawe, Bioggio, Switzerland).

Procedure, evaluation criteria, and responsibilities

For an overview, see the flowchart in Fig. 1. All participants gave written informed consent. The entire study comprised a total of four visits to the dental clinic for each participant.

The filming procedure was the same for all participants for all visits. Participants were filmed (not watched by the investigators), through a mirror while toothbrushing at baseline (baseline filming), after the first instruction (post-instruction filming) and after the second instruction (post-motivation filming). Participants in the control group were also filmed after the instruction at the last appointment (post-instruction control group filming).

Directly after filming, the instructions were given to the participants in the leaflet instruction group and the demonstration group. They were instructed in the brushing sequence [14] and in the MBT. A standardised text was used for the instruction of all participants. Participants were told that oral hygiene should take 3 min.

In the leaflet instruction group, verbal instruction was given using a leaflet, which contained the brushing sequence (Fig. 2) and the major steps of the MBT. In the demonstration group, verbal instruction was supported by demonstration with a model, but no leaflet was used. Participants in the leaflet instruction group and the demonstration group were asked to practise the MBT and brushing sequence at each toothbrushing within 2 weeks of both training periods. In the control group, no oral hygiene instruction was given. Since the oral hygiene instruction should not be withheld from the control group, these participants received verbal instruction supported by demonstration during the last visit and were filmed directly afterwards without any training period (post-instruction control group filming).

Evaluation criteria

To quantify the extent to which the MBT was adopted, the jaws were divided into sextants (Fig. 2); adoption was measured in one sextant per side (vestibular/oral) resulting in 12 score values per participant. The mean adoption score was calculated from the 12 score values for each participant.

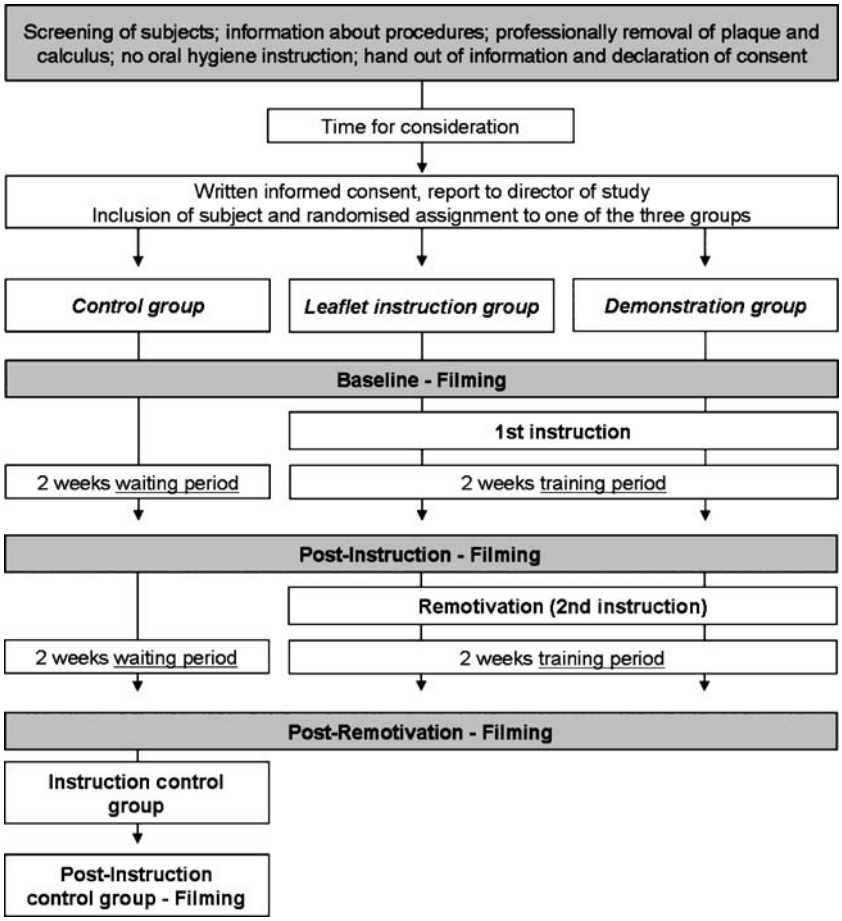

Fig. 1 Flowchart of the study procedures

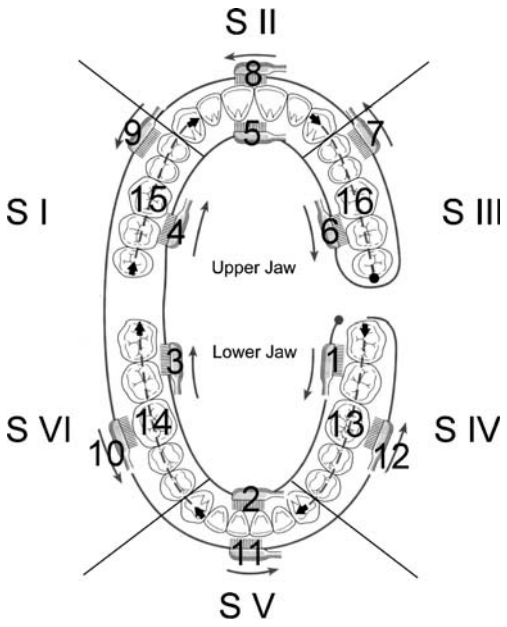

Fig. 2 Figure includes the brushing sequence [14] for right-handers (a mirror-inverted scheme was used for left-handers); the brushing sequence point score, which can be scored for each position; the frequency with which subjects adhered to the correct order (Arabic numbers); and the sectioning into sextants (Roman numbers)

The scoring system was

- score 1: "technique not adopted" (inadequate back and forth movement; incorrect wiping out; no right angle between the tooth surface and toothbrush),
- score 2: "technique partially adopted" (either the back and forth movement or the wiping out was correctly performed), and
- score 3: "technique totally adopted" (the horizontal as well as the vertical movements were correctly performed in terms of sequence and direction; the angle between tooth and toothbrush was correct).

To measure the adoption of the brushing sequence, a point score from 0–16 was given, depending on whether each position was achieved in the correct sequence (Fig. 2). Zero meant that the participant started at the wrong position, and 16 meant that the participant performed the complete brushing sequence in the correct order.

The duration of toothbrushing was recorded. According to the prevailing recommendations to brush at least 3 min, duration was classified with the following score:

- score 1: "tooth less than or equal to 180 seconds" and
- score 2: "toothbrushing longer than 180 seconds".

Responsibilities

The study director was responsible for the study logistics and the randomisation procedure. Investigation and data evaluation were carried out by two investigators. Investigator 1 was responsible for the initial tooth cleaning and the instruction. Investigator 2 was responsible for recording and evaluation of the films. Since investigator 2 did not know the group classification of participants, the evaluation of films was performed in a blinded manner. The investigators were carefully trained and calibrated. For calibration, investigator 2 evaluated three films ten times for technique, brushing sequence, and brushing duration (reproducibility was ±0.09 for the technique, ±0 for the brushing sequence, and ±0 s for brushing duration).

Randomisation and statistical analysis

Randomisation was performed using computer-generated random numbers, which were allocated to one of the instruction forms. The numbers were sealed in opaque envelopes, which were opened by the director of the study at the time when a participant was reported.

Statistical analysis was performed at the end of the study. No interim analysis was planned or performed. All statistical procedures were performed with the Statistical Package for Social Sciences for Windows (SPSS 11.0, Chicago, IL, USA). Data were tested for normal distribution with the Kolmogorov–Smirnov test. Since data were not normally distributed, non-parametric tests were performed. In cases of continuous data (median of technique adopting score and median of brushing sequence score), the Mann–Whitney test was used for group comparisons. The Wilcoxon test was used to compare the results of different recordings within one group. For comparison of discrete, ordinal scaled data (toothbrushing duration score), the Mann–Whitney test was used to compare the results from different groups; for comparisons of different recordings, the McNemar test with cross tabulations was performed. The level of significance was set at 0.05.

Results

A total of 98 participants were randomised into groups (control group and demonstration group, $n = 33$ each; leaflet instruction group, $n = 32$). Four participants were excluded after the second visit because they already knew the MBT (two in the control group and two in leaflet instruction group). For unknown reasons, ten participants failed to show up to the third visit (control group, three; leaflet instruction group, three; and demonstration group, four), and another seven failed to show up to the fourth visit (control group, one; leaflet instruction group, three; and demonstration group, three). A total of 77 participants completely finished the study (control group, 27; leaflet instruction group, 24; and demonstration group, 26). The mean age of participants was 26.6 years (range 19–42 years).

Modified Bass technique

At baseline, none of the participants used the MBT (all participants: technique score 1). After the first instruction (post-instruction), only 19% in the leaflet instruction group in contrast to 41% in the demonstration group fully performed the MBT. Thirty percent of participants in the leaflet instruction group but only 7% in the demonstration group did not change their brushing technique. A remotivation yielded an improvement in the adoption of the MBT. Only 25% in the leaflet instruction group totally adopted the technique; whereas, 62% in the demonstration group did so. The proportion of those who did not change their brushing habits diminished to 8% in the leaflet instruction group and 0% in the demonstration group. After instruction in the control group (post-instruction control group), 20% totally adopted the MBT; in 4%, no change of brushing habits was observed. Medians for all groups are displayed in Table 1.

Results split by sextant and side are displayed in Fig. 3a–d. Except for sextants II and V, the results were similar among the sextants. On the vestibular side, in both sextants II and V, fewer participants adopted the MBT after the first leaflet instruction. On the oral side, however, the percentage of subjects who adopted the MBT in both sextants after the first leaflet instruction was higher than in the other sextants. The differences nearly disappeared after the second leaflet instruction (remotivation). After the demonstration, there were no differences among the sextants after either the first instruction or after the remotivation.

Brushing sequence

In all groups, none of the participants performed the brushing sequence (score 0) at baseline. After first instruction (post-instruction), 36% in both instruction groups fully adopted the brushing sequence (score 16). Forty percent in the leaflet instruction group and 60% in the demonstration group displayed scores of 3 or less; 20% in the leaflet instruction group and 32% in the demonstration group yielded a score of 0. After remotivation, 63% in the leaflet instruction group and 48% in the demonstration group reached a score of 16. Only 26% in the leaflet instruction group and 19% in the demonstration group achieved scores of 3 or less; the fraction of participants who scored 0 declined to 11% in the leaflet instruction group

Table 1 Medians of technique and brushing sequence score and percentage of participants per group that brushed longer than 180 s

Group	Baseline			Post-instruction			Remotivation			Post-instruction control		
	Technique	Sequence	Duration (>180s)	Technique	Sequence	Duration (>180s)	Technique	Sequence	Duration (>180s)	Technique	Sequence	Duration (>180s)
Control	1.00^{A}	0^{A}	$19\%^{A,B}$	$1.00^{B,a}$	$0^{B,a,b}$	$43\%^{A,a}$	$1.00^{C,a}$	$0^{C,a,b}$	$37\%^{B,a,b}$	$2.25^{A,B,C}$	$12^{A,B,C}$	$85\%^{A,B}$
Leaflet instruction	1.00^{A}	$0^{A,B}$	$30\%^{A,B}$	$2.00^{A,B,a}$	$6^{A,a}$	$67\%^{A}$	$2.46^{A,B,a}$	$16^{B,a}$	$88\%^{B,a}$	–	–	–
Demonstration	1.00^{A}	0^{A}	$30\%^{A,B}$	$2.45^{A,a}$	$3^{A,b}$	$76\%^{A,a}$	$3.00^{A,a}$	$14^{A,b}$	$89\%^{B,b}$	–	–	–

Same *capital letters* indicate statistical significance within one group between different video recordings (lines); same *lowercase letters* indicate statistical significance between groups within one video recording (columns); $p \leq 0.05$

No statistical significance was found between control group values after the instruction (post-instruction control) and demonstration group values after the first instruction (post-instruction)

and to 10% in the demonstration group. After instruction in the control group during the last visit (post-instruction control group), 36% totally adopted the brushing sequence (score 16), which corresponds to "post-instruction" in the demonstration group. Thirty-seven percent of participants in the control group obtained scores of 3 or less after instruction, but only 5% scored 0. Medians for all groups are displayed in Table 1.

MBT and brushing sequence

The total adoption of both technique and brushing sequence was calculated by adding the technique score and the brushing sequence score for each participant. A maximum of 19 points could be obtained. After the first instruction, only 12% in the leaflet instruction group and 28% in the demonstration group adopted both and achieved a point score of 19. The values increased after the remotivation to 16% in the leaflet instruction group and to 38% in the demonstration group. After the instruction of the control group at the fourth visit (post-instruction control group), the adoption rate was considerably lower compared to the post-instruction values of the demonstration group; only 14% completely adopted both the technique and the brushing sequence.

Discussion

This randomised, controlled clinical study is the first to investigate the implementation or adoption of a brushing technique, a brushing sequence, and changes in brushing duration after different methods of instruction utilising video recordings. The technique of filming participants through a mirror has previously been used successfully and has negligible impact on the participants' behaviour [7, 17].

Although the question of how people acquire new motor skills has long been a focus of research [9], no consensus exists, at least in dentistry, about the optimal method of instruction [1, 8, 15, 18, 23]. Therefore, in the present study, the most established methods in daily clinical practise were compared: verbal instruction by means of a leaflet (leaflet instruction) and verbal instruction supported by demonstration with a model (demonstration). The study group was selected for high homogeneity. Furthermore, one can assume that highly educated people normally have the capacity for abstraction that facilitates learning.

With regard to the instructional technique, demonstration was superior to leaflet instruction. These results confirmed studies from dental research (for example, Addy et al. [1], Renton-Harper et al. [15], and Zaki and Bandt [23]). Previous reports have revealed that the demonstration of brushing technique with a model supported by verbal

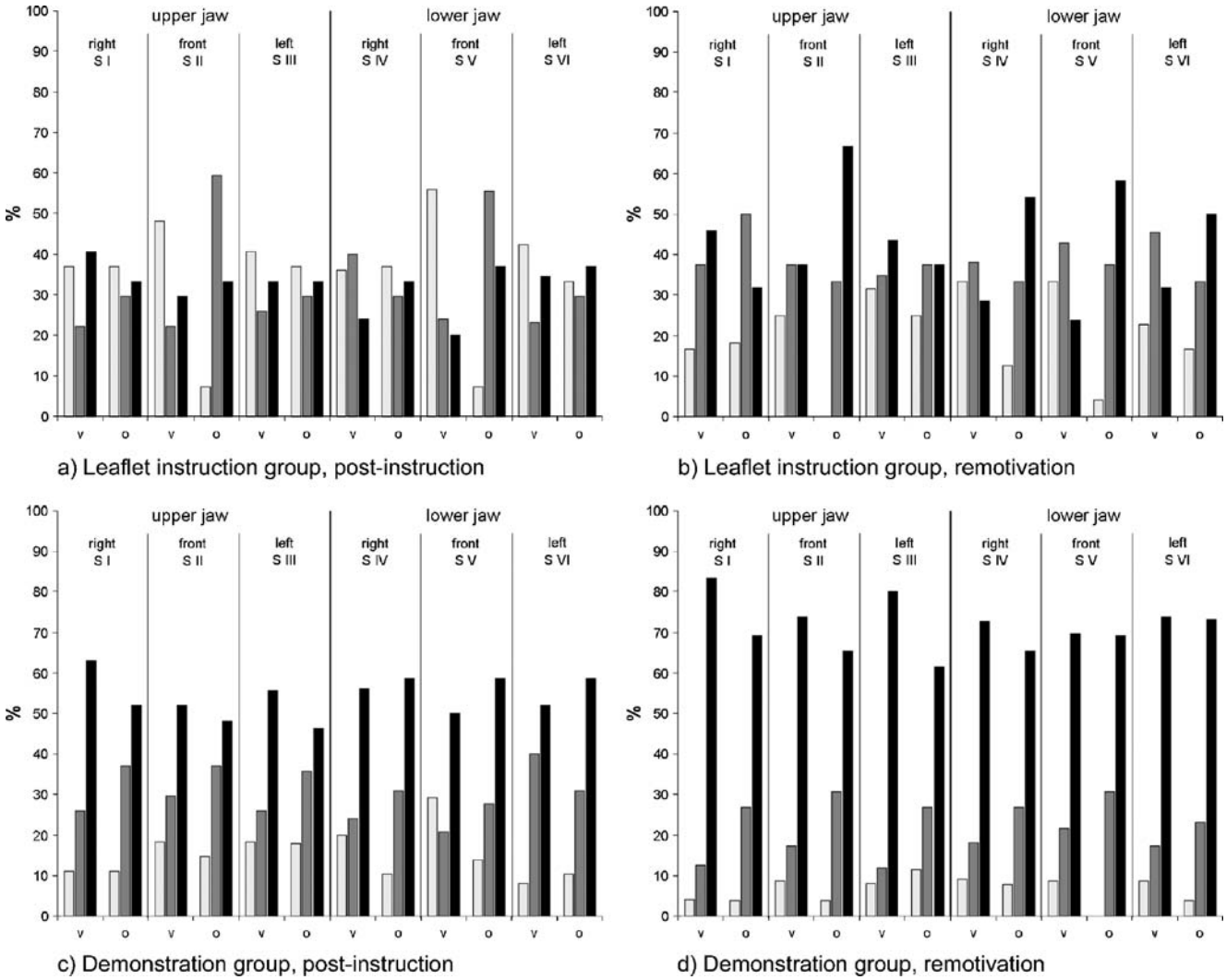

Fig. 3 Histogram of the adoption of the technique, sextant-wise (*light grey columns*: technique not adopted, score 1; *dark grey columns*: technique partially adopted, score 2; *black columns*: technique adopted, score 3 in the leaflet instruction group (**a**, **b**) and in the demonstration group (**c**, **d**) after the first (post-instruction) and the second instruction (remotivation; S I–S VI: sextant 1–6; *v* vestibular site; *o* oral site)

instructions [23] or the showing of an instructional video seems to be the most effective methods for conveying any brushing technique to a patient [1, 15]. Interestingly, in studies from sports science or motor behaviour dealing with different instruction methods [2, 9], a similar trend was shown: a demonstration of the relevant motions in combination with verbal instruction or instruction by means of a video resulted in the best implementation, since the demonstration conveys the form of the movement and the verbal instruction transmits the new information [9]. In cases of only verbal instruction using a leaflet, however, the participant has to visualise the movement and has to compose a complete moving sequence from the pictures and words. Studies from cognitive brain research have shown that it is essential to imagine or visualise a motion before learning is possible [3], and this requires substantially more cognitive performance to imagine and compose a motion from words and pictures as opposed to seeing a complex motion sequence.

Interestingly, the results of the control group after the instruction during the last visit (post-instruction control group) were only slightly inferior to the results in the demonstration group after the first instruction, indicating that a 2-week training period in the intervention groups had only a limited effect on the results. Likewise, a study investigating the learning of motions in sports after video demonstrations has shown that the performance of the motions directly after demonstration was similar to the performance 48 h after the instruction [20]. One could expect that complex motion sequences require considerable dexterity, necessitating a training period. However, the implementation of the technique seems to be primarily a

problem of comprehension and not of dexterity. The learning of new motor skills can be divided into two stages. During the early stage, the understanding of the task and the adjustment of existing movements are the major goals. Existing behaviours, however, (e.g., during habitual toothbrushing) can be very steady. In a previously performed study, it was shown that habitual brushing among participants, recorded during a 10-day interval, showed very high reproducibility [7]. During the advanced stages of learning, the movements become more automatic or routine. The advanced stages, however, are not achieved after a single training period of 2 weeks without any positive or negative feedback [9]. In general, the relatively good results in technique adoption in the demonstration group and after the instruction in the control group reflected the special characteristic of the study group: highly educated people (students) who were very motivated and interested in dental hygiene. With a study group, which is less selective and represents the general population more, less good results would probably be achieved.

The second instruction, especially in the demonstration group, led to improved adoption of the technique, confirming the results of previously studies [5, 22]. The principle of repeated instructions is also known from sport science. The more an athlete repeats one movement, the better he gets at it [21]. The mechanism explaining how the technique is retained over a longer period could not be answered with the present study, but long-term studies over 6 months or longer could provide more information.

In general, it is assumed that the success in toothbrushing depends on the location: for a right-hander, the right side of the jaw is said to be more difficult to brush than the left side. In general, the oral sites are assumed to be more difficult to access than the vestibular sites. The distribution of the results per sextant (Fig. 3a–d), however, showed that this assumption is not supported by the present results. In the demonstration group, there were no differences among the sites. In the leaflet instruction group, differences were only found at the upper and lower front sextants (S II and S V) but not in the molar region. Moreover, within these two sextants, the technique was much less frequently adopted at the vestibular than at the oral sites. However, these differences disappeared after the remotivation.

Considering the brushing sequence, it is remarkable that, even if the differences between both instruction groups were not statistically different after the second instruction, the brushing sequence was adopted less frequently after the demonstration as compared to after the leaflet instruction, meaning that the brushing sequence seemed to be better understood from the leaflet. It could be that the picture as a whole can be easily committed to and recalled from memory. After a demonstration, however, the single motions of the brushing sequence, which comprise multiple steps, have to be mentally assembled and manually transferred to the patient's mouth. Studies have shown that with complex motion sequences, the ability to use the information effectively and translate it into actions is important [9]. As shown in cognitive brain research studies, translation will be easier for motions or movements, which can be easily imagined before performing them (e.g., after seeing it on a scheme) [3].

The main problems regarding the brushing sequence lie in finding the right starting point and correctly performing the first few steps. Thirty-two percent of subjects in the demonstration group and 20% in the leaflet instruction group did not start in the right position. If the participant started correctly, the most difficulty arose from the movement between jaws (especially from station 3 to station 4). If station 4 was executed correctly, relatively few participants made mistakes in the following steps. These results should be considered if the brushing sequence is explained. The right starting point and the first switch between the jaws should be explained more explicitly.

The differences between the efficacy of demonstration and leaflet instruction in terms of technique and systematic could explain the low adoption percentage of both brushing sequence and technique. Improved technique acquisition may be facilitated by using a model for technique instruction and a leaflet for brushing sequence instruction in a repetitive manner.

Concerning the duration of brushing, we found an increase in all groups. Duration increased in 24% of participants without instruction (control group) and in 70% (90%) after the first (second) instruction, independent of the instruction method. Studies have shown that the Hawthorn effect can account for about 25% improvement [6, 16]. The increase in the control group corresponded to this effect, as the participant's attention was drawn to the oral cavity or oral hygiene. Generally, the brushing duration in the present study appeared to be relatively long, which was probably due to the fact that the participants were highly educated (students), very interested in dental hygiene, and motivated, since they had volunteered for the study.

Conclusion

Even if a special, relatively selective group was recruited for this study, only 16% in the leaflet instruction group and 38% in the demonstration group totally adopted both the MBT and the brushing sequence. The results presented indicate the need to improve instructional strategies. In this context, it is important to consider the research findings from sports and cognitive brain research. The combination of technique demonstration and instruction by means of a

leaflet for brushing sequence seems to be the most promising for teaching these dental hygiene practises, at least in the population studied.

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Conflict of interest None.

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