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FEATURE ARTICLE

An evaluation of the effectiveness of four mechanical plaque-removal devices when used by a trained care-provider

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for an aging population**

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An evaluation of the effectiveness of four mechanical plaque-removal devices when used by a trained care-provider

Many care-dependent elderly individuals live in nursing homes and must depend on nursing home aides for oral hygiene care. It is generally agreed that the level of oral hygiene care among care-dependent nursing home residents is less than optimal. Two reasons are time constraints and the difficulty involved in brushing other individuals' teeth. The identification of effective and efficient plaque-removal devices for use by care-providers should make it easier for nursing home aides to incorporate effective oral hygiene care into their daily routines. This pilot study was undertaken to determine the relative effectiveness of four plaque removal devices with different basic designs when used by a non-professional care-provider on 10 healthy volunteers. A brush with curved bristles on the lateral aspect of the brush head and short straight bristles in the center (Collis-curve®) and an electric toothbrush with tufts that rotate reciprocally (Interplak®) were the most effective, a conventional brush (Oral-B®) was somewhat less effective, and a disposable foam brush (Abco®) was least effective and similar to the pre-brushing plaque score (baseline). All the volunteers reported that the Collis-curve® was the most comfortable brush, and the care-provider reported that it was the easiest to use.

A substantial segment of the elderly population is dependent on others for the care of their mouths and provision of oral hygiene, often receiving no oral hygiene care or very limited care from untrained care-providers. Studies have consistently shown that the presence of bacterial plaque on teeth is an important etiological factor in both dental caries and inflammatory periodontal diseases.^{1,6} The removal of bacterial plaque from the tooth surfaces can prevent and control these diseases.^{2,5,7-10}

In nursing homes, plaque removal responsibilities generally fall on the nursing home aides, and the care that is provided is often less than ideal.¹¹ Studies have found that approximately two-thirds of dentate nursing home residents have dental caries.^{12,13} Perhaps better oral hygiene intervention by aides can help prevent dental caries. Emphasis must be placed on the effectiveness and efficiency of the plaque-removal device used in order to facilitate oral hygiene care.

Literature review

Obstacles to mechanical plaque control for the care-dependent elderly could include the limited importance that the care-provider assigns to his or her actions and the limited amount of time he or she is willing or able to devote to it. Most people spend very little time brushing their own teeth and probably are unlikely to spend more time brushing another's teeth. One study reported that most people spend between 40 and 60 seconds brushing their own teeth¹⁴, and another study reported that 73% spend 3 minutes or less¹⁵, while it has

been recommended that a minimum of 5 minutes is necessary to achieve effective plaque control for oneself¹⁶. (No similar standard has been stated for the care-dependent.) A recent survey found that nursing home aides self-reported spending an average of 4 minutes brushing residents' teeth.¹¹ Therefore, when evaluating mechanical plaque-removing devices for use in nursing homes, one must take into consideration the workload of the care-providers and critically examine the ease and time involved in the use of each device. Many nursing homes use either a conventional toothbrush or a disposable foam toothbrush for the oral hygiene of the care-dependent elderly.

Studies on the effectiveness of different toothbrush designs have not demonstrated definitively that any one head design, shape, or texture is absolutely better than another for routine removal of dental plaque.¹⁷⁻²² Electric toothbrushes have received considerable attention, but it has not been demonstrated that electric toothbrushes are consistently superior to manual toothbrushes in removing dental plaque and debris.²³⁻³⁶

There are few published studies that have investigated the efficacy of mechanical plaque-removal devices when used for care-dependent persons by responsible care-providers.³⁷⁻⁴¹ A study of nursing home residents³⁷ showed that a conventional straight-bristle toothbrush was more effective in stimulating gingival tissue and removing soft tooth debris than was the disposable foam brush. There were no statistically significant differences in plaque reduction between a conventional toothbrush

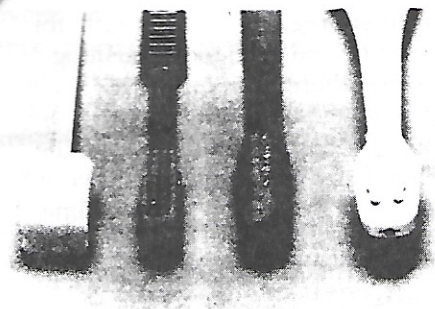


Fig 1. Mechanical plaque-removal devices (l-r): Abco[®], Oral-B 35[®], Collis-curve[®], and Interplak[®].

and the Collis-curve[®] toothbrush when used on profoundly mentally retarded individuals.³⁸ However, they reported that the same amount of plaque reduction could be achieved with the Collis-curve[®] toothbrush in about half the time. The Collis-curve[®] toothbrush removed significantly more plaque than did a conventional toothbrush when used by nursing staff on nursing home residents.³⁹ The majority of the nursing staff also reported that the Collis-curve[®] toothbrush was easier to manipulate and took less time.

Two recent studies^{40,41} compared the performance of two electric toothbrushes (Interplak[®] and Rotadent[®]) with that of conventional toothbrushes when dental students were providing the brushing with a geriatric population. Both studies found the electric toothbrushes to be more effective in reducing plaque and gingival inflammation. There are no published studies directly comparing all four devices (disposable foam brushes, Collis-curve[®], electric toothbrushes, and conventional toothbrushes), whether with healthy individuals or in a care-dependent population.

The identification of the most effective plaque-removal devices will aid health care professionals in recommending their use for the oral hygiene of the care-dependent. At present, few scientific data exist on the effectiveness of different mechanical plaque-removal devices when used with the oral-hygiene-care-dependent. The use of an effective plaque-removal device could decrease the incidence or severity of dental caries, gingivitis, and periodontitis and could

result in a cleaner and healthier mouth and increase oral comfort, taste perception, function, sense of well-being, and self-esteem. Substantial morbidity and health care treatment costs could be avoided.

The purpose of this pilot study was to evaluate plaque-removal effectiveness of four toothbrushes with different designs when used by a non-dental care-provider to brush another individual's teeth.

Materials and methods

Participants were selected from volunteers at the University of Iowa College of Dentistry. Thirteen volunteers were selected. Twelve healthy volunteers aged 20-42 were selected to act as care-dependent subjects. The screening criteria were:

- (1) a minimum of 24 teeth with no edentulous spaces between them;
- (2) no painful gingival inflammation;
- (3) no restorations with unacceptable margins or contours;
- (4) no teeth with caries adjacent to the gingival tissue;
- (5) not receiving antibiotic agents; and
- (6) no need for prophylactic antibiotics.

One volunteer, who was a homemaker, was selected to act as the non-professional care-provider. Informed consent was obtained from each volunteer.

The four mechanical plaque-removal devices (Fig. 1) compared were:

Device I. Abco[®], a disposable foam device (Abco Dealers, Inc., Milwaukee, WI 53218).

Device II. Oral-B 35[®], a conventional toothbrush with polished rounded straight bristles (Oral-B Laboratories, Inc., Redwood City, CA 94065).

Device III. Collis-curve[®], a toothbrush with curved bristles on the lateral aspect of the brush head and short, straight bristles in the center (Collis-curve, Inc., Minneapolis, MN 55409).

Device IV. Interplak[®], an electric-powered toothbrush with tufts that

rotate reciprocally (Bausch and Lomb Oral Care Division, Inc., Tucker, GA 30084).

Brushing techniques used with the four mechanical plaque-removal devices were:

Device I—A motion mimicking the Bass Technique.

Device II—Bass Technique.

Device III—Traditional Collis-curve[®] scrub method. Short, back-and-forth scrubbing strokes with the brush placed over the tops of the teeth so that the outside curved bristles straddled the teeth (as recommended by the manufacturer).

Device IV—Guiding the instrument slowly with the bristles perpendicular to the tooth surfaces (as recommended by the manufacturer).

Each device was used by the volunteer care-provider once on each subject. The brushing time for each device was exactly three minutes. Prior to the actual testing, the volunteer care-provider was trained and practiced using each device until she felt proficient.

A crossover design was used, with the order of the brushes chosen at random. Each device was used once with each subject at an interval of 24 hours after the previous device had been used. Each subject abstained from all mechanical plaque removal, *i.e.*, brushing and flossing, for 24 hours prior to baseline examination and before having their teeth cleaned with each device by the volunteer care-provider. Thus, each subject abstained from brushing independently for a total of five consecutive days.

The participants received a prophylaxis by one investigator (PK) prior to each 24-hour period of abstention from brushing. This investigator had no knowledge of which device was to be used.

Plaque levels of each subject were recorded by a second investigator (SL) who had no knowledge of what device had been used. Plaque levels were recorded at baseline and immediately after brushing with each device.

When the plaque level was scored, all remaining teeth (except third molars) were assessed. The facial and

lingual surfaces of each tooth were divided into five sections as described by Podshadley and Haley.¹² Vertically, there were three divisions: mesial, middle, and distal. Horizontally, the middle third was subdivided into gingival, middle, and occlusal or incisal thirds. A disclosing agent (Trace 28[®], the Lorvic Corp., St. Louis, MO 63134) was used to help determine the presence of bacterial plaque. The absence of plaque on an area was assigned a score of zero. The presence of any stained plaque on a given area was assigned a score of one. No attempt was made to differentiate the quantity of plaque on a given area. This was done to improve reliability. Thus, the total score for a single facial or lingual surface, obtained by summing the individual area scores, could vary from a minimum of zero to a maximum of five, and the tooth score could, therefore, vary from zero to ten.

The number of teeth varied from 24 to 28 (mean, 27.2) among the 10 volunteers who completed all examinations. Two subjects missed an examination and have been excluded from these analyses. Thus, the total number of areas examined varied from 240 to 280 per person (mean, 272). Each subject served as his/her own control within the crossover design.

To ensure standardization of scoring, the investigator conducting the plaque assessments (SL) was calibrated during a preliminary trial to establish consistency with the index being used. Four volunteers were examined twice each, with random sequencing, but no subject was scored consecutively. The scores were compared and analyzed for reproducibility by means of percent agreement and kappa scores.

The data analysis included descriptive statistics, repeated-measures analysis of variance, and Duncan's multiple range tests for comparison of individual means.^{13,14} Findings were considered statistically significant at $p < 0.05$.

Results

Intra-examiner reliability was 94% agreement, and Kappa was 0.876 for

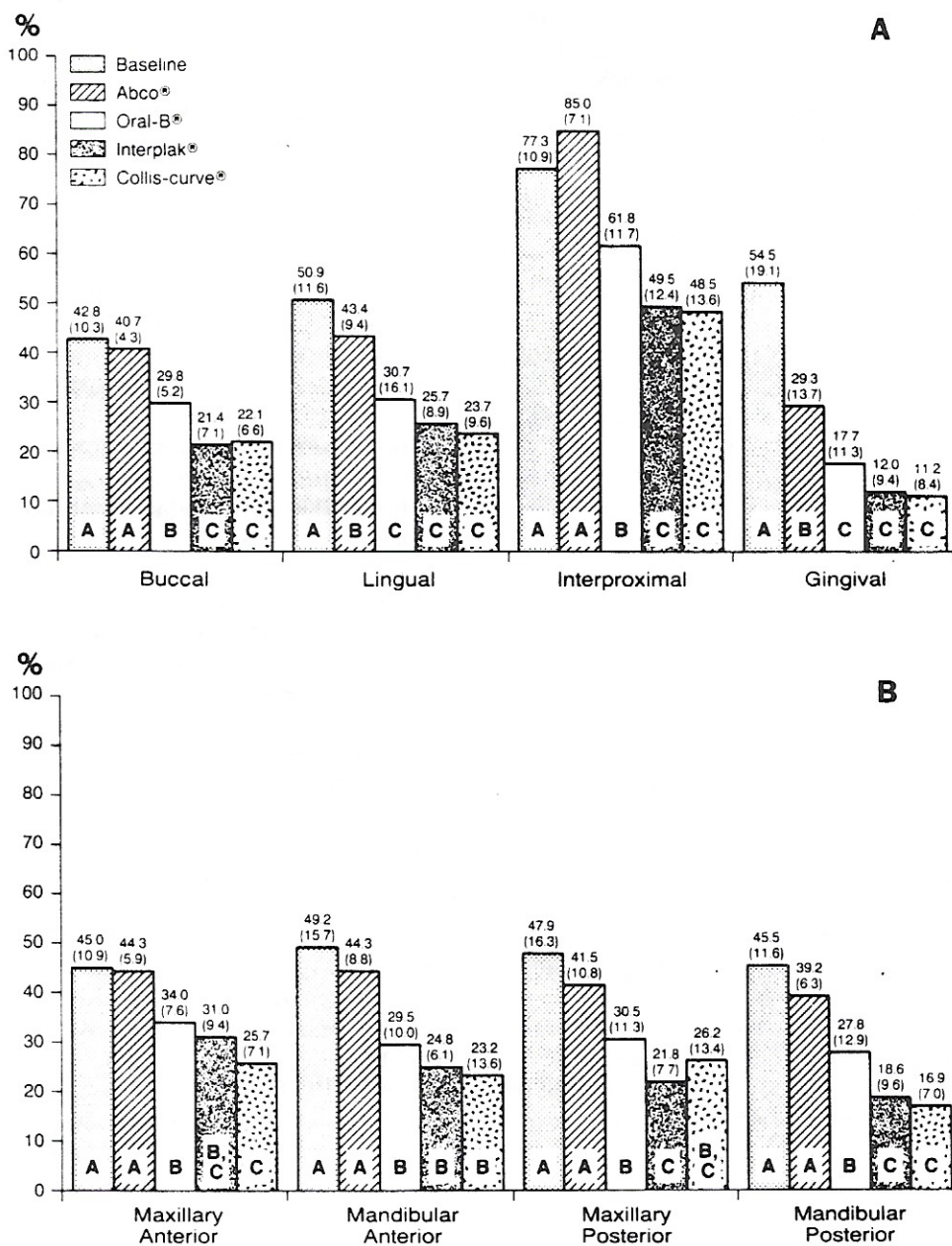
duplicate plaque score exams on the four subjects.

At baseline, subjects had plaque on an average of 42.8% of buccal areas, 50.9% of lingual areas, 77.3% of interproximal areas, and 54.5% of gingival areas examined (Fig. 2A). For each toothbrushing device, greater percentages of interproximal surfaces had plaque than did buccal, lingual, or gingival surfaces. Lingual surfaces were next most likely to be plaque-covered, followed by buccal and then gingival.

Figs. 2B and 3 show that in the

different regions of the mouth, for baseline and each toothbrushing device, there were fairly consistent percentages of tooth areas with plaque. For the whole mouth, the mean percentages of areas covered with plaque were 47% at baseline, 42% for Abco[®], 30% for Oral-B[®], 24% for Interplak[®], and 23% for Collis-curve[®] (Fig. 3).

When percentages of tooth areas with plaque were compared according to the five groups (baseline and the 4 devices), repeated-measures analysis of variance (ANOVA) showed an



Figs 2A and 2B. Mean percentages of areas with plaque by tooth groups (S.D.). Groups with the same letters had nonsignificant differences between means, $p > 0.05$.

presence of plaque, enhanced examiner reliability. A full-mouth plaque index such as this one, instead of one using index teeth only, is especially useful when studies with small samples are being conducted.

This study supports the findings by Blahut *et al.*^{40,41} that the electric toothbrush is more effective in plaque reduction than the conventional toothbrush when used by a care-provider. In this study, the electric toothbrush (Interplak[®]) consistently removed more plaque than did a conventional manual toothbrush (Oral-B[®]) from all tooth areas and tooth groups, although statistically significant results were found only with some tooth areas and tooth groups, including the whole mouth. A manual toothbrush with a non-conventional head design (Collis-curve[®]) removed slightly more plaque than did the electric toothbrush; however, none of the differences was statistically significant.

When the manual toothbrushes were compared, the Collis-curve[®] removed more plaque on all tooth areas and groups than did the conventional brush, with statistically significant differences for some areas and groups, including the whole mouth. Both of these manual toothbrushes were clearly superior to the Abco[®].

These results support the results of other studies^{37,39} which found that the conventional toothbrush was more effective than the disposable foam brush, and the Collis-curve[®] more effective than the conventional toothbrush when used by a care-provider. This study's agreement with previous studies on the lack of effectiveness of the disposable foam brush suggests that its use should be limited to situations where the patient cannot tolerate any other devices, such as in cases of severe mucositis or when used only as a moisturizer.

The observations from this study that the Collis-curve[®] was both the easiest brush to use and the most comfortable are consistent with findings from two other studies.^{38,39} In one study of a mentally retarded population, plaque removal with the Collis-curve[®] took less time, while in a study of a nursing home population, it

was easier to manipulate and also took less time.

It is important to point out that in this study the brushing time was limited to three minutes. The reason for this was to try to simulate the average brushing time among the general population and the institutional care setting, where time may be an important factor because of inadequate staffing or lack of time.¹¹ Somewhat different results might have been obtained if time had not been constrained. Even though plaque-removal results with the Collis-curve[®] and Interplak[®] brushes were not significantly different from each other, the Collis-curve[®] brush, which is a manual toothbrush, may be better received by the nursing home community, because it costs less and requires less maintenance. Cross-contamination with the electric toothbrush may also be a factor if, in an effort to keep costs down, the electric toothbrush power source is shared among multiple residents.

More research needs to be done to improve the oral health among the care-dependent population. A longitudinal study of longer duration evaluating various mechanical oral hygiene devices should be conducted in actual nursing homes to verify the effectiveness of the different toothbrushes reported from this pilot study and other studies. It is very important that such studies also evaluate the acceptance of the devices among the care-providers and the care-recipients.

Summary

In this pilot study, which simulated the conditions for the care-dependent, the Collis-curve[®] and Interplak[®] toothbrushes were the most effective in removing plaque when used by a lay care-provider on 10 volunteers. The Oral-B 35[®] conventional toothbrush was also effective in plaque removal, but less effective than the Collis-curve[®] and Interplak[®]. Abco[®] was ineffective in plaque removal, with little improvement over baseline values where no oral hygiene had been performed.

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