A CLINICAL TELEVISION EVALUATION OF PLAQUE FORMATION AND GINGIVITIS IN HANDICAPPED CHILDREN

by

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INTRODUCTION
Because of the physical limitations and varying levels of mental retardation, regular oral hygiene procedures are often difficult or impossible for the handicapped patient. Many investigators have reported on the high incidence of caries,\textsuperscript{1-5} periodontal disease,\textsuperscript{6-10} and malocclusion\textsuperscript{11} in the handicapped patient. Periodontal disease has also been a common finding among normal children,\textsuperscript{12-17} and several investigations\textsuperscript{18-22} have shown improvement in the condition of gingival tissues after periods of controlled toothbrushing procedures.

In evaluating oral hygiene procedures and the condition of the gingival tissues, Ash\textsuperscript{23} noted that investigators are plagued by such factors as the absence of a common method of evaluation, marked variation in criteria, examiner error, differences in groups evaluated, and statistical problems. These problems are apparent in many reported studies and it is therefore difficult to make valid conclusions about the effectiveness of the electric toothbrush,\textsuperscript{24-28} modified toothbrush,\textsuperscript{29} or other approaches to oral hygiene.\textsuperscript{30-34} Several clinical indices which measure changes in gingival tissues and amounts of plaque on the tooth have been reported.\textsuperscript{35-45} Many of these are also subject to errors. More accurate measurements of plaque from clinical photographs with a planimeter have been reported.\textsuperscript{46-47}
Arnim\(^{14}\) was aware of these discrepancies in evaluation of oral hygiene and the effects on oral health:

"...the revealing disclosing solutions upset these preconceived notions (fibrous foods clean teeth; teeth should be brushed after every meal) ....oral hygiene methods conventionally taught failed to clean those surfaces and gingival areas where dental disease usually begins.... A statistically significant reduction of plaque is not necessarily good enough to produce a thoroughly clean surface or to prevent dental caries and periodontal disease."

The purpose of this thesis was to evaluate changes in the gingival tissues and in the level of oral hygiene in a group of handicapped patients using two oral hygiene devices. One of these was a sponge rubber device\(^{14}\) which requires little manual dexterity for its use while the other was a manual toothbrush. To evaluate results obtained with these two devices, clinical plaque and gingival indices were used as well as area measurements of plaque on anterior teeth from photographs by means of a television measurement instrument.
REVIEW OF LITERATURE
In summarizing the history of oral hygiene, Hirschfeld described the use in prehistoric time of a device such as a toothpick or a piece of straw for removing food from between the teeth. Twigs were used as toothbrushes several centuries ago while the bristled toothbrush was first reported in the seventeenth century. Hirschfeld was keenly aware of the insight of nineteenth century dentists who taught oral hygiene to their patients:

It is intriguing to find that many dentists of more than a century ago were hardly a minute behind us in modern thought, and that we have added comparatively to the fundamental knowledge of oral hygiene already registered by them.

The role of oral hygiene in the prevention of caries and periodontal disease has often been discussed. Dental disease has been related with the frequency of toothbrushing and more recently with the occurrence of dental plaque. Stallard pointed out that periodontal disease is a chronic condition originating in the young, with dental plaque thought to be the main etiologic agent, and he concluded:

By improvement of the oral hygiene status, the result is always a reduction in both diseases caries and periodontal disease.... The maintenance of a clean healthy mouth for every patient must be the goal for the entire profession.

A positive correlation between the amount of plaque on the teeth and the degree of gingivitis was reported by Ash and his associates after measuring plaque and gingivitis in a group of 78 periodontal patients. Arnmim related caries and periodontal disease to microbial masses—"microcosms"...
found on the teeth. He felt that changes in dietary habits as well as strict adherence to an oral hygiene program which would include the use of a soft nylon-bristled toothbrush, unwaxed dental floss, disclosing wafers, and an irrigator, could prevent these diseases. Bibby also felt that removal of microorganisms was necessary to prevent periodontal disease. He wrote:

More lasting results can be obtained by keeping accumulations of bacteria away from the necks of the teeth by means of good oral hygiene, good periodontal scaling and cleaning, and where necessary, the re-establishment of conditions which will make this possible.

Brandtzaeg reported a linear relationship between periodontal scores and plaque indices in a group of Norwegian army recruits. The reported frequency of toothbrushing, educational level, or place of residence prior to induction bore no relationship to the gingival conditions observed.

A number of investigations on the effects of oral hygiene in the prevention of gingivitis were conducted by Linde, Koch and their co-workers. In their investigations, Swedish school children were taught a rigid brushing method which they executed each day in school under the supervision of a nurse. Other groups of children were observed as controls and either received free dentifrice for home use and no instructions, rinsed their mouths with distilled water at school on occasion, or did nothing. A reduction in the amount and severity of gingivitis was observed in the experimental
groups. However, a follow-up study by the same investigators one year after the completion of the program showed little difference between the gingival tissues of the control group and the experimental group. The writers felt that brushing had regressed in the experimental group during the year since brushing technique had been stressed more than reasons for brushing.

One can conclude from the aforementioned studies that plaque is an important factor in gingival and periodontal disease and that plaque removal can improve the gingival tissues. The role of oral hygiene in the prevention of dental caries, however, has been subject to more controversy. Conflicting results have been reported in the literature: some investigators have shown a reduction in caries with "good oral hygiene," but others have shown no effects or even undesirable effects with a hygiene program. However, all of these studies have been based mainly on the frequency of toothbrushing, and little or no mention has been made regarding the efficiency of brushing in these studies. For example, Manbridge reported a lower incidence of caries in school children with regular brushing habits, as did Kerr and Kesel and Brucker. Studies by Miller, and Hewat, on the other hand, showed either no effect of brushing or an actual increase in new carious lesions when brushing was the only preventive procedure utilized.
ORAL HYGIENE REGIMENS

In evaluating toothbrushing methods for preschool children, McClure found that many of the children were unable to manipulate a toothbrush by themselves and that the most effective oral hygiene resulted when the parent was instructed in a "scrub-brush" type of method advocated by Starkey.

Dahl and Davis found that children between the ages of six and fifteen do not brush frequently. An average brushing time of 60 seconds and an average brushing frequency of 1.4 times per day were reported.

Comparative studies of toothbrushes have produced varying results. Huff and Taylor compared eight toothbrushes commonly used in pediatric practices with an electric toothbrush. They concluded that the electric toothbrush was superior since it took 23 seconds less on the average to clean one-half of the mouth than did the conventional brush. Of the eight conventional toothbrushes used, the brush with natural bristles was found to be the least effective.

A number of other investigators have also found the electric toothbrush to be superior to the manual brush. The criteria used ranged from more efficient removal of plaque and debris to changes in the gingival tissues. However, other investigators have reported no significant differences in the cleaning ability of
the electric toothbrushes. In general, these latter studies have had fewer variables measured with quite sensitive measurements being made over longer periods of time.

Bay and his co-workers found that an unconventional brush with converging bristles removed plaque more effectively than six other commonly used brushes. Maurice and Wallace, on the other hand, found that the manner in which a toothbrush is used is more important that the type of brush used.

Archer concluded that the toothbrush is an inefficient tool and that its proper use demands too much to affect adequate cleansing of the teeth. Several attempts have been made to improve oral hygiene by methods other than brushing. The self-cleaning action of the mouth in English school children after eating bread was measured by Goose and Jones. They described a concept of food "awareness" in the mouth and felt that a person who is not "aware" of the presence of retained food would be less likely to have a self-cleansing mouth. The idea of stimulating saliva to remove this remaining food was presented by two investigators. Clark reported that a tablet which stimulated all four types of taste buds induced a copious supply of saliva which enhanced food removal. Slag and his co-workers found that these tablets reduced the incidence of new carious surfaces in elementary school children but that the degree of cooperation of the subjects was a variable which would significantly limit the effectiveness of such an approach on a mass scale.
The use of chewing as an aid in oral hygiene has been suggested by several investigators. Whitling\textsuperscript{32} noted the impracticality of carrying a toothbrush for regular use and felt that a palatable, fibrous material which contained no fermentable carbohydrates might be an acceptable substitute. Packman and his co-workers\textsuperscript{23} found that chewing gum caused a more rapid rise in oral pH conditions after a glucose rinse than did toothbrushing.

To further study the use of mastication for oral hygiene, Levenson\textsuperscript{40} developed a chewable sponge device which is designed to clean the teeth and stimulate the gingival tissues by physical scrubbing and interdental hydraulic flushing. The use of this sponge device for the application of topical medications in the dental office or at home has also been reported.\textsuperscript{78-79} This type of device seems well suited to the application of topical fluorides, and Carter\textsuperscript{78} feels that satisfactory results can be obtained when there is close cooperation between children, their parents, and the dentist. No clinical results have yet been published. Levenson and Burwasser\textsuperscript{79} showed with fluorescing disclosing solutions that topical solutions could be forced into interdental areas with a chewable sponge device.

Several investigators have reported on the effectiveness of patient education in promoting oral hygiene. The role of the dentist and dental hygienist in motivating people to
brush their teeth was studied by Dudding and Muhler. They found that 61 per cent of children with what was classified as "good" oral hygiene had been taught to brush by a dentist. Massler and his co-workers concluded from observations of the oral hygiene and gingival conditions of naval recruits participating in a toothbrushing program that little improvement in gingival conditions could be observed when oral hygiene materials were given without any instructions. Christman found that sixth-grade children who received dental health lectures in school as part of a self-applied prophylaxis program were motivated towards dental care and improved their oral hygiene. Williford also found an improvement in oral hygiene and gingival conditions among high school students receiving an educational program in dental health. A noticeable difference in retention of dental health education material between socio-economic groups was reported by Haefner. He found that subjects from lower socio-economic groups retained health information when fear was induced while subjects from higher socio-economic groups retained information when it was presented objectively.

The use of disclosing solutions as adjuncts to brushing has also been widely discussed. In a study of the effectiveness of various oral hygiene measures, Armin felt that disclosing wafers should play an important role in the improvement of oral health as part of a comprehensive oral
physiotherapy regime. Teutsch advocated use of the wafers in a pedodontic practice as a means of pointing plaque material out to parents and children during tooth-brushing instructions. Toto and his co-workers found that children receiving instructions in brushing with disclosing wafers could clean their teeth more effectively than children who did not use the disclosing wafers, whether a conventional or electric toothbrush was used. Toto and Sawinski found that detailed instructions and the use of disclosing wafers resulted in cleaner teeth in a group of 579 young school children using either electric or manual toothbrushes. The type of brush was not considered as significant as the type of instructions given, and brushing without dentifrice did not reduce the effectiveness of the brushing program.

PERIODONTAL DISEASE IN CHILDREN

Zappler described four characteristics of the gingival tissues of children: a more pronounced red color than is usually seen in adults; a shinier, less-stippled surface texture; rounded margins; and in general, flabbier tissue tone. She also concluded that an average sulcus depth from two to six millimeters could be considered normal. Rosenblum studied the clinical depth of the gingival sulcus in the primary dentitions of 29 pre-school children. Deciduous teeth that were free of gingival inflammation were measured with a modified anesthetic syringe which was sensitive to 0.1 millimeters. A mean depth of 2.1 millimeters
from a total of 2900 measurements was reported, and an increase in sulcus depth from anterior to posterior teeth was found in most of the subjects observed. McIntosh\(^90\) reported a high prevalence of "periodontal pockets" in children between the ages of six and eleven. However, it must be pointed out that any sulcus over three millimeters was considered to be a periodontal pocket and it was not specified which teeth were in the process of exfoliation or eruption at the time of the study.

Calculus deposits, which are considered to be prime etiologic agents in gingival disease, were observed in 95\(\%\) elementary school children by Everett and his co-workers.\(^91\) They found very little calculus in general, and they reported that supra-gingival calculus on the lingual surfaces of mandibular incisors was the most common type of deposit observed. No significant differences between sexes or socio-economic groups could be observed, and an increase in the incidence and size of deposits with age was reported.

A number of studies on the prevalence of gingivitis in children have been reported. A high incidence of gingivitis, mainly in papillary areas,\(^12\)\(^-\)\(^14\) has been a common finding, and an increase in incidence from ages three until eleven, with a subsequent decrease, has also been observed.\(^12,\)\(^13,\)\(^15\) Little difference has been found between sexes\(^12,\)\(^14\) or socio-economic backgrounds.\(^12\)\(^-\)\(^16\) Gingivitis has been a very common finding around exfoliating deciduous teeth and erupting permanent
teeth, 15, 17, 68, 92 and this may account for the increase and subsequent decrease in gingivitis observed during and following periods of tooth eruption.

ORAL CONDITIONS OF HANDICAPPED PATIENTS

Massler 93 defined the handicapped child as any child in whom there exists a physical, mental or emotional defect which interferes with his ability to solve life's problems and prevents him from integrating into normal daily activity. Many reports in the literature describe various dental problems observed in children with cerebral palsy, 94, 1-6, 11, 99, 100, 104, 65, 107 mentally retarded children, 1, 7-9 and children with epilepsy. 108

Cohen 95 said that the inability for handicapped patients to chew well, the resulting soft diets usually rich in carbohydrates, and the complete or nearly complete lack of oral hygiene were etiologic factors in the high incidence of dental disease among these patients. Hori 96 studied dietary habits of 30 cerebral palsy patients and found that their diets were predominantly soft and lacking in calories, ascorbic acid, and calcium when compared to 30 normal children examined as controls. Elfenbaum 97 pointed to a normal musculature and properly maintained dentition as necessary for rendering the mouth self-cleaning, and said that any condition interrupting normal function could predispose the mouth to disease. An electromyographic study of the obicularis oris muscle of spastic diplegics
by Buckley\textsuperscript{98} showed that the fibers on the affected side were hyperactive when the patient was performing routine functions such as drinking through a straw and swallowing yet normal when at rest.

The caries experience of cerebral palsy patients has been found to vary in several reported studies. Most investigators have found that cerebral palsy patients had more caries than normal children. For example, Album and his associates,\textsuperscript{1} Mangnusson and DeVal,\textsuperscript{2} Lyons,\textsuperscript{3,4} and Schmaarak and Bernstein\textsuperscript{5} reported a higher incidence of caries in the cerebral palsy patient. Fishman and his co-workers\textsuperscript{104} in a study of cerebral palsy patients and their siblings found that caries incidence within families was very similar. Leonard\textsuperscript{105} reported less caries in cerebral palsy patients than normal children, but his patients were from dentally-educated families with higher socio-economic backgrounds.

Herman\textsuperscript{106} reported an incidence of enamel hypoplastic defects in cerebral palsy children six times greater than in a group of normal children examined as a control.

Gingivitis in the cerebral palsy patient is a common finding. Mangnusson and DeVal\textsuperscript{2} found three times as much gingivitis in children with cerebral palsy as normal children, while Weisman\textsuperscript{6} reported a 90 per cent incidence in spastics, 83 per cent incidence in ataxic children, and 67 per cent incidence in athetoids. It must be pointed out, however, that Weisman did not examine normal children as controls, and that other studies\textsuperscript{12-17, 92} have reported
similar findings in normal children. In general, poor oral hygiene is blamed as the primary cause of gingivitis in these patients. Other conditions that have been cited as causes of gingival disease in the child with cerebral palsy include the following: Malocclusion\(^1,100\) vitamin deficiencies,\(^{100}\) lack of muscular coordination with associated mouth breathing, bruxism and drooling,\(^2, 104, 107\) changes subsequent to dilantin therapy,\(^{99-100}\) and neglect by parents and the dental profession.\(^3, 4, 99, 101, 105\)

A high incidence of malocclusion has been reported in children with cerebral palsy.\(^1, 3, 4, 11\) Koster\(^11\) associated the Angle Class II division 2 malocclusion with athetoid children and unilateral crossbites with the affected side of spastic diplegics. Album\(^1\) reported a very high incidence of class II malocclusions with anterior open bites as a common finding in cerebral palsy patients. Rosenbaum\(^102\) reported rather different findings. In a well-controlled study where normal children were examined as a control and careful observations of the occlusion were made, he found that incidence of malocclusion, tongue thrust, open bite, or bruxism was the same for both groups but that the conditions are generally more severe and thus more noticeable when observed in the cerebral palsy patient. A roentgenographic cephalometric study conducted by Fettes\(^103\) also showed that cerebral palsy patients in general have similar skeletal patterns as those seen in normal children.
The dental problems of mentally retarded children have been discussed by several investigators. After examining 113 non-institutionalized mentally-retarded children, Snyder and his co-workers\(^7\) found that caries incidence was low but that periodontal disease was prevalent when compared with normal children. It was found that about half of the group used a toothbrush less than once a week. After one year, Snyder\(^8\) reported that the dental health picture of this same group had changed as a result of the examination and the suggestions made to parents of the children. Periodontal disease was more prevalent but less severe, oral hygiene and frequency of toothbrushing had improved, diets were more favorable, and the children were seeing the dentist more frequently.

In a comparative study of mongoloid and non-mongoloid mentally-retarded children, Johnson\(^9\) found that both groups had a 100 per cent incidence of some form of periodontal disease, but that the mongoloid children had more severe horizontal bone loss to be a common finding\(^9,6\) in mongoloid children.

Adelson\(^10,8\) observed epileptic children and noted a frequent finding of fractured teeth, scarred tongues, signs of bruxism, and gingival enlargement subsequent to dilantin sodium therapy. No normal children were observed as controls in this study.
ORAL HYGIENE FOR THE HANDICAPPED PATIENT

The importance of oral hygiene for the handicapped patient was outlined by Fuller and Dunn:109

1. Hygenically, it allows the handicapped person to care for the teeth and supporting structures.
2. Physically, it gives a purposeful activity to daily living.
3. Psychologically, it gives a feeling of self-esteem and accomplishment to the otherwise frustrated, discouraged handicapped individual.

Bush110 felt that low carbohydrate diets, fluoride treatments, thorough brushing, and stimulation of the gingiva were all necessary for the handicapped child to follow in order to maintain oral health. She noted that the parents of these children often have to brush the teeth and suggested a position in back of the child since it not only is comfortable for both child and parent but also provides emotional security for the child. A program in toothbrushing for 12 mentally retarded children in a special education class111 showed that these children required much individual help and repetition to master and retain information and techniques of toothbrushing.

Tronquet112 also noted that hospitalized patients have very poor oral hygiene because of physical limitations and lack of personnel adequately instructed in hygiene procedures. A toothbrush attached to hospital suction equipment was described, and it was felt that hospital personnel could use this brush at bedside to maintain or improve the oral hygiene of bed-ridden patients.
The electric toothbrush has been suggested as an adjunct to hygienic procedures for the handicapped patient because it requires less manual dexterity than conventional brushes. Lucente reported that the electric toothbrush is a valuable aid in an institution for severely retarded children. He did not present data but noted that attendants could clean the mouths of the children easily and that children did not object to brushing as much as they did when conventional brushes were used.

Some studies with electric toothbrushes for handicapped patients have shown the electric brush to be superior to the conventional brush. Smith and Blankenship evaluated twenty handicapped children who used either electric toothbrushes or conventional brushes. Some of the children brushed themselves while attendants brushed for the more debilitated children. The authors concluded that the electric brush was accepted with more enthusiasm and that it removed plaque more effectively.

A group of twenty spastic children used automatic brushes and conventional brushes for two-week periods. It was noted that both brushes produced an improvement in oral hygiene, but after a period of time, the conventional brush was not used as effectively since patients forgot the proper brushing techniques. Doykos and his associates found that thirty children who because of physical disability
were unable to use a conventional toothbrush significantly improved their oral hygiene and reduced gingivitis over a six-month period while using electric toothbrushes. Only one type of brush was used, however, and no other children were used as controls.

Other studies have shown improvement with both conventional toothbrushes and electric toothbrushes. Kelner\textsuperscript{118}, \textsuperscript{119} evaluated the electric and conventional brushes with a group of mentally retarded. In one study\textsuperscript{118} he reported a 69 per cent improvement in hygiene in the group using the electric brush and a 33 per cent improvement in the group using the conventional brush. Criteria for evaluating the hygiene level were not clearly outlined, however.

Gartenrich and Lewis\textsuperscript{120} studied four large groups of institutionalized children ranging from educable to severely retarded levels. The educable children had their teeth brushed by attendants. The authors observed that an electric toothbrush produced consistently "good" results but tended to regress during the same stressful period. The authors concluded the trainable and educable children are capable of the same results with manual or electric toothbrushes and that the decision to have all automatic brushes should be weighed very carefully when funds for health services are limited.

In still another study of the effects of electric toothbrushes, Oldenburg and Wells\textsuperscript{116} evaluated thirty-nine
children with cerebral palsy after using a manual brush for two weeks and then an electric toothbrush for two weeks. A debris index was used and the examiners did not know which brush the patients were using at the time of the examinations. Their results showed no significant difference in the reduction of debris in the two groups.

On the basis of these reports, it appears that the electric toothbrush is quite useful in providing oral hygiene for handicapped persons but that manual brushes in many cases can produce equally good results. Thus, the routine endorsement of electric toothbrushes for all handicapped patients should be questioned.

Special modifications to conventional or electric brushes which enable the handicapped patient to brush himself have also been suggested.\textsuperscript{122, 124} Hoffman and his co-workers\textsuperscript{124} described a large self-curing acrylic handle which could hold various toothbrush heads bent in different directions. The large handle makes it easier to manipulate the brush and the various heads give access to different parts of the mouth. Chilton and Kutscher\textsuperscript{122} described a modified handle for an electric toothbrush which allowed a man with arthrogryposis (a condition severely limiting limb movements) to brush his teeth by himself. The condition of his gingival tissues improved after he had used the brush for a time.
A sponge device which can clean the teeth and stimulate the gingival tissues by physical scrubbing and interdental hydraulic flushing has already been described.¹⁴ This device was shown to improve hygiene and reduce gingival inflammation in a group of handicapped persons, but Levenson¹⁴ did not use normal persons as a control nor did his sample use conventional brushing methods. This chewable device was compared with a toothbrush in a group of orthopedic patients by Holcomb.¹²⁵ One-half of his sample used manual toothbrushes and the other half used the chewable sponge device. Using a plaque index in conjunction with a disclosing solution, he found that the chewable sponge improved oral hygiene, but did not significantly, while the toothbrush improved hygiene significantly. Although Holcomb felt that neither device could be graded superior in cleaning ability because of uncontrolled variables, he noted that the chewable sponge was easier to use than the toothbrush and could be a valuable adjunct to the oral hygiene program for handicapped patients. It should be noted, though, that his study was limited to hospital patients and covered only the time of their hospital stay, which ranged from four to fifteen days.

Finally, mouthwashes have been suggested as an adjunct to hygiene for the handicapped.¹²⁶,¹²⁷ Tassman and his associates¹²⁶ evaluated a carbamide peroxide mouthwash in 141 patients, of whom 25 were handicapped. The authors reported an improvement in oral hygiene and a reduction in
gingival inflammation when this solution was applied daily with a gauze square. No control was reported, however, and the criteria used to evaluate hygiene and gingival tissues were not spelled out. In another study, Weisman\(^{127}\) reported similar improvements in hygiene and reduction in mouth odors in sixty-two handicapped patients who used a chloropatic mouthwash for ninety days. No criteria were listed, and no control was reported used.

**INTRACRORAL MEASUREMENT OF HYGIENE AND GINGIVAL CONDITIONS (Indices and Instrumentation)**

A number of indices for evaluating the periodontal status of patients have been reported. O'Leary and his associates\(^{40}\) spelled out the criteria for a good index:

1. It must have definitive, easily understood criteria.
2. It must assess both the gingival and periodontal structures.
3. It must accurately detect the presence of gingival or periodontal disease requiring treatment.
4. The procedure must be such that it can be carried out within a reasonable time (four to six minutes).
5. The examination must be of a nature that it can be readily taught to general dentists.

Indices which relate crevicular or pocket depth to a numerical value have been advocated by Ramfjord\(^{36}\) and Russell.\(^{35}\) These indices place more emphasis on increasing pocket depth and do not allow for sensitive measurement of stages of gingival inflammation. Masler\(^{37}\) described an index which measures only gingival changes and which artificially divides the gingival tissues in unit groups of papillae, margins, and attached tissues. Other indices which measure discreet inflammatory changes in the gingival
tissues have been described by Lee, Greene, and O'Leary is made up of three separate divisions:

1. A gingival score which has an average of six segmental scores.
2. A periodontal score based on sulcular depth; the cemento-enamel junction is used as a reference point.
3. An irritant score which measures the presence of calculus, materia alba, and defective restoration margins.

This particular system was found to be very consistent between examiners and to show a high correlation between segmental scores in which the most involved tooth in a segment determined a segment score and other scores in which all teeth in the mouth were assigned a value. O'Leary concluded that a segmental-type of index is a more accurate measurement of an individual's periodontal status while an index which measures a few selected teeth is adequate for epidemiologic studies.

Measurements of the amount of plaque on teeth have been made to evaluate the hygiene status of individuals. Greene and Vermillion described a debris index in which selected teeth were evaluated with an explorer for the presence of materia alba or debris. Shick and Ash modified this index by subdividing tooth surfaces into smaller areas. With this index, small amounts of plaque in the gingival one-half could be measured. McClure divided primary tooth surfaces into nine areas and recorded the number of areas covered
by plaque. In both of these investigations, disclosing solutions were used to delineate plaque, while the Greene and Vermillion index used an explorer point rubbed over the surface to measure the extent of the debris.

Ritsert and Bins charted areas of plaque on a record sheet. A millimeter grid was then placed over the charts and the percentage of the tooth area covered by plaque was recorded. Transfer of plaque areas to the chart, however, was subject to examiner error. Arnim and Reyes measured the plaque more precisely by taking clinical photographs of teeth after the application of disclosing solution. The photographs were enlarged, tracings of the anterior teeth and plaque areas were made, and a planimeter was used to outline areas and record in square millimeters. Plaque was reported as the percentage of the tooth surface area, and the results were shown to be very reproducible.

Koch and Lind found that plaque in a selected group of school children participating in a rigid daily brushing program was quite different from plaque in another group of children examined as a control. They concluded that the texture and quality of plaque material are different and that an index which measures the quality of plaque as well as the amount is indicated if accurate judgments are to be made about the relationships between plaque and dental disease.
Food clearance as measured with radioactive foods, iron-labelled biscuits, or microorganisms present in the mouth before or after eating have been reported as methods of evaluating oral hygiene procedures. Wainwright and his associates\textsuperscript{128} labelled foods with radioactive isotopes and tested the ability of various rinses, chewing gums, and brushing to remove the food. Golden and his associates\textsuperscript{129,130} incorporated radioactive iodine in peanut butter in a test utilizing a special type of toothbrush. Cobb and his co-workers\textsuperscript{131} made a quantitative evaluation of iron incorporated in a gingerbread biscuit remaining in the mouth after eating. Knighton\textsuperscript{132} inoculated yeast cells in the mouth of ten subjects before eating, collected saliva following various oral hygiene procedures, and used the growth of yeast cells as a measure of the method's effectiveness. Dunkin\textsuperscript{133} used a "microbial index" in which organisms were plated and grown after various toothbrushing procedures to test the effectiveness of the oral hygiene procedures and to measure reductions in gingivitis.

Chemical changes following the ingestion of various foods have also been reported. Coykendall\textsuperscript{134} used color changes in Fehling's solution following ingestion of refined sugars, and Morch and Waerhaug\textsuperscript{135} measured pH changes after glucose rinsing during and after various hygiene procedures.
CLINICAL PHOTOGRAPHS FOR MEASUREMENT

The use of clinical photographs for measuring plaque on the teeth has already been noted. Massler advocated the use of color photographs to evaluate oral hygiene and gingival tissues and stressed the importance of good technique to provide unbiased pictures. Beube and his associates used color photographs of the teeth after application of disclosing solution as a permanent record of plaque removal in a tooth-brushing study.

Van Huyssen and Boyd used color photographs to evaluate the cleaning ability of dentifrices in 1952. They arranged photographs of each subject in order from "cleanest, to least clean." These observations were subjective, but the authors cited two advantages of clinical photographs: they constitute a permanent record and any number of investigators can make observations from them.

King and his co-workers pointed out that clinical photographs of before and after conditions in the mouth could be misleading because of technical errors. A difference in angulation of more than fifteen degrees in two successive photographs was found to limit effective measurements from photographs.

TELEVISION MEASUREMENT INSTRUMENTATION

In a survey article, Klein pointed out the need for more exact measurement instrumentation in dental research.
Klein and MacPhearson\textsuperscript{139} described a television pulse generator mixer which enables one to make very specific measurements from dental radiographs or other televised images. The mixer makes multiple measurements possible and allows one to include all aspects of a desired observation on one television image. An intra-oral micromeasurement instrument was also described by Klein and MacPhearson.\textsuperscript{140} Images made with the microscope could be stored electronically or on videotape for electric measurement. These measurements and images can be photographed for recording purposes.

Kerkhove and his fellow investigators\textsuperscript{141} evaluated indirect pulp treatments in 76 teeth using the television measurement instrument. They found that radiographic changes could be discerned much more accurately by the use of the television instrument than by the unaided eye.

In a study of the spongy bone architecture in the dentulous mandible, de Aguir\textsuperscript{142} used the television measurement instrument by mixing positive with negative images of radiographs. In this way, a three-dimensional-type image of trabeculae and medullary spaces was made and measured electronically.

Norwitz\textsuperscript{143} evaluated marginal deterioration of 51 mesiobuccal amalgam restorations in deciduous molars using the television microscope. Measurements sensitive to 0.01 millimeter were used to measure deterioration on
individual scan lines of the televised image of the enlarged amalgam margin.

Geller\textsuperscript{144} used the television measurement instrument to evaluate the amount of sclerotic dentin observed on serial radiographs after placing amalgam restorations over calcium hydroxide and methyl cellulose bases in cavities prepared in deciduous molars. Traubman\textsuperscript{145} measured the density and width of dentin underneath indirect pulp treatments on serial radiographs with a similar instrumentation arrangement.
METHODS AND MATERIALS
The sample came from three areas: (1) handicapped children attending the James E. Roberts School of Indianapolis who were selected by teachers and the school physical therapists as having poor oral hygiene and limited manual dexterity, (2) cerebral palsy patients attending the Cerebral Palsy Clinic at the James W. Riley Hospital Dental Clinic who showed poor oral hygiene, limited manual dexterity and expressed an interest in participating in an oral hygiene study, and (3) normal children selected at random from the Children's Clinic of the Indiana University School of Dentistry. There were 24 male and 17 female handicapped patients with a mean age of 12.125 years who were divided into two experimental groups (Groups HA and HB). There were 10 male and three female normal children with a mean age of 9.89 years who were divided into two control groups (Groups NA and NB).

During the first examination period, all subjects were instructed in the use of either a manual nylon-bristled toothbrush\(^a\) or a chewable sponge device.\(^b\) (Figure 1.) A normal and handicapped group used the toothbrush first while the other normal and handicapped groups used the chewable device first. After five weeks,

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\(^a\)Oral B/40 soft-bristled nylon brush; Oral B Company, Wayne, N.J.

\(^b\)Prototype "Chew-clean" Faultless Rubber Company, Ashland, O.
Figure 1. (A) The multi-tufted soft-bristled toothbrush and (B) the "Chev-clean" device used by the subjects.

Figure 2. The clinical camera system used for photographing the subjects.
A. Single lens reflex camera body
B. Extension tubes
C. Ring light flash source
D. Bracket with "T" at point of focus
E. Patient identification information
Figure 3. Data sheet used to record findings at clinical examination.

Figure 4. Instruction sheet given to subjects with "Chew-clean" after being shown how to use the device.
THE NEW TOOTH-CLEANING DEVICE YOU HAVE BEEN GIVEN IS CALLED A "CHEW-CLEAN" AND IS USED DIFFERENTLY THAN A REGULAR TOOTHEBRUSH. THEREFORE YOU WILL NEED TO FOLLOW THESE INSTRUCTIONS VERY CAREFULLY.

PLEASE USE YOUR NEW "CHEW-CLEAN" AS INSTRUCTED TWO TIMES A DAY UNTIL YOUR NEXT APPOINTMENT. DURING THAT TIME, PLEASE DO NOT USE ANY OTHER TOOTHEBRUSH.

THANK YOU,

THE NEW TOOTH-CLEANING DEVICE YOU HAVE BEEN GIVEN IS CALLED A "CHEW-CLEAN" AND IS USED DIFFERENTLY THAN A REGULAR TOOTHEBRUSH. THEREFORE YOU WILL NEED TO FOLLOW THESE INSTRUCTIONS VERY CAREFULLY.

PLEASE USE YOUR NEW "CHEW-CLEAN" AS INSTRUCTED TWO TIMES A DAY UNTIL YOUR NEXT APPOINTMENT. DURING THAT TIME, PLEASE DO NOT USE ANY OTHER TOOTHEBRUSH.

INSTRUCTIONS

1. Moisten the sponge with water; place 3 dabs of toothpaste in both slots.
2. Place the sponge in the mouth; slide the teeth into the slots.
3. Chew up and down, moving sponge from center to sides of mouth; chew approximately 10 times in each position.
4. To rinse: hold sponge under running water and replace in mouth; chew 2 or 3 times in each position.
5. Remove, rinse the sponge, clean, and squeeze dry with a cloth or paper towel.
6. Let sponge air dry until next use.
all subjects were re-examined, instructed in the device they had not yet used, and asked to use it for another five weeks, so that each subject used both devices. A final evaluation was made at the end of the second five-week period.

At the first examination, each subject was photographed and the name, age, sex, medical diagnosis, and study identification number were recorded on the data sheets. (Figure 3) The parent and child were questioned as to frequency and type of oral hygiene procedures being used at home. Parents were asked if they helped with or supervised the brushing.

The gingival tissues were then examined for the amount and severity of gingivitis. The gingival index developed by O'Leary and his associates\textsuperscript{40} was used. The mouth was divided into six segments: two maxillary and two mandibular posterior segments, each consisting of all posterior teeth up through the first premolar or first primary molar, and two anterior segments, a maxillary and mandibular, including all the anterior teeth. The segments were dried, examined and assigned a score as determined by the most severely involved tooth in the segments. The following values were used:

0—Normal tissue color, form consistency.

1—Inflammatory changes such as redness, slight swelling, or distention of tissues from the tooth with a blast of air (these changes do
not encircle more than one-half of the tooth).

2--Inflammatory changes similar to those in "1" but encircling more than one-half of the tooth.

3--More severe changes observed as ulceration, hemorrhage, loss of papillary tissue, or marked defects such as gross thickening of tissues or gingival clefts.

The scores for the six segments were then totaled and divided by six to give a gingival index score (GI).

A disclosing solution made from Red-Cote Disclosing Wafers\(^a\) was applied to the teeth with a cotton-tipped applicator. The subject was then asked to rinse vigorously with water. A clinical photograph was made of the subject's anterior teeth with a fixed-focus 35 millimeter single lens reflex camera.\(^b\) Close-up extension tubes, a ring light flash, and an aluminum bar which set the focal length and held an identification number were used to help reduce photographic errors and produce consistent photographs. (Figure 2) Subjects were asked to slide the mandibular anterior teeth to an end-to-end relationship with the upper teeth while an assistant held cheek retractors.

A clinical evaluation of the plaque present was then made utilizing a plaque index previously reported by

\(^a\)"Red-Cote" Disclosing Wafers; John O. Butler Co., Chicago, Illinois. Tablets crushed into powder and mixed with water in ratio of approximately one tablet to 5 cc. water.

\(^b\)Yashica 35 mm. Single-lens reflex camera with extension tubes \#1 and \#2; Mighty Lite Ring Flash.
Shick and Ash. Plaque was recorded for both facial and lingual surfaces of the following teeth: upper and lower first permanent molars (second primary molars were substituted when permanent molars were unerupted), upper and lower canines (either permanent or deciduous), and upper and lower lateral and central incisors (either permanent or deciduous). Each surface was then assigned a score from 0 to 3 based on the following values:

0—absence of plaque on the gingival one-half of the surface.

1—less than one-third of the gingival one-half covered with plaque.

2—one-third to two-thirds of the gingival one-half covered with plaque.

3—two-thirds or more of entire surface covered with plaque.

The handicapped subjects in group "HA" and the normal subjects in "NA" were then given a manual toothbrush with a tube of unmarked stannous fluoride dentifrice. Instructions in the oral hygiene devices were given by a dental hygiene student, a dental assistant, or the examiner. A scrub-brush type of brushing in all buccal, occlusal, and lingual areas was demonstrated to the brushing groups. Each subject was then asked to demonstrate the same method for the instructor.

Stannous fluoride dentifrice #26A; Department of Preventive Dentistry, Indiana University School of Dentistry.
If the child was unable to manipulate the brush at all, the parent was asked to brush the teeth for the child. The subjects instructed with the brush were asked to use the brush twice daily until the next examination and to stop any other oral hygiene methods during that time.

The subjects in Groups "EB" and "NB" were given the "Chew-clean" device, a tube of the same dentifrice given to the brushing group, and printed and personal instructions in its use. (Figure 4) Each subject was then asked to demonstrate the use of the "Chew-clean" device for the instructor and was observed for his ability to place the device properly in the mouth, to chew without gagging or choking, to move it from side to side, to apply dentifrice to the device, and to rinse and dry it without assistance. If the child could not place the "Chew-clean" in the mouth or place dentifrice on it, the parents were asked to assist him. Subjects were asked to use this device twice daily and to stop using any other hygiene methods until the next examination.

At the second examination, five weeks after the first one, vital information previously recorded was placed on new data sheets, and a gingival evaluation, a photograph with disclosing solution on the teeth, and a plaque evaluation were made. The subjects in groups "HA" and "NA" were then instructed in the use of the "Chew-clean"
device and subjects in groups "EB" and "NB" were instructed in the use of the toothbrush and then evaluated on their ability to use them. The subjects were asked to stop using any other hygiene methods and to use only the new device given that day twice daily until the third examination. The third examination was made five weeks after the second, and a similar examination routine was followed.

In an effort to evaluate the same oral hygiene procedures in a non-supervised environment, 19 subjects at the James E. Roberts School were asked to use either or both devices during the forthcoming summer vacations. No mention of any further examinations was made. The choice of which device to use was left up to the subjects. These subjects were then examined unannounced at the beginning of the school year.

MEASUREMENT PROCEDURES

The plaque scores from each data sheet were totaled and divided by the number of surfaces scored to give a "Plaque score" (all surfaces). In addition, totals for the labial surfaces of all incisors scored were calculated and divided by the number of labial surfaces to give a "Plaque score" (labial surfaces).

The incisal edge of the right central incisor on the transparency taken at each examination appointment was measured with a pair of dividers; the transparency was then placed in a photographic enlarger and enlarged until
Figure 5. Sample tracings from photographs of two subjects. The tracing of the plaque is superimposed over the tooth area. The series of tracings on the left is from a subject who used a toothbrush and then a "Chew-clean." The series of tracings on the right is from a subject who used the "Chew-clean" first and then the toothbrush.
Figure 6. An electronic block diagram of the Television Area Measurement Instrument.
Figure 7. The T.V. Area measurement instrument which consists of: (A) tracing and light source, (B) T.V. camera, (C) Monitor, (D) Area measurement generator, (E) Master Monitor and (F) Digital counter.

Figure 8. A monitor view of a tracing. The digital score for that plaque area shown on the monitor is superimposed at the top of the screen.
the measured tooth was enlarged by a factor of four. At this time, a tracing of the labial outlines of the maxillary and mandibular central and lateral incisors was made on acetate tracing paper. The tracing paper was then moved, and another tracing was made of the stained plaque areas seen on the same teeth. All photographs for each subject were traced on the same sheet of tracing paper. (Figure 5) The tracings were filled in with a dark type "B" drawing lead to produce opaque tooth and plaque tracings.

These tracings were measured with an area measurement television instrument. (Figures 6, 7) The blackened tracing indicating tooth or plaque, as the situation dictated, was illuminated from above by an incandescent lamp and viewed by the television camera. The television camera image is electrically inverted so that the tracing becomes white and the background black. (Figure 8) The video image is connected to a small display monitor the video mixer and the area measurement unit. The purpose of the Measurement Window Generator is to generate two vertical lines and two horizontal lines which may be positioned as described to restrict the area of measurement.

The Area Measurement Unit consists of an internal clock generator, logic control circuitry, and output drivers which generate a serial train of output pulse (dots) when the tracing video image "enables" the unit, i.e., activates
the area measurement units. This unit is timed with the television system so that the tracing video image is measured once each second and the output pulses (dots) are counted by the Count Display Unit. The count is digitally displayed for one second, then zeroed and the count cycle repeated. The output pulses are also connected to the Video Mixer where they are mixed into the composite image viewed on the Master Monitor. The Area Measurement Unit Video slicing level is set just below a point where a spill over of dots occurs so that the tracing area is completely covered with dots. This renders a numerical count proportional to the area of tooth or plaque being measured, as the situation indicates. Plaque area was divided by the tooth area measured to give a percentage score which was then recorded on the data sheet. In another investigation using this area measurement instrument, several tracings of the same photograph were made and measurements were made from these. An error of less than 1% between measurements was found.
RESULTS
The data for all four groups are presented in Tables I, II, III, and IV. The mean scores, variance and standard deviations for the four groups are presented in Table V. This table shows an increase in gingivitis in group HA when using both the toothbrush, and then the "Chew-clean." This group showed a reduction in plaque when using the toothbrush and an increase in plaque when using the "Chew-clean." In Group KB, an increase in plaque was observed when the "Chew-clean" was used and a decrease in plaque was observed when the brush was used. The normal children in Group NA showed a decrease in gingivitis and plaque when using the toothbrush, and then an increase in gingivitis and plaque greater that "before" levels when using the "Chew-clean." The normal children in NB showed an increase in plaque and gingivitis when using the "Chew-clean" and a decrease in plaque and gingivitis when the toothbrush was used. The decrease in plaque was to a level below the starting point while the decrease in gingivitis was only slight during the period when the toothbrush was used.

The results from the examination of subjects from the Roberts School which occurred after a summer vacation of non-supervised oral hygiene activities are compared with the initial scores in Table VI. The mean values show an increase in gingivitis and plaque (all three indices) after the summer.
Because of the small sample and unequal size groups, it was not possible to analyze all of the data statistically. The methods of evaluation (i.e. gingival index, clinical plaque scores and t.v. area percent scores) were compared using the Pearson Product Moment Correlation Coefficients. Computations for this project were performed at the Indiana University Medical Center Research Computation Center.*

These results are shown in Table VIII, and the high correlations between labial plaque scored clinically and labial plaque scored by television area measurement in both handicapped and normal children indicate that these two indices are comparable within the same group of children.

Correlations are high for all plaque indices for both groups of children, except for the "before" scores of normal children. This exception, however, may be due to the small sample size in normal children. Correlations for plaque and the gingival index seem to be higher for the normal children than for handicapped children.

*Supported in part by Public Health Service Research Grant FR 00162
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<th>SUBJECT NO.</th>
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<th>Plaque (T.V. Area %)</th>
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*Labial-Lingual Surfaces of anterior and posterior teeth
*Labial Surfaces Incisor Teeth Only
### TABLE II. Handicapped Group HB--Data

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<td>0.833 1.714 0.266</td>
<td>18.6 41.5 1.1</td>
</tr>
<tr>
<td>B606</td>
<td>0.667 1.167 1.500</td>
<td>1.600 1.333 0.833</td>
<td>1.000 1.750 0.250</td>
<td>14.9 38.8 1.2</td>
</tr>
<tr>
<td>B607</td>
<td>0.333 1.000 0.667</td>
<td>0.700 1.167 1.000</td>
<td>0.714 2.143 1.000</td>
<td>31.3 58.9 5.4</td>
</tr>
<tr>
<td>B608</td>
<td>0.000 0.500 0.000</td>
<td>0.813 0.875 0.185</td>
<td>0.375 1.000 0.125</td>
<td>8.2 38.0 0.0</td>
</tr>
<tr>
<td>B609</td>
<td>0.000 1.167 0.000</td>
<td>0.571 1.679 0.893</td>
<td>0.167 2.000 0.667</td>
<td>15.8 49.0 1.9</td>
</tr>
<tr>
<td>B611</td>
<td>0.633 1.000 1.000</td>
<td>1.467 1.233 0.964</td>
<td>1.125 2.125 0.125</td>
<td>29.6 57.8 0.0</td>
</tr>
<tr>
<td>B616</td>
<td>0.500 0.333 0.333</td>
<td>0.543 1.000 0.679</td>
<td>0.625 2.250 0.250</td>
<td>25.6 56.6 7.5</td>
</tr>
<tr>
<td>B618</td>
<td>0.333 0.833 1.000</td>
<td>0.893 1.667 0.406</td>
<td>0.567 2.851 0.000</td>
<td>60.3 5.9 2.8</td>
</tr>
<tr>
<td>GROUP</td>
<td>GINGIVAL INDEX</td>
<td>PLAQUE INDEX (ALL)</td>
<td>PLAQUE INDEX (Labial)</td>
<td>PLAQUE (T.V. Area %)</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>-------------------</td>
<td>-----------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>before</td>
<td>1st 5wks</td>
<td>2nd 5wks</td>
<td>before</td>
</tr>
<tr>
<td>MEAN</td>
<td>0.7499</td>
<td>1.0415</td>
<td>1.1644</td>
<td>1.5362</td>
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<tr>
<td>ST. DEV.</td>
<td>0.4513</td>
<td>0.5594</td>
<td>0.6296</td>
<td>0.4788</td>
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<tr>
<td>VARIANCE</td>
<td>0.2036</td>
<td>0.3129</td>
<td>0.3964</td>
<td>0.2293</td>
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<tr>
<td>HB**</td>
<td>1.0556</td>
<td>1.0445</td>
<td>1.1667</td>
<td>1.6975</td>
</tr>
<tr>
<td>ST. DEV.</td>
<td>0.5656</td>
<td>0.5252</td>
<td>0.4836</td>
<td>0.4243</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>0.3202</td>
<td>0.2756</td>
<td>0.2341</td>
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<tr>
<td>NA**</td>
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<td>VARIANCE</td>
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<td>0.0440</td>
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</tr>
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<td>NB**</td>
<td>0.4443</td>
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<td>0.6111</td>
<td>0.8561</td>
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<tr>
<td>ST. DEV.</td>
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<td>0.5001</td>
<td>0.4106</td>
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<tr>
<td>VARIANCE</td>
<td>0.0972</td>
<td>0.0958</td>
<td>0.2501</td>
<td>0.1686</td>
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</tbody>
</table>

* Toothbrush 1st Five Weeks, "Chew-clean" 2nd Five Weeks.
** "Chew-clean", 1st Five Weeks, Toothbrush 2nd Five Weeks.
### TABLE VI. Handicapped children before and after summer vacation

<table>
<thead>
<tr>
<th>SUBJECT NUMBER</th>
<th>GINGIVAL INDEX before</th>
<th>PLAQUE (All) before</th>
<th>PLAQUE (Labial) before</th>
<th>PLAQUE (T.V. Area) before</th>
<th>GINGIVAL INDEX after</th>
<th>PLAQUE (All) after</th>
<th>PLAQUE (Labial) after</th>
<th>PLAQUE (T.V. Area) after</th>
</tr>
</thead>
<tbody>
<tr>
<td>A902</td>
<td>0.667</td>
<td>1.000</td>
<td>1.531</td>
<td>2.500</td>
<td>1.500</td>
<td>3.000</td>
<td>19.3</td>
<td>78.7</td>
</tr>
<tr>
<td>A903</td>
<td>0.500</td>
<td>0.833</td>
<td>1.000</td>
<td>1.656</td>
<td>3.000</td>
<td>3.000</td>
<td>62.4</td>
<td>78.3</td>
</tr>
<tr>
<td>A904</td>
<td>0.333</td>
<td>0.500</td>
<td>0.750</td>
<td>0.750</td>
<td>0.250</td>
<td>0.000</td>
<td>7.9</td>
<td>3.6</td>
</tr>
<tr>
<td>A905</td>
<td>1.000</td>
<td>1.000</td>
<td>1.906</td>
<td>2.031</td>
<td>2.250</td>
<td>2.875</td>
<td>34.1</td>
<td>83.2</td>
</tr>
<tr>
<td>A907</td>
<td>0.333</td>
<td>1.000</td>
<td>1.600</td>
<td>3.280</td>
<td>1.000</td>
<td>3.000</td>
<td>19.0</td>
<td>80.7</td>
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<tr>
<td>A908</td>
<td>0.000</td>
<td>0.333</td>
<td>0.812</td>
<td>1.833</td>
<td>0.500</td>
<td>2.571</td>
<td>4.1</td>
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<td>A909</td>
<td>1.333</td>
<td>1.167</td>
<td>1.333</td>
<td>2.657</td>
<td>1.250</td>
<td>2.875</td>
<td>24.0</td>
<td>83.9</td>
</tr>
<tr>
<td>A910</td>
<td>0.333</td>
<td>1.500</td>
<td>1.571</td>
<td>1.644</td>
<td>2.250</td>
<td>1.500</td>
<td>50.0</td>
<td>59.1</td>
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<td>A912</td>
<td>0.833</td>
<td>1.000</td>
<td>0.862</td>
<td>2.219</td>
<td>0.875</td>
<td>2.500</td>
<td>15.5</td>
<td>75.2</td>
</tr>
<tr>
<td>A919</td>
<td>0.667</td>
<td>0.500</td>
<td>1.429</td>
<td>2.000</td>
<td>1.250</td>
<td>3.000</td>
<td>25.1</td>
<td>70.5</td>
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<td>A920</td>
<td>0.833</td>
<td>0.333</td>
<td>1.733</td>
<td>1.357</td>
<td>2.000</td>
<td>1.750</td>
<td>19.0</td>
<td>47.8</td>
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<td>A924</td>
<td>1.500</td>
<td>1.500</td>
<td>1.967</td>
<td>2.333</td>
<td>2.625</td>
<td>3.000</td>
<td>67.5</td>
<td>82.8</td>
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<td>0.333</td>
<td>2.484</td>
<td>1.844</td>
<td>3.000</td>
<td>3.125</td>
<td>84.8</td>
<td>68.2</td>
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<td>A931</td>
<td>0.667</td>
<td>0.167</td>
<td>1.877</td>
<td>1.464</td>
<td>1.500</td>
<td>1.375</td>
<td>34.9</td>
<td>41.1</td>
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<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
<td>1.625</td>
<td>1.625</td>
<td>61.7</td>
<td>48.3</td>
</tr>
<tr>
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<td>0.333</td>
<td>2.133</td>
<td>1.100</td>
<td>2.250</td>
<td>0.750</td>
<td>36.5</td>
<td>26.5</td>
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<td>B936</td>
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<td>1.167</td>
<td>2.156</td>
<td>2.063</td>
<td>3.000</td>
<td>3.000</td>
<td>82.0</td>
<td>86.7</td>
</tr>
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<td>B937</td>
<td>1.667</td>
<td>1.500</td>
<td>1.500</td>
<td>1.875</td>
<td>2.250</td>
<td>3.000</td>
<td>54.7</td>
<td>85.6</td>
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<tr>
<td>B938</td>
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<td>0.333</td>
<td>2.031</td>
<td>2.156</td>
<td>1.750</td>
<td>1.750</td>
<td>52.5</td>
<td>78.9</td>
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<tr>
<td>MEAN</td>
<td>0.842</td>
<td>0.866</td>
<td>1.630</td>
<td>1.903</td>
<td>1.796</td>
<td>2.300</td>
<td>39.74</td>
<td>66.22</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>0.2237</td>
<td>0.2135</td>
<td>0.2177</td>
<td>0.3089</td>
<td>0.6609</td>
<td>0.8408</td>
<td>525.15</td>
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<td>ST. DEV.</td>
<td>0.4730</td>
<td>0.46203</td>
<td>0.4666</td>
<td>0.5557</td>
<td>0.8252</td>
<td>0.9169</td>
<td>24.440</td>
<td>22.916</td>
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</tbody>
</table>
TABLE VII. Distribution of handicapped subjects by medical diagnosis.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
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<tbody>
<tr>
<td>Cerebral Palsy</td>
<td>18</td>
</tr>
<tr>
<td>Muscular Dystrophy</td>
<td>4</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>2</td>
</tr>
<tr>
<td>Congenital Defects</td>
<td>2</td>
</tr>
<tr>
<td>Scoliosis</td>
<td>1</td>
</tr>
<tr>
<td>Amyotonia</td>
<td>1</td>
</tr>
<tr>
<td>Friedreich's Ataxia</td>
<td>1</td>
</tr>
<tr>
<td>Polio</td>
<td>1</td>
</tr>
<tr>
<td>C.N.S. Degeneration</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>31</td>
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</table>
### Table VIII. Pearson Product Moment Correlation Coefficients for measurement indices.

**Gingival Index vs. Plaque (All)**

<table>
<thead>
<tr>
<th></th>
<th>Handicapped Group (31)</th>
<th>Normal Group (13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>.190</td>
<td>.400</td>
</tr>
<tr>
<td>After (5 wks)</td>
<td>.393*</td>
<td>.741**</td>
</tr>
<tr>
<td>After (10 wks)</td>
<td>-.059</td>
<td>.261</td>
</tr>
</tbody>
</table>

**Plaque (All and Labial)**

<table>
<thead>
<tr>
<th></th>
<th>Handicapped Group (31)</th>
<th>Normal Group (13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>.832**</td>
<td>.503</td>
</tr>
<tr>
<td>After (5 wks)</td>
<td>.670</td>
<td>.837**</td>
</tr>
<tr>
<td>After (10 wks)</td>
<td>.644**</td>
<td>.773**</td>
</tr>
</tbody>
</table>

**Plaque (Labial) and T.V. Area (%)**

<table>
<thead>
<tr>
<th></th>
<th>Handicapped Group (31)</th>
<th>Normal Group (13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>.877**</td>
<td>.686**</td>
</tr>
<tr>
<td>After (5 wks)</td>
<td>.862**</td>
<td>.745**</td>
</tr>
<tr>
<td>After (10 wks)</td>
<td>.700**</td>
<td>.944**</td>
</tr>
</tbody>
</table>

* p < .05

** p < .01
DISCUSSION
Two different methods of oral hygiene were tested in a group of handicapped children which indicate that a decrease in plaque was observed when subjects used the toothbrush and an increase in plaque was observed when the "Chew-clean" was used. A decrease in gingivitis might be expected with a decrease in plaque, but an actual increase in gingivitis in the handicapped group using the toothbrush first was observed. This increase might be related to the increased physical activity of brushing by subjects with limited manual dexterity, as well as differences in diet previously noted. In addition, differences in examiner scoring from one examination to another with the small groups used in this study could account for these differences. The group of handicapped subjects using the "Chew-clean" device first, on the other hand, showed a very slight decrease in gingivitis and a very slight decrease in plaque (all surfaces) but an increase in plaque on the labial surfaces.

The normal group of patients showed a decrease in plaque and gingivitis when using the toothbrush and an increase in plaque and gingivitis when using the "Chew-clean." These findings seem to indicate that the "Chew-clean" is ineffective.

Several problems which became apparent after the study was well under way bear discussion. For example, each subject used both oral hygiene devices, with one part of
the sample using the "Chew-clean" initially while the other group was using the toothbrush first, but there was no buffer period between the two periods of use. To permit statistical analysis, such a period should have been provided between experimental periods. In addition, group sizes should have been equal.

It was hoped that the degree of physical handicap could be related to the subject's ability to use a toothbrush since the new device is expressly for the person unable to manipulate a manual toothbrush. A handicap index was devised and recorded for the initial group of subjects consisting of a series of motor tasks necessary for adequate toothbrushing. These included bringing the hand to the mouth, grasping the toothbrush, rotation of the head, internal and external rotation of the shoulder, forearm supination and pronation and wrist flexion and extension. Upon observation, however, it was found that even the severely handicapped subjects could execute most of these movements, but many of them had great difficulty in sustaining the movement long enough to brush their teeth, and as a result, these observations were not recorded. Before an accurate handicap index can be developed, it will be necessary to measure objectively the patient's ability to make and sustain the movements used in toothbrushing.
At the first two examinations, instructions were given to parents and the child, and the parents were asked to supervise the children in their oral hygiene procedures each day. Upon later examination, it became clear that parental cooperation is hard to obtain in a study like this.

It appears that the degree of physical handicap does not affect a subject's ability to perform oral hygiene procedures as much as the motivation provided by the subject himself, by the parent, or by the dentist. A number of the subjects showed a keen enthusiasm for the procedures they were being shown and were able to work with the toothbrush and "Chew-clean" quite well even though their physical appearance indicated that they would have great difficulty. In contrast, some patients with very little debilitation showed little interest in the procedure and show smaller changes in the level of oral hygiene during the study. (Figures 9 and 10).

Other problems grew out of the difficulty of communicating with these subjects regarding their frequency of brushing. Many of them, although they are educable, are in ungraded classes and are mentally retarded to some degree, which means that their responses to questions of this type have questionable validity. Also, some subjects did not understand the original instructions and switched to different oral hygiene devices during the period of the
Figure 9a. Intraoral view of an athetoid cerebral palsy patient on first examination whose mother had been brushing the teeth.

Figure 9b. Intraoral view of same patient after using "Chew-clean" twice daily for five weeks. Note stained plaque areas on teeth.

Figure 9c. Intraoral view of same patient after using toothbrush by himself twice daily for five weeks.
Figure 10a. Intraoral view of patient with congenital defect affecting lower limbs and upper limbs to only a slight degree on first examination. The subject reported that he brushed his teeth at least once a day.

Figure 10b. Intraoral view of same patient after using a toothbrush by himself for five weeks. Note stained areas of plaque remaining on labial surfaces on maxillary incisors.

Figure 10c. Intraoral view of same patient after using "Chew-clean" for five weeks. Note plaque areas remaining on maxillary and mandibular teeth.
investigation, making their data unusable. Absences from school for medical reasons eliminated several other subjects. The small final sample size in the normal group was poor.

As previously noted, a group of subjects were examined after a summer period to observe what changes in oral hygiene or gingival health might occur. (Table VI). Since all subjects did not receive the fourth examination, this measurement could not be statistically analyzed. Clinical observations did show an increase in gingivitis and stained plaque areas after a summer with no supervised oral hygiene. As noted by Koch and Linde, the reasons for brushing probably affect a patient's motivation for brushing rather than thoroughness of instructions. Future studies can evaluate the effects of supervision and instruction on oral hygiene.

The "Chew-clean" device used in this investigation has a wide groove in which the teeth are supposed to fit, and the rubber forming the ridges is rather thin. Minor discrepancies in tooth position can deflect this rubber so that the labial or lingual surface of the tooth is not cleaned. For example, the finding in the data which showed proportionally much more plaque remaining on the labial surfaces of anterior teeth than on all recorded surfaces might be attributed to irregularities in anterior tooth position which were frequently observed. (Table V).
A number of subjects mentioned a definite preference for the "Chew-clean" device over the toothbrush. Other subjects complained that the teeth did not feel clean after using the "Chew-clean," especially the interproximal areas. This complaint, along with the constant observation of plaque in the interproximal areas is not consistent with the interproximal flushing reported by Levenson.\textsuperscript{48}

The author feels that the device might be improved by using a more rigid material with a narrower groove or even incorporating soft nylon bristles into the device which could more effectively scrub the tooth surface.

Arnim\textsuperscript{46}, has stated that a significant reduction in plaque, in either the normal or handicapped patient, need not be accompanied by a reduction in dental disease since the areas of plaque which are causing the disease process may comprise a very small part of the total region covered with plaque. Interproximal areas and areas near the gingival sulcus are samples of this. These very areas were either small factions of the total measured by clinical observation or television area measurement, or could not be measured at all. It is the author's feeling that the indices used to evaluate plaque are not closely related to the area of pathogenesis, and that a microbiologic test which would identify specific pathogens found in plaque is needed to evaluate the true effectiveness of oral hygiene methods in preventing caries and periodontal disease.
Photographic errors were a significant problem in this investigation. Even though the camera was pre-focused and the focal length was pre-set, the angulation of the camera could not be fixed, nor could the position of the teeth be standardized. An interocclusal record made of impression compound attached in some way to the camera would have made photographs reproducible. Since the subjects in the present study were examined in a school setting as well as a busy dental clinic, it was not feasible to make the interocclusal records, and subjects were asked to move their mandibular teeth into an end-to-end relationship with the maxillary teeth for the photograph. In any further studies using photographs for measurement of teeth or plaque, a more reproducible photograph should be considered.

Even though the results have shown a high correlation between the amount of plaque on the labial surfaces of incisors and the amount of plaque on lingual and labial surfaces of anterior and posterior teeth, a measurement in the anterior labial segment of a device that is especially ineffective in the anterior area (such as the "Chew-clean" device) would be far different from a measurement which included posterior areas.

The tracing procedure was tedious and time-consuming. If the area measurement instrument is to be further used, areas should be measured directly in the mouth. In the
meantime, clinical indices, although limited, provide more information about all tooth surfaces than the area measurement instrument.
SUMMARY AND CONCLUSIONS
The common finding of gingivitis in the handicapped patient and the reported success of an oral hygiene device requiring no manual dexterity led to the author's interest in this study. A group of 31 handicapped patients divided into two groups and 13 normal patients also divided into two groups participated in the investigation. Vital information and gingival and plaque scores were recorded on a data sheet. Intraoral color photographs after the application of disclosing solution were made of each subject.

The subjects were then instructed in the use of either a soft-bristled multi-tufted nylon toothbrush or a rubber "Chew-clean" device and asked to use it twice a day until the next examination, which occurred in five weeks. At that time, the subjects were examined, instructed in the other device, and asked to use it until the third examination. A group of subjects were then examined following a summer vacation to observe what changes would occur following a period of non-supervised oral hygiene.

Tracings of the labial outlines of the lateral and central incisors and the stained areas of plaque on these teeth were made, darkened with a pencil, and measured with a television area measurement instrument.

The subjects show a preference for the "Chew-clean" in general, even though the clinical results showed that
there was an increase in plaque and gingivitis after it had been used, while the toothbrush tended to reduce plaque and gingivitis in the handicapped subjects and normal subjects.

Statistical analysis showed a correlation between plaque and gingivitis in the normal children but not in the handicapped children, which indicates external or systemic factors may be involved in gingivitis in handicapped children. Analysis also showed that in the same group of children, a plaque index score for labial and lingual surfaces of anterior and posterior teeth in comparable with a plaque score for the labial surfaces of the incisor teeth and the plaque scores for the labial surfaces of incisor teeth are comparable with scores obtained with the television area measurement of intracoronal transparencies.

On the basis of this investigation, the author has concluded that the toothbrush is the more effective means of the two tested in providing oral hygiene for the handicapped patient. The "Chew-clean" concept, since it requires little dexterity and is easy to use, might show promise if modified in such a way as to remove plaque more efficiently.

Parental cooperation in an oral hygiene investigation of handicapped and normal children, whether conducted in a dental clinic or in a school setting, is questionable, and reports on the frequency of toothbrushing from patients
are of doubtful value. Handicapped patients are often capable of providing their own personal oral hygiene when properly motivated, however, and the physical appearance or amount of debilitation should not dissuade one from giving instructions in hygiene to the handicapped patient.

More accurate means of studying the effects of oral hygiene on the prevention of dental disease should be developed, such as a microbiologic test for specific dental pathogens.
REFERENCES


|-----|--------------------------------------------------------|


CURRICULUM VITAE

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American Society of Dentistry for Children
Associate--Student Clinicians of American Dental Association
American Academy of Dentistry for the Handicapped
A CLINICAL TELEVISION EVALUATION OF PLAQUE AND GINGIVITIS IN HANDICAPPED CHILDREN

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This study was initiated to evaluate the effects of oral hygiene procedures on gingival health in a group of handicapped patients. Thirty-one handicapped children and 13 normal children participated in the study. A clinical examination was done, gingival index and plaque scores were recorded, and color transparencies of the incisor teeth were made with a close-up camera. Tracings of tooth and plaque area outlines were then made and measured with a television area measurement instrument.

Subjects were instructed in the use of either a soft-bristled nylon toothbrush or a sponge rubber device which required no manual dexterity for its use. The subjects were asked to use the device or the toothbrush twice daily for a five-week period. The subjects were then examined, instructed in the other device and asked to use it for five more weeks and then re-examined.

The results showed that the toothbrush was more effective in removing plaque than the chewable device, even though the subjects showed a preference for the new device. Statistical analysis showed that plaque was correlated with gingivitis except in handicapped patients. It is suggested that a more accurate means of evaluating the true effectiveness of oral
hygiene procedures, such as a microbiologic test specific for pathogens which cause dental disease, be developed.