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A new oral hygiene strategy

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This study was designed to see if toothbrush pressure could be considered a significant factor in the reduction of plaque among a group of orthodontic patients. Eleven orthodontic patients who had been identified previously as having chronic poor oral hygiene and the ability to tolerate only small toothbrush pressures (an average of 3 oz) were selected to participate in this study. At the beginning of the study, each of the patients was supplied with a specialized toothbrush feedback mechanism that was to be used in the routine home care. The feedback mechanism permitted the patients to gradually increase their tolerance to toothbrush pressure by moving from a target pressure of 2 oz to a target pressure of 16 oz over a period of several weeks. When the target pressure was reached, a light on the end of the brush mechanism came on, thus alerting the patient that the target had been reached. Only one of the eleven patients failed to improve her plaque score. There was, on the average, a 47% reduction in plaque scores. The statistical evidence indicates that the improved plaque scores were directly related to the higher toothbrush pressures. The present study was undertaken as an extension of a previous study that indicated good orthodontic toothbrushers used four and one half times more pressure than did chronically poor toothbrushers. This study suggests that poor toothbrushers can improve their oral hygiene significantly by increasing the pressure with which they brush.

Key words: Oral hygiene, plaque, toothbrush pressure, feedback, behaviorism, reinforcement, shaping, pain threshold

A previous study demonstrated that orthodontic patients with habitually poor oral hygiene use, on the average, four and a half times less force than those patients who habitually practice good oral hygiene.[1] This study suggested that toothbrush pressures are directly related to the patient's pain tolerance in that if patients could tolerate higher pressures, they did; and if they were unable to tolerate higher pressures they neglected their oral hygiene. This neglect has a cumulative effect, as there is a direct relation between plaque build-up and the amount of gingival inflammation that ensues.[2] Inflammation per se also lowers pain tolerance,[3] and this cycling effect—from neglect to inflammation and pain and then back to further neglect—contributes to the development of poor oral hygiene habits.

This particular study was undertaken as an extension of the aforementioned article to see if the chronically poor oral hygiene behavior of some orthodontic patients could be improved by behavioristic shaping and reinforcement techniques.

REVIEW OF THE LITERATURE

All orthodontists are aware of the importance of good oral hygiene being practiced by their patients because of the proven relationship between the quality of orthodontic treatment and the quality of the patient's oral hygiene.[4] In reviewing the published articles regarding the teaching of oral hygiene, however, one receives the definite impression that the profession believes that all that is lacking is a proper transfer of information between dentist and patient. Several excellent oral hygiene techniques have been introduced during the past two decades,[5–9] but none of these have suggested that the inability to remove plaque might be a function of the patient's pain tolerance with respect to brush pressure.

Pain tolerance is alterable, and it was this particular idea that occurred to Dr. Horace Wells after attending a laughing gas exhibition in 1866. Dr. Wells subsequently discovered how nitrous oxide could be used in the painless extraction of teeth, and the healing arts have never been the same.[10]

Some of the most modern, thorough, and thoughtful investigation regarding pain modulation has been done by Melzack and Wall.[11] They have been able to document how pain modulation can be altered by three interacting neural systems: the sensory-discriminative dimension, the motivational-affective dimension, and the cognitive-evaluative dimension.[12] It is the latter two processes that offer dentists the most opportunity of controlling as they seek to modify patients' pain tolerances.

The subject of pain modulation is an extremely complex affair, and a complete description is not my intention. Rather, by knowing that pain tolerances can

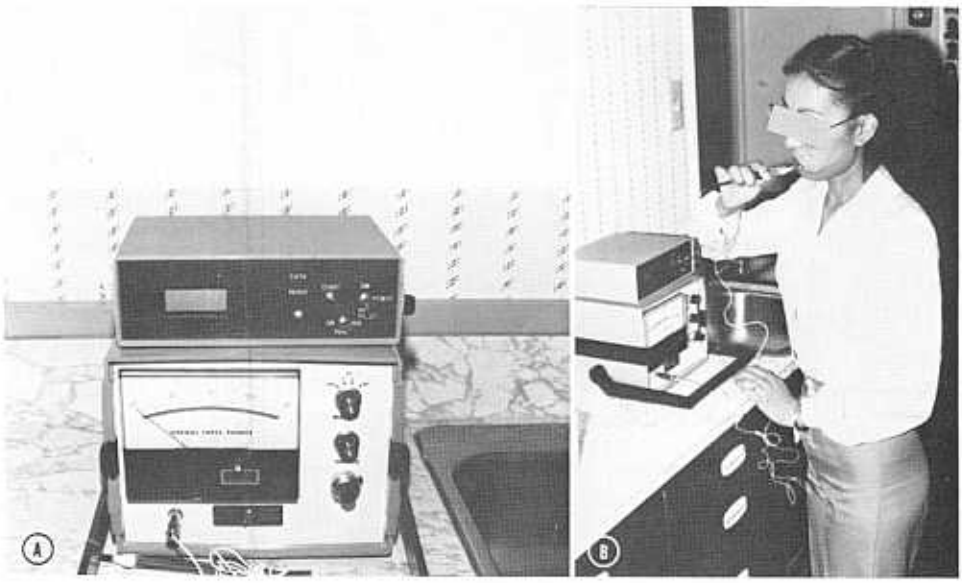

Fig. 1. A, Toothbrush-feedback unit. B, Patient using strain-gauge toothbrush.

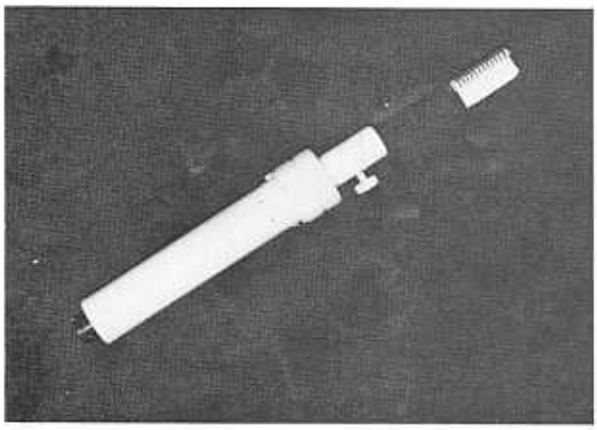

Fig. 2. Feedback toothbrush.

be altered, I have developed a new oral hygiene strategy that offers a qualitative difference from previous techniques.

It is obviously difficult to teach a proper brushing technique to a patient whose gingiva is inflamed. As the instructor presses the brush against the gingiva, the patient begins to squirm, protest, and move away (true aversive reaction). Rather than remembering the technique that is supposed to restore his dental health in the near future, the patient remembers the enormous discomfort brought about by the "proper brushing," which simply guarantees that this technique will be avoided. In any learning event, immediate reinforcements are more effective than distant, nebulous ones. Consequently, many dentists are unsuccessful in improving the oral hygiene habits of some patients. Often our instruction techniques are successful only in teaching patients avoidance behaviors.[13]

Personal experience with teaching failures such as this prompted me to develop a brushing technique using the concepts of shaping and positive reinforcement.[14] Shaping is a technique of getting someone to learn a new way of doing something by starting where he is and rewarding every small step in the direction of the thing one wants him to do. The logic of shaping is simple. People are much more likely to take a small predictable step than a large uncertain one. Perhaps more teaching and learning failures are due to violation of the shaping principle than to any other thing. We overwhelm people by expecting them to perform behaviors that are beyond their ability to understand or perform. When tasks are broken into smaller, simpler parts, they become manageable and repeatable events.

A concept of shaping would not expect a patient whose gingiva is inflamed and who is capable of withstanding only a few ounces of pressure from a toothbrush to suddenly tolerate a full pound of pressure. Such a patient cannot and will not do it! However, if the patient is permitted to increase the toothbrush force gradually by a few ounces per week, there is much more likelihood of achieving an optimum higher toothbrush force.

The concept of positive reinforcement relies upon some kind of immediate reward for desired behavior. The light on the end of this brush gives the patient the kind of immediate, positive reinforcement that is con-

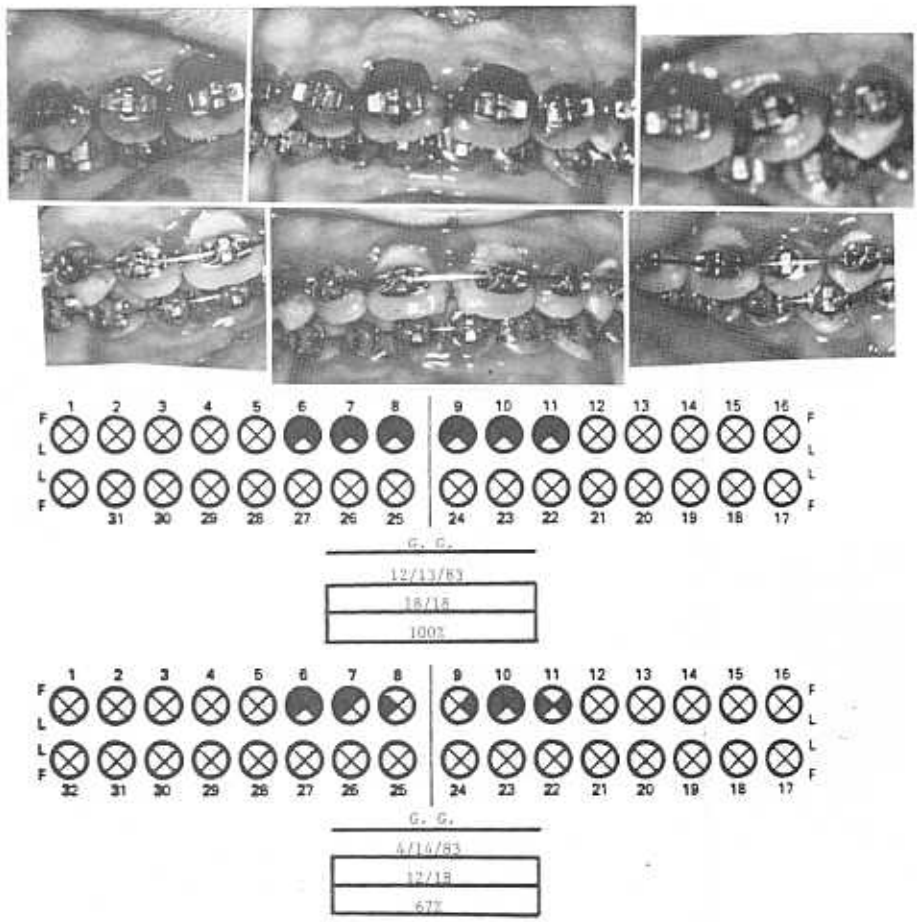

Fig. 3A.

sidered optimal by behavior scientists. The importance of immediate feedback cannot be overemphasized, because current learning theory has established, beyond any doubt, that learning is faster and less complicated if the learner receives accurate and immediate information about his learning task.[15, 16] This reinforcement schedule does not rely upon usual tangible rewards but upon human curiosity about one's status and his delight upon hitting targets or reaching goals.

Various systems of reinforcement techniques for teaching oral hygiene have been reported in the literature,[17–19] but few of them have been successful over a long period of time. Almost all of the specific oral hygiene behavioral change programs report good success in the first few months while the rewards still have their potency. However, as the patients become satiated or jaded by the rewards or, more usually, when the rewards are totally withdrawn, the former oral hygiene behavior returns.

METHODS AND MATERIALS

Eleven orthodontic patients who had been identified previously as having habitually poor oral hygiene were selected to participate in this study. All of the participants in this study had been given the same oral hygiene instruction at the beginning of their orthodontic treatment. The toothbrushing technique taught was a marginal scrub method with a multitufted soft-bristle toothbrush and strong emphasis had been placed on behavioristic techniques of learning.[14] Since it was impractical to furnish each patient with a sophisticated strain-guage toothbrush as was used in the parent study (Fig. 1), a specialized, pressure-sensing mechanism that could be used with the patients' regular toothbrush (Fig. 2) and that could be taken home to use on a daily basis was developed. The essential parts of this apparatus are a housing receptacle for the brush, a handle that contains the pressure-sensing device and the 1.5-volt battery, and a light on the end of the apparatus that

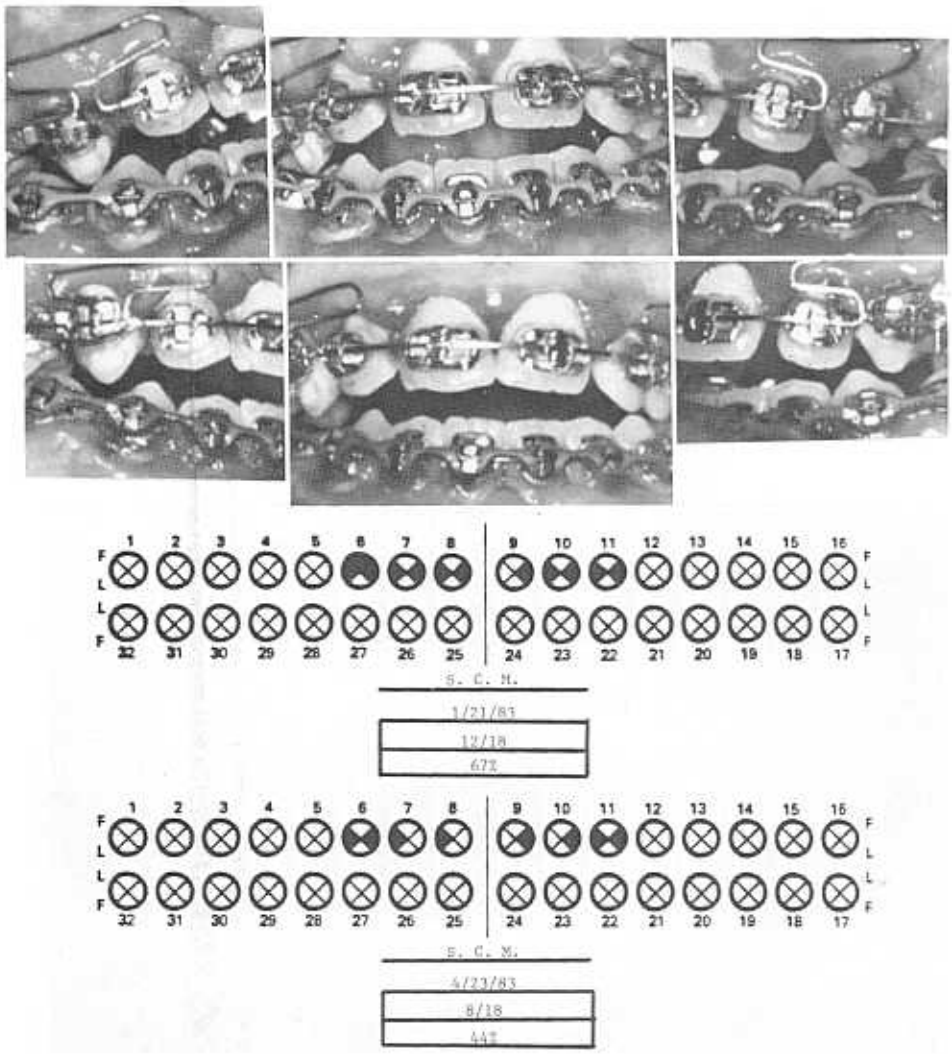

Fig. 3B.

serves as feedback for the patient. Two feedback mechanisms were considered: visual and auditory, but the visual feedback was the simpler of the two to implement and it was chosen for this experimental toothbrush. The pressure-sensing device is variable and can be adjusted for pressures of 1 oz through 1 lb.

Patients were instructed to start with a minimum pressure of 2 oz and to press the brush bristles against the gingivae until the light came on. They could see the light in the bathroom mirror above the basin where they were brushing. The patients were instructed to vibrate the brush head against the gingivae without letting the light go off. They were also cautioned about letting the light flicker on and off while they used the brush against the gingivae. Constant contact between the brush and the gingiva prevented erratic pressures. Once an area had been thoroughly stimulated with the brush, the patients were asked to move to an adjacent area and repeat the pressure brushing until every area in the mouth had been brushed.

The patients were instructed to increase the pressure 2 oz each week until they had reached 16 oz. Sixteen ounces was not an arbitrary number but was the approximate average pressure used by a group of excellent orthodontic brushers in a previous study.[1] An attempt was made to see patients every 2 weeks to check on their progress and to review their brushing technique. At each appointment the patients were asked to brush in a routine manner and to check their brushing effectiveness closely in a mirror before sitting in a treatment

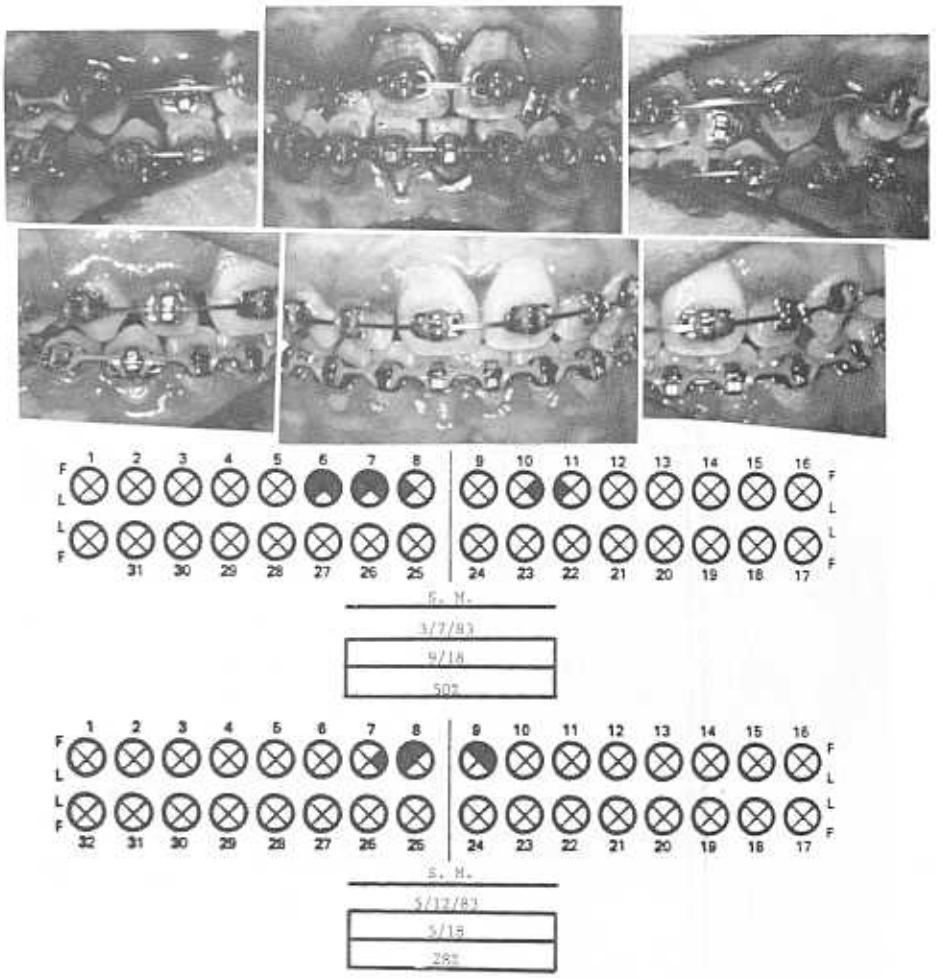

Fig. 3C.

chair. The patients' teeth were then stained with a dark purple disclosing solution so that any remaining plaque would be apparent and would photograph well in order that the subsequent photographic plaque evaluation would be objective and accurate. A photographic technique for the evaluation of periodontal conditions was first suggested by Pilot[20] in 1968 and has been reliable.

The photographs displayed in Fig. 3 show the appearance of the teeth and gingivae at the beginning of the test period and at the end of the test period. There was no rigid schedule for the patients and, as can be seen from the dates on the photographs, some patients arrived at the 16-oz target quicker than others. Occasionally a patient who was using heavier pressures but who was still not placing the brush against the gingiva would be seen. When this deviation occurred, the patient's toothbrush mechanism would be set to a pressure which was tolerable and the shaping would begin afresh. Most of the patients were able to reach 16 oz within 2 months, but some took as much as 4 months. There was no attempt to make the patients reach 16 oz of pressure within a particular time frame, since this would have violated the shaping purpose.

There are many factors associated with the removal of plaque, such as brushing technique, type of toothbrush, bristle type, dentifrice, bristle placement, etc., but these were not germane to this particular study.[21–23] The intention of this study was to see if pressure, per se, could be considered a function of plaque removal.

In observing these photographs, the reader should keep in mind that the patients had brushed and were satisfied that they had done a good job. It is hard to imagine how people could use any brushing technique

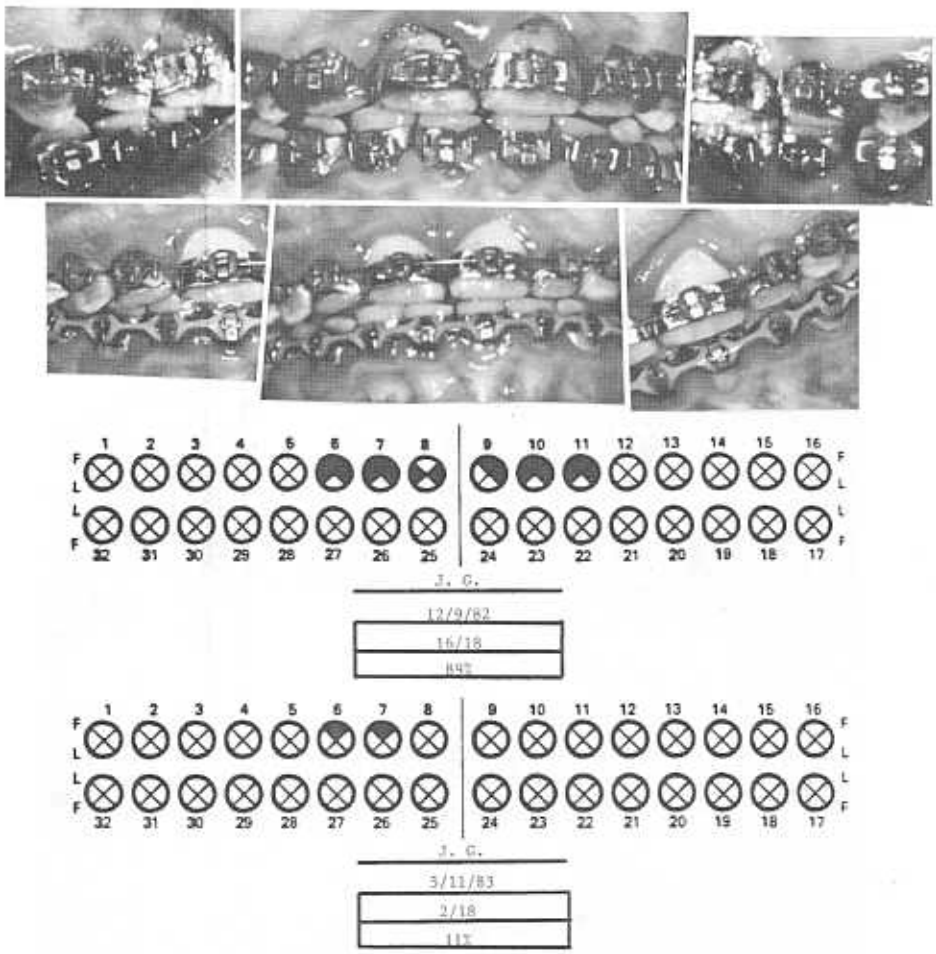

Fig. 3D.

and leave as much plaque as some of these patients did but orthodontists know that patients such as these may be seen in any practice.

For reasons of objectivity, the photographs were evaluated by a periodontist in the Periodontal Department at Baylor Dental College, using an abbreviated Hygiene Analysis Index.[24] The Hygiene Analysis Index considers an evaluated surface as either clean or dirty after use of a disclosing solution. If there is any stained plaque attached to the surface being examined, it is given a rating of 1; if not, it is given a rating of 0. A percentage score is given to each patient by dividing the number of stained surfaces by the number of examined surfaces (Figs. 3*A* through 3*D*). Only the six anterior maxillary teeth were used in this evaluation.

RESULTS

The before and after scores of each patient are seen in Fig. 4 and Table I. There was, on the average, a 47% improvement in plaque scores. Only one patient failed to show any improvement with this regimen. A t test based upon the null hypothesis that the toothbrushing pressures did not affect plaque scores gave a score of 5.04 ($p < 0.001$), demonstrating that the improved plaque scores were probably related to the increased pressures.

DISCUSSION

Many features of oral hygiene have been studied and reported in the literature, but no one has yet made a systematic study to see if the force of brushing might be related to the quality of a patient's toothbrushing. In fact, there are several references in the dental literature specifically warning patients not to use too much force when brushing because of the danger of dental and gingival erosion.[25–28] Force, however, is difficult to evaluate objectively. How much is enough? A previous study revealed that good orthodontic toothbrushers use

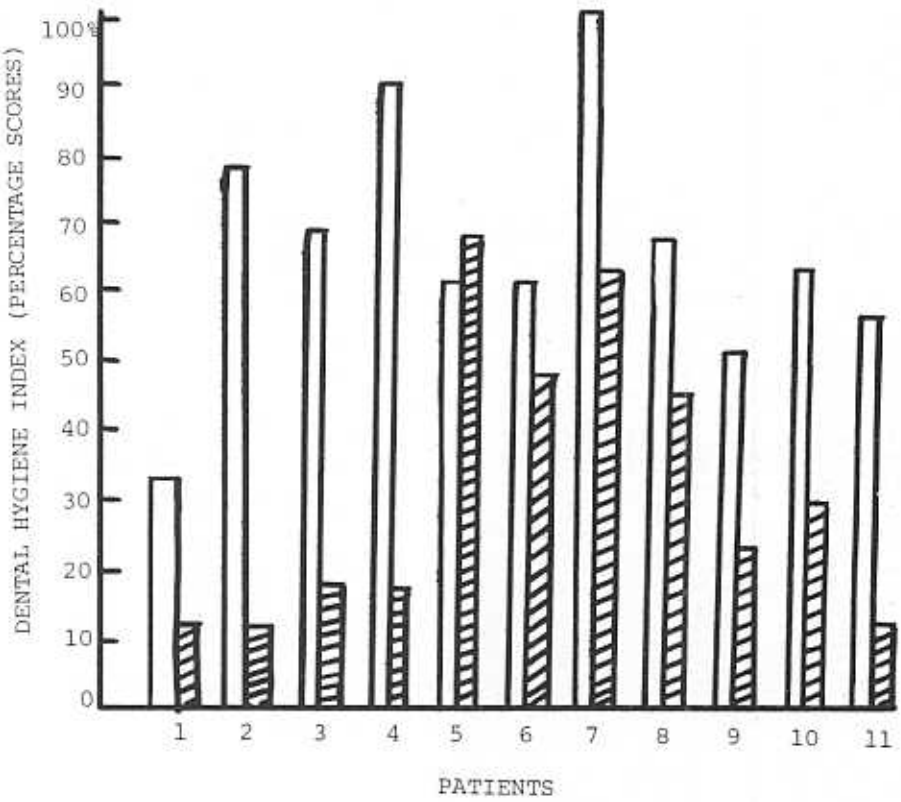

Fig. 4.

almost 1 lb of pressure when they brush (with no dental or gingival deterioration), and the poor brushers use only about 3 oz of pressure.[1] This is not to say that faulty brushing habits cannot damage teeth and gingiva. There is ample evidence that it does occur,[29-31] but the use of soft, rounded bristles, proper bristle positioning, a nonabrasive dentifrice, and a circular or vibratory stroke has not damaged the gingiva or teeth of the patients we have studied when forces near 1 lb were used.

When patients were allowed to develop their own schedule of shaping for increasing their personal toothbrush pressures, the target pressures were kept within manageable and endurable amounts and the patients learned that the targets were not unduly punishing.

One misunderstanding about reinforcement schedules is that they unnecessarily coax the performance of behaviors that should somehow occur naturally, but a natural behavior for one person is often quite unnatural for another. Obviously, this is true for chronically poor orthodontic toothbrushers. Brushing well is not a natural behavior for these patients. Another misconception is that reinforcements must be of a material nature. There is no doubt that tangibles are effective reinforcers, but this neglects the motivating power of immediate knowledge about an assigned task. If a reinforcement schedule is not effective, it is usually not powerful enough or is too tardy. Often both com-

Table I

Patient	*Before DHI score*	*After DHI score*	*Difference*
G.G.	18	12	6
S.C.M.	12	8	4
S.M.	9	5	4
M.D.	6	2	4
D.H.	14	2	12
E.C.	11	5	6
R.B.	11	12	−1
R.C.	11	8	4
C.P.	12	3	9
J.G.	16	2	14
B.E.	10	2	8
	Mean = 11.8	Mean = 5.6	Mean = 6.36
	Mode = 11.0	Mode = 2	Mode = 4
	Median = 11.0	Median = 5	Median = 5

SD = 4.20.
SE = 1.26.

$$\frac{\text{Mean average score after} - 5.6}{\text{Mean average score before} - 11.8} \times 100 = 47\%$$

bine to give a powerful disincentive for behavioral change.

The design of the feedback mechanism developed for this study was based upon the concept of immediacy and accuracy of feedback. Although these are tangibles that can be seen and relied upon, they are not materialistic in the usual sense. Nevertheless, they were powerful enough to evoke major changes in patients' oral hygiene scores.

This study has shown that orthodontic patients who were consistently poor toothbrushers could improve their brushing effectiveness by the slow acquisition of greater toothbrush pressures. By imitating the forces used by good toothbrushers, most of these orthodontic patients were able to improve their oral hygiene significantly. In addition, once these patients achieved 1 lb of pressure, it was not difficult for them to maintain it.

Since pain tolerance is alterable and is quite responsive to what we perceive as immediate and necessary demands, the ability of these patients to withstand greater toothbrush forces is probably due to an increased pain tolerance. It is not yet known if this brief behavioristic program is capable of permanently altering toothbrushing pressures. The permanent change effected by other behavioristic oral hygiene programs has not been good, once the positive reinforcements were stopped. It may be that the reinforcement schedule of this study will need to be maintained indefinitely to provide these patients with continued good oral hygiene, and this should be the focus of a future study.

SUMMARY

Eleven patients who had been identified previously as having chronically poor oral hygiene associated with small toothbrushing pressures were taught to use a feedback mechanism that was attached to their regular toothbrushes. This mechanism permitted the patients to shape their own oral hygiene behaviors toward higher toothbrush pressures at home. They started with 2 oz of pressure and were encouraged to increase the pressure 2 oz per week until they reached the ultimate target pressure of 16 oz. When the target pressure was set and achieved, a light came on, thus informing the patient that the target had been reached. There was an average improvement of 47% in the Dental Hygiene Index of the group. Only one patient failed to show improvement. Statistically, the improved oral hygiene scores were significantly related to the increased toothbrush pressures. A future study should determine if this improvement can be maintained without the feedback mechanism.

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