peroxide and baking soda and in some cases drugs), and assessment of bacterial control by regular microscopic examination of material from the periodontal tissues. It involves the use of water irrigation of the gums and other easily learned hygiene procedures. Some claim that, if properly used, the Keyes technique could reduce dramatically the quantity of peridontal surgery performed.

In the next three parts of this case study, we present layman's definitions of periodontal disease; a description of the technologies currently being used on a widespread basis to prevent and treat periodontal disease and an assessment of what is known about their effectiveness, based on a review of the literature: and a description of the Keyes rationale and how it may be used for diagnosing, controlling, and preventing periodontal disease.

Next, we present some preliminary results of our recent study on 18 dental practices in the Washington, D. C., Standard Metropolitan Statistical Area (SMSA) that use the Keyes technique. With data on ***190*** patients and over ***800*** dental visits, we provide a short-term assessment of the effectiveness of the Keyes technique and estimate the cost of delivering the Keyes technique to the patients in our study. The results of our study provide new and useful data on the Keyes technique, but larger scale and long-term studies are needed before more definitive conclusions can be drawn.

The final part of this study contains a brief summary of some of our major conclusions. Also discussed are a few of the steps that need to be taken in order to allow a complete cost-effectiveness analysis (CEA) of the Keyes technique. We did not perform a CEA of the current technologies used for treating periodontal disease, and no such analysis is available in the published literature. Hence, we are unable to compare the cost effectiveness of the Keyes technique to the cost effectiveness of the current treatment of periodontal disease.

PERIODONTAL DISEASE

Tooth loss, in contrast to popular opinion and mythology, is not a natural concomitant of age—it is caused by disease processes. The disease processes of the periodontal, or supporting, structures of the teeth, known collectively as "periodontal disease" or "periodontal infection," are responsible for 70 percent of all tooth extraction and are the principal cause of tooth loss (6,13,15,33).

Data show that some form of periodontal disease affects anywhere from 75 percent to virtually all of the adult population in the United States, and a destructive form involving tissue loss affects approximately one-third of the adult population (6, 15,16,22,29). Periodontal disease does afflict children, but it is more common and more severe among adults. Although the disease increases in prevalence and severity with age, it is not the aging process that causes it; rather, it is the length of time that the teeth and supportive tissues are exposed to the causative factors (21).

One of the difficulties in dealing with periodontal disease is its insidiousness. The onset of disease is gradual. Afflicted individuals are generally symptomless for long periods of time. Often patients have extensive disease, involving the loss of supporting structures and formation of deep pockets around the teeth, without being uncomfortable or even aware of the problem. All too often patients will have undiagnosed periodontal disease for years even though they have been regularly seen by a dentist.

The reasons for undiagnosed periodontal disease are several. Many dentists concentrate only on restorative problems of the teeth and thus ignore or fail to recognize periodontal disease until it has progressed to an advanced stage. The diagnosis of early or incipient periodontal disease requires not only visual inspection, but probing, staining for plaque, and radiographic (X-ray) diagnosis; typical symptoms such as bad breath, spontaneous bleeding, and pain tend to occur only after the disease has progressed to

the moderate or advanced stage. Furthermore, some dentists may not have been adequately trained in diagnosing and treating periodontal disease.

As is the case with many other chronic diseases, early diagnosis of periodontal disease affords a better chance for successful treatment. If disease is detected early, therapy requires less time and effort by the dentist, less discomfort to the patient during therapy, less difficult oral hygiene measures by the patient, and considerably less cost. Moreover, the destructive form of periodontal disease first goes through a relatively innocuous inflammatory stage, and, if diagnosed and treated at that time, the disease is in most instances easily reversible. The universality of periodontal disease is the most vexing part of the problem, because in over ***90*** percent of instances, such disease is potentially preventable by relatively inexpensive means known and available today (13,28,29).

Periodontal disease is a disease complex, a *group* of diseases placed under a single heading for purposes of convention. The term "periodontal disease" is generally used to refer to what are by far the two most prevalent periodontal diseases: gingivitis and periodontitis. Gingivitis is inflammation of the gingiva (gum) only and is generally considered a reversible process (8). Periodontitis is inflammation of both the gum and the other supporting structures of the teeth (i. e., the outer bone of the tooth socket, the outer layer (cementum) of the root of the tooth, and the soft tissues which attach these structures to one another). Periodontitis also connotes destruction or loss of the supporting structures of the teeth. Once destruction takes place, complete regeneration of the affected tissues does not occur (8). The **loss or** destruction of the supporting structures results in the formation of pathologic spaces or pockets around the teeth. [5] If this process continues, the teeth lose their supporting structure, become loose, and eventually have to be removed. Unfortunately, no accepted diagnostic method to determine at a given point in time whether the destructive process is active or quiescent is currently available (14), a circumstance with significant therapeutic implications.

Experientially, most dentists feel that the progression of gingivitis to periodontitis is part of a continuum ***(25),*** i.e., if gingivitis persists long enough, it will inevitably progress into periodontitis. However, there is no documented scientific evidence for this view. It is known that periodontitis does not develop in the absence of gingivitis ***(25);*** and it does appear that, in most instances, untreated gingivitis will progress into periodontitis (25). At the same time, there is great variability in the time it takes for progression to occur (gingivitis per se may exist for many years); and in some instances, progression does not occur at all ***(8,25). The distinction be***tween gingivitis and periodontitis is emphasized, because gingivitis, by far the most common form of periodontal disease, is relatively innocuous. Most important, it is potentially reversible in a majority of instances. Uncomplicated by any other factor, gingivitis is usually relatively easy to treat with methods that produce little or no discomfort to patients, and the cost of treating gingivitis is a small portion of what it costs to treat destructive periodontitis.

Bacteria] infection is the essential factor in the initiation and propagation of periodontal disease ***(30,32).*** The exact mechanisms by which the germs produce their deleterious effects remain undiscovered, but there is little doubt that bacteria are the principal cause of periodontal disease. The sine qua non in the etiology of periodontal disease is the presence of a microbial population in the form of dental (or bacterial) plaque. Dental plaque is a gummy bacterial substance that adheres to the teeth; it cannot be seen by the naked eye, but is easily demonstrated by various stains. In the absence of bacterial plaque, periodontal disease does not occur; removal of such plaque halts the progression of, produces remission of, or *reverses ex*isting disease. Further evidence of the role of bacteria in causing periodontal disease is the fact that antimicrobial agents are often effective in controlling such disease (25,32).

[5] The normal space between the gum and the tooth is called a SUlCUS. When this space deepens or extends past its normal boundary as a result of the inflammatory process, it is called a pocket.

Bacterial populations in the mouth differ under conditions of health and of disease, a finding which has also has therapeutic implications (13). Furthermore, the same evidence points to differences in the microbial composition of gingivitis and periodontitis. The importance of the role of bacteria in causing periodontal disease must be emphasized, because the fundamental aim of periodontal treatment is to control bacterial plaque or to facilitate its control by the patient, and the principal goal of prevention is to inhibit its formation.

Faulty or improperly placed margins of dental restorations (fillings) are recognized as a factor contributing to periodontal disease (21,29). In the face of these margins, plaque accumulates readily, and the existing inflammatory process is enhanced. What is not clear is whether faulty margins actually initiate or just worsen the disease process. In either case, improper margins have to be dealt with as a part of treatment.

There are other factors allegedly associated, causally, with periodontal disease. A list would include, in no relative order of importance, malocclusion (malpositioning of the jaws with respect to one another), faulty tooth position, genetic predisposition, systemic disease such as diabetes mellitus, and malnutrition. No further discussion about these factors is warranted, since they are not thought to be essential in causing periodontal disease, and at most are considered adjunctive to periodontal disease (i.e., they might exacerbate preexisting periodontal disease) (21,25,34). Also, the consideration of these factors in a CEA of periodontal therapy would be negligible.

TRADITIONAL TECHNOLOGIES USED TO TREAT PERIODONTAL DISEASE

The traditional technologies used to treat periodontal disease can be placed into two broad general categories—nonsurgical and surgical.

Nonsurgical Technologies

Plaque Control

There is a well-documented, direct relationship between the frequency of plaque removal and gingival and periodontal health ***(5,29,31).*** Daily plaque removal is considered optimally conducive to gingival health. Obviously, individuals cannot have dental care professionals remove plaque every clay. Patients must learn to remove plaque by themselves, a task not terribly onerous, but requiring some knowledge and mastery of technique.

The plaque control programs of periodontal therapy are aimed at instructing patients in the oral hygiene techniques that will remove plaque and prevent it from accumulating in harmful amounts. Basically, these oral hygiene techniques are the application of stain to detect plaque and the brushing and flossing of teeth to remove it. Professionally supervised practice of these techniques is usually a basic part of periodontal therapy. The outcome of periodontal therapy depends on how well the patient controls plaque formation. In the absence of plaque control, any therapy is of little or no value (4,23,26,29).

On the basis of the prevalence of periodontal disease (6,16,22), it appears that, unfortunately, most people do not effectively control plaque formation, including many who have had extensive instruction and have been treated for destructive periodontal disease. The issue is not simple. Plaque control is more than a question of instruction about the proper methods. It requires individuals to change or modify their behavior so they not only know the correct methods, but are motivated to use them routinely.

Scaling and Root Planing

Scaling and root planing are professionally applied mechanical techniques. Scaling is used to remove calculus (hard deposits) from the teeth, root planing to smooth the root surfaces,

ostensibly to make the roots less susceptible to microbial activity. The largest proportion of the time and effort expended in treating patients with periodontal disease is devoted to scaling and root planing (11). In some instances, surgical techniques are used to make the roots more accessible to this type of instrumentation.

Although it is generally assumed that the gingiva are irritated by the mere physical presence of calculus, this assumption awaits substantiation by scientific data (9). The microbial plaque covering the calculus is the noxious agent. Removal of gross or obvious calculus appears to be indicated; however, what is not clear is whether it is worthwhile to spend the time and effort required to remove small amounts of calculus that are difficult to detect, particularly since plaque re-forms in ***24 to 36*** hours (19,29).

There is also disagreement about the benefits of root planing. The little evidence available suggests that the primary rationale for root planing is to remove calculus; root smoothness may be inconsequential in retarding plaque formation ***(11,29).*** At any rate, the most important determinant of periodontal health is the degree to which patients exercise plaque control ***(23,27,29).***

Another issue relates to the frequency of prophylaxis (professional scaling) required to maintain periodontal health. A landmark study indicates that the optimal frequency is at 2-week intervals (5). However, other data suggest that quarterly intervals are also beneficial, although not as effective as 2-week intervals (29). Again, the benefits of scaling are believed to be less important than the patient's personal oral hygiene and plaque control. Unfortunately, more people rely on the dentist or hygienist for prophylaxes than practice good plaque control themselves. Thus, the issue of frequency must be examined, particularly from a standpoint of cost effectiveness. On the basis of available evidence, prophylaxis at 2-week intervals would be cost prohibitive for most individuals. Moreover, given current methods of dental practice, there is inadequate manpower to routinely clean people's teeth at 2-week intervals.

Correcting Margins of Restorations

Since improper margins of dental restorations contribute either to the initiation or severity of periodontal disease, the correction of such margins is an integral part of therapy. The most important reason for correcting improper margins is to facilitate plaque control, because in the face of an overhanging restoration, for example, plaque removal is exceedingly difficult. Generally, correction in the form of reducing bulk or smoothing is done at the time of scaling and root planing; but it is a requirement of periodontal therapy regardless of **when** it is done.

Chemotherapy

Substantiation of the fact that micro-organisms are a primary causative factor in periodontal disease has sparked much interest in chemotherapeutic control measures (1,20,29, 30). Some of the initial attempts to control periodontal disease with certain antimicrobial agents have been successful, but these attempts must be considered only trials. Essentially, insufficient evidence is available to warrant the routine use of these agents ***(29).*** Furthermore, a limitation of the studies thus far conducted is that they have been short-term. Periodontal disease is of long duration and requires what amounts to a lifetime of effort in controlling plaque formation; an antimicrobial agent may suppress bacteria or reduce plaque formation in a short-term clinical trial, but this does not mean that it will do so effectively and safely, without side-effects, for a long period of time. Nonetheless, further chemotherapeutic experimentation is warranted. However, at this time, chemotherapy is not considered a primary technology in the control of plaque or periodontal disease.

'Chemotherapy, the use of chemical agents—in this case antibiotics—to treat disease, is not an accepted, routine part of periodontal therapy. It is included here because the role of micro-organisms in causing periodontal disease has been shown only recently, and the principal method of treating microbial diseases generally is with these agents. As specific bacteria are identified as causative agents, much more emphasis is likely to be placed on the use of chemotherapy. The discussion of chemotherapy is also included because of cost implications.

Surgical Technologies

Periodontal surgery, in one form or another, is a common procedure used to eliminate the pockets that occur in destructive periodontal disease (24). Different surgical techniques are used for different purposes. Eliminating pockets, making root surfaces more accessible to removing plaque, inducing reattachment of tissues, and restoring destroyed tissues are the main clinical objectives of employing these techniques (7). In practice, two or more techniques often are used together to achieve a specific result.

Regardless of the objective of the specific surgical method, the fundamental rationale of periodontal surgery is to prolong the functional life of the teeth. The ultimate success or failure of the particular surgical method, therefore, should be judged by the extent to which the method conserves tooth life. Unfortunately, there are few baseline data on which to make objective evaluations. With only a few exceptions ***(7,23,24),*** the studies of the different surgical methods are short term. Longitudinal studies (longer than 5 to 10 years) required of diseases having the apparent chronicity of periodontal disease are needed. Until such scientific studies have been carried out, objective measurements of surgical effectiveness must remain tentative at best.

Those studies that have been done do not unequivocally point to one technique's being superior to another ***(7,23,24,27).*** Moreover, although the reasons for doing periodontal surgery can be supported experientially, scientific evidence does not show that any of these surgical techniques alone is effective in prolonging the life of the teeth. Periodontal surgery makes no difference in the absence of reasonable oral hygiene by patients combined with professional maintenance ***(23,24,26,27).*** The surgery by itself will not restore health to diseased periodontal tissues.

In summary, we conclude that there is considerable controversy surrounding the efficacy of the various surgical techniques used in the treatment of periodontal disease. It is also fair to note that the emphasis on surgical technology may be misplaced ***(29)*** and the type of surgery that is performed is considered far less important than whether or not the teeth can be maintained in a state of good oral hygiene ***(4,23,24, 26,27).***

THE KEYES TECHNIQUE

Dr. Paul Keyes and associates have developed and are testing a technology they believe suppresses plaque microbes and arrests, or markedly abates, the progression of destructive periodontal disease (17,18). This technology involves the use of a meticulous diagnostic and therapeutic regimen, the latter involving the application of certain salt solutions in all instances, and periodic courses of systemic antibiotics when indicated. Therapeutic regimens are based on microscopic sampling of plaque in the pocket areas as a means of monitoring bacterial activity. An integral part of the Keyes program is to show the patient the actual bacteriologic activity in the periodontal tissues though a microscope, the intent being to convince the patient of the extent of the problem and to motivate him or her to help in its remediation. Oral hygiene and plaque control instruction is given in a slow, stepwise fashion over a 3- to 4-week period. Patients are also advised to rinse their mouths after eating, whenever possible, and to use a pulsed-water irrigation device, such as a Water Pik, once a day.

Earlier we stated that there is no diagnostic method available to determine whether or not destructive periodontal disease is in an active state. The Keyes method purports to distinguish active from inactive disease by assessing the specific microbial population and inflammatory process in the pocket area. Dr. Keyes asserts what others believe but are not willing to assert without more substantiating evidence—that the

specific bacteria identified via the microscope are predictors of pathologic status and that the bacteria associated with disease differ from those found in healthy periodontal tissues. With the information obtained via microscopic examination, treatment is initiated which is aimed at suppressing the microbial population and facilitating the patient in controlling plaque formation.

Although the Keyes method is still in the early stages of being tested, Keyes has reported marked improvement in patients he has treated ***(18).*** It should be emphasized that the effectiveness of the Keyes method, like that of other treatments, depends on the patient's assiduously following the prescribed plaque control program (18). If it turns out that the Keyes method is as effective as its developers believe, then that would mean, among other things, that the patients using the Keyes method are doing a better job of controlling plaque than they would with other technologies. That in itself would be a most significant outcome.

Many individuals do not practice good oral hygiene. Even patients who have undergone extensive periodontal surgery and have received intensive oral hygiene instruction as a part of therapy often do not exercise adequate plaque contro; the recurrence rate of periodontal disease in such patients is high (24). If the Keyes method proves more effective than others, that will mean that something about this method enables or makes it easier for patients to exercise plaque control better than the other methods used to date. It could be the Keyes method's slow, stepwise fashion of patient instruction. Possibly, showing patients microbes taken from their tissues under a microscope impresses the nature of the problem upon the patients in a more effective manner. This is only speculation, and, of course, it is far too soon to tell if the Keyes technique has lasting effect. Much more evaluation—particularly long-term evaluation—is needed. (In the next part of this case study, we present the first systematic assessment of the effectiveness of the Keyes technique in multiple practice sites.)

Figure 1 shows some of the important similarities and differences between the Keyes and traditional technologies for treating periodontal disease. The "traditional" technology is shown in the lower half of the figure and the steps are labeled by capital letters. The "Keyes" technology is shown in the upper half of the figure, with the steps labeled by lower case letters.

Regardless of which technique will be applied to an individual patient, all patients—those who will be managed traditionally as well as those who will not—initially go through about the same diagnostic and treatment planning procedures. Once periodontal disease is diagnosed (Aa), patients can be treated either by "traditional" methods or the "Keyes" method. At this juncture, all patients with periodontal disease receive oral hygiene instruction and extensive tooth cleaning (scaling and root planing), see (B) and (b) on the figure. A comparison of (B) and (b) shows that the patients being treated by the Keyes method also receive a microscopic examination and are placed on a regimen that includes salt-solution therapy.

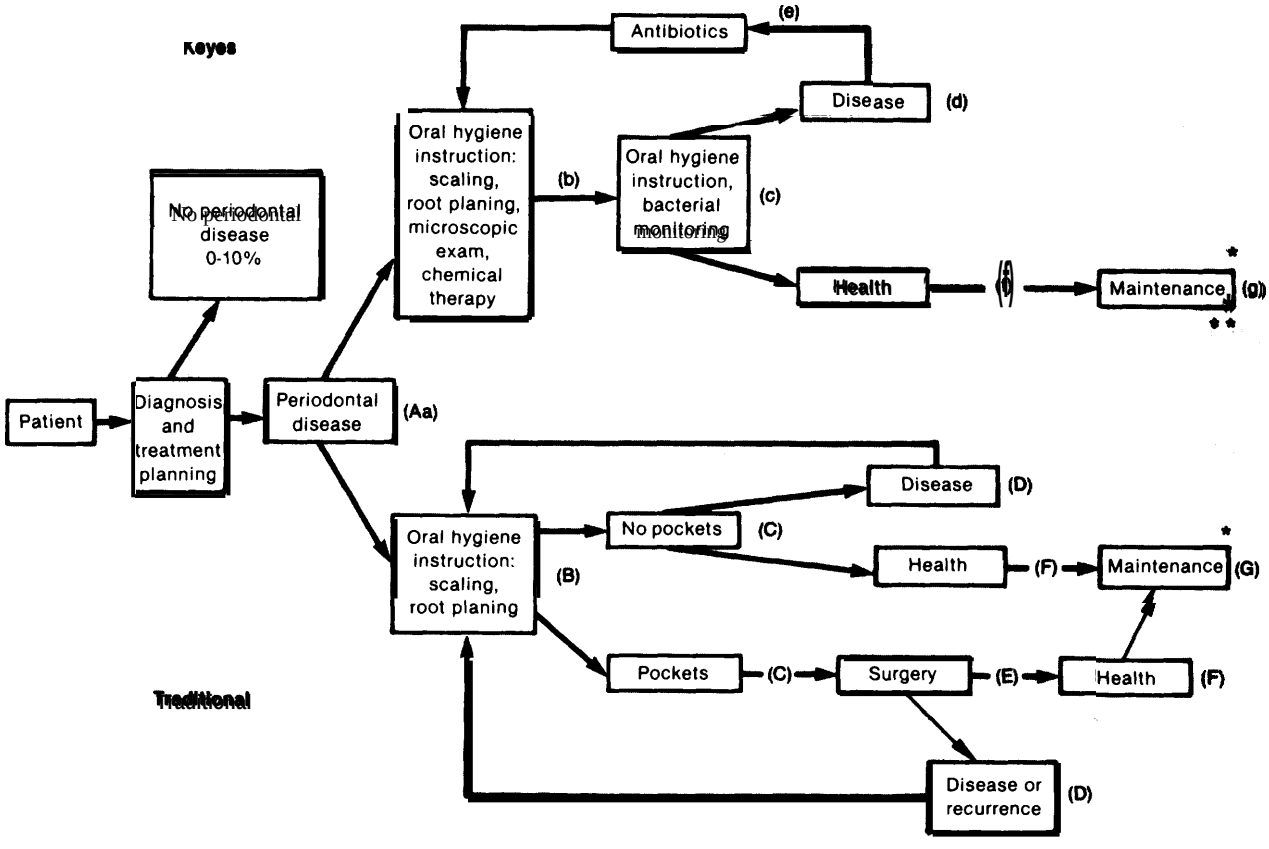
In patients being treated by the "traditional" method, a determination is then made of the presence or absence of pockets (C). If there are no pockets but disease is present (D), the patient receives further tooth cleaning and hygiene instruction (B). If pockets are present, some form of surgery is usually, but not always, performed (E). After surgery, if disease persists or recurs (D), the patient receives additional tooth cleaning and hygiene instruction (B). If no pockets are present and the patient is in reasonable oral health (F), a maintenance phase is begun (G).

In patients being treated by the "Keyes" method, by contrast, oral hygiene instruction and bacteriologic monitoring continue (c), but there is no surgery. If disease (d) persists, the patient is generally placed for 2 weeks on a regimen of antibiotics,[7] and oral hygiene instruction, microscopic examination, and tooth cleaning are continued (b). If the patient is in reasonable oral health (f), a maintenance phase is begun (g).

The Keyes technology differs from the traditional method of treating periodontal disease in three essential ways: 1) Microscopic diagnosis

[7]'Antibiotics may also be used in the traditional method, but are not used as routinely.

Figure 1.—Comparison of the Keyes and Traditional Methods Used To Treat Periodontal Disease



* Maintenance— assumes reasonable plaque control by patient, and assumes periodic professional scaling, oral hygiene instruction, etc.

** Includes bacteriologic monitoring.

and monitoring of microbial activity is the basis for therapeutic decisions; 2) salt solutions are used routinely and antibiotics are used often; and 3) periodontal surgery to eliminate pockets is used infrequently, since complete pocket elimination is not a goal of the Keyes method. The Keyes method is founded on Keyes' belief that halting the progression of the destructive process and allowing natural healing to occur does not depend on surgical elimination of the pocket, but does depend on controlling bacterial activity.

It should be emphasized that the steps shown in figure 1 are general, and some of the particular steps may differ, especially in the "traditional" technology. These differences or changes depend on several factors, such as extent of disease, the patient's overall health, the patient's ability or willingness to pay, and the personal treatment philosophy of the practitioner. Also, it should be reemphasized that the ultimate success of therapy, regardless of method, depends more on how well the patient practices good oral hygiene than on what the dentist does for the patient.

NEW EVIDENCE ON THE EFFECTIVENESS AND COST OF THE KEYES TECHNIQUE

Data Collection

To perform our study of the effectiveness and cost of the Keyes technique, we collected data in 1979 on ***18*** dental practices from the Washington, D. C., SMSA that currently use this technique.[8] Using written questionnaires, we collected data on each practice and on a selection of the patients in each practice who are currently being treated with the Keyes technique.'

Data on ***8*** of the practices were obtained via a mail survey, and data on the other 10 were collected by dental students.'" All 18 of the dental practices surveyed were owned and operated by solo general practitioners. The average age of these practitioners was 47. The average length of time they had been in practice was almost 12 years; they had used the Keyes technique for 13.7 months on the average.

Using information from the patients' records, we completed a written questionnaire on about 10 patients in each practice who were beyond their initial visit for the Keyes technique.[11] The questionnaire used to collect data on individual patients is reproduced in appendix B. Using this questionaire, we obtained data relating to the patient's oral health status before treatment and at the time the questionnaire was administered. Data were also obtained on the services delivered to the patient during the first six visits and the maintenance visit, on who delivered these services, and in what amount of time. The charges for each visit were also recorded. Usable data for our estimates were collected on 190 patients and over 800 dental visits. Approximately 63 percent of the patients were female. The average age of all patients was ***42.***

The Effectiveness of the Keyes Technique

In order to demonstrate the effectiveness or lack of effectiveness of the Keyes technology, five measures were used as general indicators of periodontal disease of the patients in the study before and after treatment. All five oral health indicators showed some improvement following treatment (see table 1).

A number of the important indicators changed dramatically. Bleeding of gums upon probing, an indication of early or beginning disease, dropped from 99 percent of the patients showing it before treatment to 34 percent of the patients showing it at the time the information was obtained. Another important change was the decrease from ***65*** to ***9*** percent in the number of patients with loose teeth. This change is im-

Table 1.—Periodontal Disease **Indicators: Effectiveness or Lack of Effectiveness of the Keyes Technique**

Indicator	Percentage of patients: Status before treatment	Percentage of patients: Current status
1. Bleeding on probing	99%	34%
	N = 185	N = 185
2. Suppuration	56	23
	N = 185	**N = 181**
3. Mobile teeth	**65**	**9**
	N = 178	**N = 173**
4. WBCS microscopically evident	94	78
	N = 182	N = 172
5. Motile forms microscopically evident	62	32
	N = 170	N = 148

N = number of observations.
Probing—Placing a dental instrument under the gingiva to determine whether or not bleeding will occur and to measure periodontal pockets, if present.
Suppuration—Pus (exudate).
Mobile teeth—Loose teeth.
WBCs—White blood cells.
Motile forms—Live or moving bacteria.

'Currently, there are 26 dental practices using the Keyes technique in the Washington, D. C., SMSA. Except for the data collected at the National Institutes of Health by Keyes on his own practice, no other data of this type are currently available.

"The data collection for the study was supported in part by a grant (grant No. H.S.-O2577) from the National Health Care Management Center, Wharton School, University of Pennsylvania. That center is funded by the National Center for Health Services Research, Office of the Assistant Secretary for Health, Department ofHealth and Human Services.

"OA comparison of the data collected via mail and the data COIlected by the dental students did not show any important statistical differences. The data collected by the dental students were more complete.

"In some practices, we were able to complete questionnaires on more than 10 patients; in others, we had to settle for fewer.

portant because loose teeth are an indication of advanced disease, A "t" test on the difference between the percentages before and after treatment for each of the periodontal disease indicators in table 1 was statistically significant at the 0.01 level. Thus, these data indicate a significant overall improvement in dental health for our study population.

Moreover, at the time our study was done, ***65*** percent of the ***190*** patients in the study population had gone from treatment to maintenance, and only 35 percent required further treatment. We also performed an analysis of the data over time. This analysis included some of the patients being treated and then maintained by the Keyes method for more than ***24*** months. *[2] In these patients, the indicators of oral health continued to show almost the same level of improvement as in patients treated and maintained for less time.

Furthermore, our analysis of the data concerning the effect of the Keyes technology on the level of plaque control exercised by the patients showed that improvement in plaque control had occurred to the same extent as improvement in the other indicators (see table 2). For example, before treatment 93 patients were judged to have below-average plaque control, but at the time our data were collected only 12 patients were rated in this manner. A chi square test showed patient improvement in plaque control (as indicated by the before and after data in table 2) for all groups of patients to be statistically significant at the 0.01 level or greater. (This finding does not apply to the group of patients who were above average in plaque control before treatment.)

[12] The data used for this analysis are not presented in this discussion.

Table 2.—Plaque Control by Patients

Patient status before treatment	After treatment		
	Above average	Average	Below average
Above average (2).	2	0	0
Average (76). . , ...	56	19	1
Below average (93).	42	39	12
Total (171).	100	58	13

The Delivery and Cost of the Keyes Technique

The Keyes technique involves the delivery of 10 basic procedures. These procedures and the percentage of patients in our study population receiving them during each visit to the dentist are shown in table 3. The first visit usually involves a dental history ***(76*** percent) and a medical history (84 percent). If histories are not provided during this visit, that usually indicates that histories were provided at a visit prior to beginning the Keyes technique. This is also the case for radiographs and visual assessment. During the first visit, over half the patients undergo periodontal probing (7 I percent), a microscopic examination **(64** percent), and a scaling **(52** percent). About two-fifths of the patients receive periodontal pocket measurements (40 percent) and almost one-sixth (16 percent) receive root planing. Almost two-thirds of the patients (64 percent) also receive plaque control instruction during the first visit.

The percentage of patients receiving dental histories, medical histories, and radiographs, as expected, declines after the initial visit. Over the next two visits (visits 2 and 3), the percentage of patients receiving root planing and scaling increases. Later visits continue the use of scaling and root planing, as well as plaque control instruction and probing. The maintenance visit shows some increase in visual assessment, $scali_{ng}$, pocket measurement, and microscopic examinations. Clearly, the maintenance visit (except for the histories, diagnosis, and plaque control instruction) is somewhat similar to the initial visit in terms of the procedures performed.

To estimate the cost of producing the Keyes technique, we began with data on the amount of dentist and hygienist time used during each visit (see table 4). The majority of this time is used to instruct the patient in plaque control and provide maintenance. The first visit uses an average of 28 minutes of dentist time and 24 minutes of hygienist time. '3 For later visits (visits 5 and 6,

[13] It is interesting to note that the estimate of the average dentist time has a large standard deviation in comparison to the mean (coefficient of variation). A further analysis of the data showed that there was a significant variation among the 18 dental practices, as well as across the patients treated within each practice.

Table 3.—Mix of Services Delivered at Each Visit for the Keyes Technique

Service	Percentage of patients (N)						
	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Maintenance visit
Dental history	76% N = 184	1 % N = 177	1 % N = 158	0 N = 135	0 N =99	0 N =69	4% N = 105
Medical history	84 N = 184	6 N = 177	N =[6]158	6% N = 135	4% N =99	1% N =69	N 105
Radiographs	71 N = 184	10 N = 177	7 N = 158	N =[7]135	5 N = 100	14 N =69	14 N = 105
Visual assessment	97 N = 184	71 N = 177	71 N = 158	70 N = 135	67 N =99	67 N =69	84 N = 105
Periodontal probing	71 N = 185	62 N = 177	60 N = 158	N=99	47 N =99	45 N =69	51 N = 105
Pocket measurement	40 N = 185	20 N = 177	17 N = 158	14 N = 135	12 N = 100	19 N =69	32 N = 105
Microscopic examination	64 N = 185	62 N = 177	54 N = 158	46 N = 135	47 N =99	51 N =69	54 N = 104
Scaling	52 N = 184	63 N = 177	66 N = 158	62 N = 135	N =69	68 N =69	83 N = 105
Root planing	16 N = 185	33 N = 177	35 N = 158	28 N = 135	N =1OO	32 N =69	36 N = 105
Plaque control instruction	64 N = 185	72 N = 176	54 N = 157	44 N = 135	37 N = 100	38 N =69	26 N = 105
Other	28 N = 185	30 N = 176	36 N = 157	33 N = 135	23 N = 100	22 N =69	35 N = 105

N = number of observations.

Table 4.—Average Dentist and Hygienist Time Used for Each Visit for the Keyes Technique

	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Maintenance visit
Dentist time[a]	28 SD=22.46 N = 173	22 SD=19.83 N = 138	20 SD=18.1O N = 135	21 SD=19.00 N = 111	19 SD=16.84 N =93	22 SD=18.17 N =50	20 SD=17.56 N =92
Hygienist time[a]	24 SD= 22.43 N = 140	25 SD= 19.20 N = 143	23 SD= 19.99 N = 117	23 SD= 19.28 N =99	21 SD= 19.27 N =69	21 SD= 19.72 N =53	21 SD= 18.25 N =83

SD= Standard deviation
N = mumber of observations.
[a]Time in minutes.

and the maintenance visit), the amount of dentist time in each visit declines, while amount of hygienist time remains quite stable. (For purposes of our cost calculation, we assumed that the dentist time is spent with only one patient. However, it is likely that some dentists are treating more than one patient at a time. If that is the case, our estimates of the average variable cost of production may be too high.)

To estimate the average variable cost (in 1979 dollars) of producing the Keyes technique, we assume that the dental practice is already in operation and that the only additional expenses for producing the Keyes technique are the cost of the phase-contrast microscope and the cost of the dentist and hygienist time.[14] The scope cost is about ***$3,000,*** and we depreciate it over a 10-year period. For the purpose of our estimates, we allocate the cost of the scope to **100** patients being treated by the Keyes technique per year at $3 per visit.[15] The cost of dentist time, based on the yearly income of and hours worked by a

[14] In a technical sense, once the scope is purchased, it is a fixed cost **and not a** variable cost. Since the cost of the scope is modest, deleting the cost from our estimate would **have very** little impact.

[15] This estimate may be high, because dentists who use the Keyes technique probably treat more than 100 patients a year. In any event, the per unit cost of using the phase-contrast microscope is small; thus, alternative methods of computing its cost will have a small impact on *our* estimates.

general practitioner, is estimated at ***$25*** per hour (3). " To estimate the cost of hygienist time, we used the same costing procedure and added is percent for fringe benefits. This produced a cost of ***$8*** an hour for the hygienist time (3).17

To produce an estimate of the labor cost per visit, we applied these hourly rates to the minutes of time used by the dentist and hygienist. To this estimate, $3 was added for the use of the phase-control scope to produce estimates of the average variable cost of producing each visit (see table 5). According to our estimates, the average variable cost of producing the initial visit is higher than that of producing subsequent visits. The difference in average variable cost mostly reflects the reduction of time spent by the dentist and the different range of services provided following the initial visit (table 4).

Data from our survey on the average charge for each visit are presented in table 5. Again it is interesting to note that the average charge is highest for the initial visit. Moreover, for the maintenance visit, the average variable cost as a percentage of average charge is the lower than it is for any of the first six visits. For the dentists that charge for the Keyes technique on the basis of the total treatment cost, the average charge per case was slightly over $120. This charge per case is comparable to the total charge, on a per visit basis, of between five and six visits.

In addition to paying the dental charges for the Keyes technique, the patient needs to purchase an electric toothbrush and electrical irrigating device at a total cost of ***$30*** to **$40.** In about half the cases treated by the Keyes technique in our data base, drugs were utilized, usually tetracycline. The cost for tetracycline per prescription is between **$8** and **$10. In most** instances, one or two prescriptions are required for those patients using tetracycline. It is currentl$_y$ believed that after the patient has been treated successfully by the Keyes technique, two maintenance visits at an average charge of about **$26** per visit are required to ensure continued oral health ***(29).***

The Keyes technique may have benefits in addition to the treatment and prevention of periodontal disease. In some patients, a benefit may be a reduction in tooth loss. Furthermore, if surgery is avoided, the pain and discomfort associated with surgery are also avoided. By involving patients in improving their oral health, the Keyes technique may improve their awareness of dental disease and encourage their early use of dental services, while the disease is still treatable, often at a reduced cost.

[16]The hourly income rate of dentists in general practice was derived in the following manner. Yearly average income of general practitioner dentists for 1976 (3) was inflated to 1979 using the Consumer Price Index for dental services. The yearly income figure was then divided by the average number of hours worked per week and weeks worked per year (3).

[17]The hourly wage of hygienists for 1979 was derived by inflating their average yearly income in 1976 by the increase in the dental care component of the Consumer Price Index (3). For full-time hygienists, we divided their average yearly income by the average number of weeks worked and the average number of hours worked per week (3). To this estimate, we added an additional 15 percent for fringe benefits.

Table 5.— Estimates of the Average Variable Cost of Producing Each Visit and the Average Charge per Visit for the Keyes Technique

	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Maintenance visit
Average variable cost[b]	$17.87	$15.33	$14.40	$14.82	$13.72	$14.97	$14.13
Average charge	$31.63	$26.63	$25.80	$26.21	$23.52	$23.17	$27.83
	N = 135	N = 132	N = 112	N = 90	N = 69	N = 45	N = 64

N = number of observations
[a]All figures in 1979 dollars
[b]Estimated using the cost of dental time, hygienist time, and a phase-contrast microscope.