# Compliance as a Prognostic Indicator: Retrospective Study of 505 Patients Treated and Maintained for 15 Years

Takanari Miyamoto,*† Takashi Kumagai,‡ Judith A. Jones,*§ Thomas E. Van Dyke,‖ and Martha E. Nunn§

**Background:** The relationship of patient compliance to overall tooth prognosis remains controversial. There are little data, often conflicting, that pertain to tooth loss as a function of patient compliance.

**Methods:** This retrospective study evaluates the impact of compliance (complete versus erratic) on common periodontal clinical variables, such as probing depth, bleeding index, plaque index, and tooth loss for 505 patients in a long-term period of observation (15 to 23 years) and maintenance therapy (at least 10 years). Compliance was defined in two ways for all analyses. Under the definition for compliance 1, patients who missed <30% of all prescribed maintenance visits were classified as complete compliers. Under the definition for compliance 2, patients who never went 2 years without a maintenance visit were classified as complete compliers. Change in clinical variables was dichotomized into reduction in plaque index versus no reduction, reduction in bleeding on probing versus no reduction, reduction in the percentage of periodontal pockets >3 mm versus no reduction, no increase in decayed, missing, or filled teeth (DMFT) versus increase, and no tooth loss versus tooth loss. The effects of both definitions of compliance were then evaluated in a series of multiple logistic regression models with adjustment for potential confounders.

**Results:** The analysis of the dichotomous change in clinical parameters over time revealed that complete compliers tended to show reduction in bleeding on probing and reduction in plaque index compared to erratic compliers for both definitions of compliance. In contrast, complete compliers under compliance 2 were less likely to have a reduction in the percentage of periodontal pockets >3 mm compared to erratic compliers, whereas complete compliers under compliance 1 had about the same likelihood of demonstrating a reduction in periodontal pockets compared to erratic compliers under this classification scheme. Under both definitions for compliance, complete compliers were more likely to exhibit tooth loss than erratic compliers, with the greatest tooth loss exhibited by complete compliers under the definition for compliance 1.

**Conclusions:** Based on these results, complete compliers under both definitions tended to show a reduction in plaque and bleeding on probing over time. However, change in periodontal pockets and DMFT over time varied according to the definition of compliance that was used. In addition, the results seem to indicate that the decision for tooth extraction made by dental health professionals at maintenance visits may result in greater tooth loss. *J Periodontol 2006;77:223-232.*

**KEY WORDS**

Compliance; maintenance; prognosis.

* Department of General Dentistry, Goldman School of Dental Medicine, Boston University, Boston, MA.
† Department of Dental Public Health, School of Dentistry at Matsudo, Nihon University, Matsudo, Chiba, Japan.
‡ Private practice, Yamagata, Japan.
§ Department of Health Policy and Health Services Research, Goldman School of Dental Medicine, Boston University.
‖ Department of Periodontology and Oral Biology, Goldman School of Dental Medicine, Boston University.

Compliance has been defined as "the extent to which a person's behavior coincides with medical or health advice."[1] In dentistry, compliance has been emphasized as the cooperation of the patient in performing suggested home care and returning for maintenance visits to arrest disease progression and maintain the dentition in a state of health and function.[2] It has been reported that less plaque control over long periods (i.e., home care) may result in increased rates of caries and periodontitis, since bacterial plaque is the primary etiological factor for these oral diseases.[3,4] Also, the necessity for suggested maintenance visits has been well documented. Both prospective and retrospective studies show that patients who comply with suggested maintenance intervals are able to maintain periodontal health status, including reduced probing depth, less bleeding on probing, and reduced plaque index.[5-8] While clinical parameters such as periodontal probing depths, bleeding on probing, and plaque index are useful for the evaluation of a patient's periodontal health status, it is also advisable to use a true endpoint, such as tooth loss, when possible, rather than depending entirely upon proxy endpoints to examine the significance of prognostic factors, such as compliance. However, there are little data, often conflicting, that pertain to tooth loss as a function of patient compliance.[8-10]

Wilson et al.[9] classified the compliance of supportive periodontal therapy (SPT) as complete compliance, erratic compliance, and non-compliance. They initially compared tooth survival in patients with complete compliance to tooth survival in patients with erratic compliance. Their results showed that none of the patients who complied with all suggested maintenance visits lost any teeth, while the total number of teeth lost for the 104 patients with erratic compliance was 60 teeth over 15 years of their retrospective study. These results were confirmed in another study by Becker et al.[10] that showed similar tooth loss frequency per patient per year in untreated and unmaintained patients. However, the studies conducted by other groups have suggested that tooth survival in patients with erratic compliance is not significantly different from tooth survival in patients with complete compliance after active treatment is completed.[8,11] McGuire and Nunn[11] evaluated the survival rate of periodontally compromised dentitions and investigated the relationship of commonly taught clinical parameters to actual tooth survival. Their results indicated that compliance, as defined by Wilson,[2] did not significantly affect tooth survival.[11] Konig also conducted a retrospective comparison of clinical variables between compliers and erratic compliers and found no significant differ-

ence in tooth loss between compliers and erratic compliers during SPT.[8]

Therefore, it is still questionable if a tooth in a completely compliant patient has an improved survival rate compared to a tooth in an erratic complier. The purpose of this retrospective study was to evaluate the impact of compliance (complete versus erratic) on common periodontal clinical parameters, such as probing depth, bleeding on probing, and plaque index, and tooth survival in a long-term observation period (15 to 23 years).

## MATERIALS AND METHODS

Data for 505 patients (including treatment) who were followed for at least 15 years and were maintained for at least 10 years were selected from the patient records of one general dentist (TK) in private practice in Japan. Patients enrolled in the study were initially examined by the same dentist between 1980 and 1988. Patients provided informed consent to the treating dentist (TK) before treatment was administered. Clinical staff collected data and stripped the data of personal identifiers before providing the data to the collaborators on this project (TM and MEN). This study complied with ethical provisions for medical research set out in the Helsinki Declaration of 1975, as revised in 2000. Only patients who completed active treatment and were entered into periodontal maintenance therapy were included in our study. Following active treatment, including restorative, endodontic, and periodontal therapy, reevaluation of clinical parameters (probing depth, bleeding on probing, plaque index, and number of teeth present) was performed. Periodontal therapy, such as oral hygiene enhancement, scaling and root planing, and surgical therapy, was provided to the patients according to individual patient needs. All subjects were required to meet the following criteria before the end of active treatment and entry into periodontal maintenance therapy: 1) <10% of sites with bleeding on probing, 2) an overall plaque score <15%, and 3) <10% of sites with probing depth ≥4 mm. Baseline conditions of the subject population, including maintenance period, age, smoking status, number of teeth at initial visit and reevaluation visits, decayed, missing, or filled teeth (DMFT), bleeding on probing, plaque index, probing depth, gender, bone level on the x-ray, and periodontal disease condition, were analyzed. All patients were diagnosed, treated, and maintained accordingly under the supervision of one clinician at the same private practice (TK) for the course of this study.

To eliminate potential bias with respect to tooth loss during active treatment, tooth loss over the course of this study was calculated from the time of reevaluation after completion of active treatment. Change in all

other clinical parameters was also calculated with respect to the reevaluation visit except DMFT, which does not change between initial evaluation and completion of active treatment. The average time from initial visit to the time point of data collection at reevaluation visit was 4 years (Fig. 1).

Evaluation during the maintenance phase was performed by a dental hygienist who was regularly calibrated and worked under the supervision of the author (TK). Maintenance regimens consisted of 3- or 6-month intervals, based on the periodontal condition of the patient. All patients who demonstrated any periodontal pockets ≥ 4 mm at the time of the reevaluation visit were assigned to 3-month intervals of maintenance. Otherwise, the patients were assigned to 6-month intervals for maintenance visits. Maintenance regimens included SPT, professional mechanical tooth cleaning, reinforcement of oral hygiene, review of updated medical history, and evaluation of further change in the periodontium and tooth condition. In case of further treatment needs during maintenance therapy, the appropriate treatments, such as the extraction of hopeless teeth, restorative treatment, endodontic therapy, and periodontal treatment, were provided under the direct supervision of the same clinician (TK). In this study, any visits for the purpose of treatment outside of regular maintenance, if it was necessary during the maintenance period, were not counted as maintenance therapy.

### Classification of Bone Loss
The bone loss analysis that was used for this study involved evaluating the standardized periapical radiographs of all the teeth in the mouth. Bone loss for this study was defined in the following way: A bone loss classification of Class 1 was assigned if the average bone loss across all teeth was less than one-third of the length of the distance from the cemento-enamel junction to the apex of the tooth. Class 2 was assigned if the bone loss for all teeth ranged from one-third to one-half of the distance from the cemento-enamel junction to the apex of the tooth. An average bone loss of half this distance or greater was classified as Class 3.

### Classification of Periodontal Status
Periodontal classification was based on the American Academy of Periodontology (AAP) classification sys-

tem.[12] Gingivitis includes all kinds of gingival disease without attachment loss, and periodontitis includes localized, generalized, chronic, or aggressive periodontitis. The category of periodontitis plus risk includes the patients who represent the "periodontitis as a manifestation of systemic disease" according to the AAP classification.

### Classification of Compliance
All patients were classified into one of three groups: 1) complete compliance, 2) erratic compliance, and 3) total non-compliance. This classification was based on the punctuality of the patient's suggested maintenance visits and adherence to recommended treatment. Since the methods of classifying and/or quantifying a patient's compliance varied among the previous studies and have not been standardized, the authors developed two different compliance classification schemes (compliance 1 and 2) to fully evaluate compliance and determine the effect that different classification schemes might have on results. The two methods of classification that we used for this study are as follows. Compliance 1: patients who attended at least 70% of the expected maintenance visits were designated as complete compliers, and patients who failed to attend >30% of the expected maintenance visits were designated as erratic compliers. Compliance 2: patients who attended most scheduled maintenance visits were designated as complete compliers, and patients who failed to attend a maintenance visit for a minimum of 2 years during maintenance therapy were classified as erratic compliers. In both classification schemes, patients who did not respond to recommendations for maintenance therapy or disappeared completely during the active phase of treatment were designated as total non-compliers. In this study, total non-compliers were excluded due to the difficulty of obtaining follow-up data, since the majority of patients in this group did not return to the office for treatment during either the active phase or the maintenance phase. The differences in clinical parameters over time between complete compliers and erratic compliers were calculated and compared for both classifications of compliance (compliance 1 and 2).

### Statistical Methods
Statistical analyses were conducted using a statistical software package.[¶] Differences between complete compliers and erratic compliers in maintenance period, baseline age, smoking exposure, and baseline clinical parameters, such as number of teeth at initial and reevaluation visits, DMFT, bleeding on probing, plaque index, and probing depth level, were evaluated using Mann-Whitney U test. Categorical
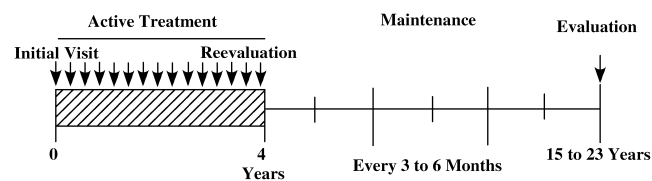


**Figure 1.**
*Timetable of active treatment and maintenance.*

baseline parameters were compared between complete compliers and erratic compliers using $\chi^2$ test of independence. Clinical parameters were classified as improved versus not improved or no change versus worsening for the change in these clinical parameters over time from the time of reevaluation. Percentage of sites involved was used for plaque index, bleeding on probing, and probing depth over time. Tooth loss and DMFT were evaluated with the patient as the unit of analysis, with patients classified as patients who lost teeth or had new caries versus patients who did not lose teeth or did not have new caries. Only the clinical parameter of DMFT was evaluated from the time of initial examination due to the nature of this parameter. Initial evaluation of the categorical change in these clinical parameters over time was conducted using $\chi^2$ test of independence. Further analysis of the categorical change in clinical parameters over time was conducted using multiple logistic regression with adjustment for potential confounding (e.g., age, smoking exposure, and gender), differences in baseline clinical parameters (e.g., percentage of periodontal pockets <3 mm, percentage of sites with bleeding on probing, etc.), and length of maintenance period.

## RESULTS

### Baseline Analysis (complete compliance versus erratic compliance)

The frequency distribution of complete compliers and erratic compliers for the two classification schemes was calculated and is presented in Table 1. Of the 505 patients who participated in the maintenance program for at least 10 years, 180 patients (35.6%) were complete compliers and 325 patients (64.4%) were erratic compliers in the compliance 1 classification, and 164 patients (32.5%) were complete compliers and 341 patients (67.5%) were erratic compliers in the compliance 2 classification. When both classifications were taken into account, 105 patients (20.8%) were complete compliers and 266 patients

**Table 1.**

### Classification of Erratic Compliance by Two Schemes: Compliance 1 (30% missed appointments) and Compliance 2 (absent for a 2-year interval)

| | Complete Compliers (compliance 1) | Erratic Compliers (compliance 1) |
|---|---|---|
| Complete compliers (compliance 2) | 20.8% (105/505) | 14.9% (75/505) |
| Erratic compliers (compliance 2) | 11.7% (59/505) | 52.7% (266/505) |

(52.7%) were erratic compliers under both systems. Slightly more than one-fourth of patients (26.6%) were classified differently by the two classification schemes. Hence, the two systems have a fairly high degree of agreement, with a κ statistic of 0.41 ($P<0.001$). In addition, based on the lack of statistical significance of McNemar's test ($P= 0.195$), disagreement between the two methods of compliance classification appears to be random in nature. Therefore, both methods of classifying compliance appear to be reasonably valid schemes for assigning compliance.

Summary statistics were calculated for the length of the maintenance period, baseline age, smoking exposure, and clinical parameters, such as number of teeth at initial and reevaluation visits, DMFT, percentage of sites with bleeding on probing, plaque index, and percentage of sites with probing depth <3 mm, for both classifications of compliance. Results are presented for both classifications of compliance in Table 2. Frequency distributions for categorical variables such as gender, bone level, and periodontal classification were also tabulated for both classifications of compliance and are presented in Table 3.

Our results demonstrated that among the subject population, there were no statistically significant differences in maintenance period, gender, or other clinical parameters (number of teeth at initial and reevaluation visits, bleeding on probing, plaque index, DMFT, bone level, or periodontal classification of existing teeth) between compliers and erratic compliers (Tables 2 and 3). However, the average age of complete compliers varied significantly, with a younger average age of erratic compliers for compliance 1 ($P= 0.005$) and 2 ($P= 0.009$). These results confirm that complete compliers tend to be older, regardless of the system of compliance classification. Furthermore, at baseline, complete compliers had a greater percentage of sites with probing depth <3 mm in compliance 1 ($P= 0.008$), and complete compliers tended to smoke more cigarettes than erratic compliers in compliance 2 ($P= 0.003$).

### Compliance Related to Improved or Worsening Clinical Factors Over Time

Table 4 shows the distribution of improved and worsening clinical parameters by compliance status after at least 15 years of observation that included treatment and at least 10 years of maintenance therapy. For compliance 1, complete compliers showed a trend toward better plaque scores ($P= 0.145$), less bleeding on probing ($P=0.457$), and worsening DMFT ($P= 0.285$) compared to erratic compliers, although none of these differences achieved statistical significance. In contrast, the results for compliance 2 demonstrated that complete compliers tended to exhibit less improvement in bleeding on probing compared

**Table 2.**

## Baseline Descriptive Statistics for Both Classifications for Compliance

| | Compliance 1 | | | Compliance 2 | | |
|---|---|---|---|---|---|---|
| | Mean ± SD (median) | Range | P* | Mean ± SD (median) | Range | P* |
| Maintenance period (years) | | | | | | |
| Complete compliers | 16.6 ± 2.09 (16.6) | 10 to 21 | | 16.7 ± 2.14 (16.0) | 10 to 21 | |
| Erratic compliers | 17.1 ± 2.11 (17.3) | 10 to 22 | 0.072 | 17.1 ± 2.09 (17.0) | 10 to 22 | 0.350 |
| Age (years) | | | | | | |
| Complete compliers | 43.2 ± 11.4 (42) | 22 to 73 | | 43.2 ± 11.7 (44) | 22 to 68 | |
| Erratic compliers | 40.2 ± 11.5 (38) | 21 to 72 | 0.005 | 40.3 ± 11.4 (39.3) | 21 to 73 | 0.009 |
| Packs of cigarettes (lifetime) | | | | | | |
| Complete compliers | 22.9 ± 14.9 (26.5) | 0.25 to 75.5 | | 27.3 ± 17.3 (26.5) | 0.45 to 75.5 | |
| Erratic compliers | 19.5 ± 16.3 (16.5) | 0.5 to 72.5 | 0.133 | 18.1 ± 14.5 (15.7) | 0.25 to 72.0 | 0.003 |
| N teeth at initial visit | | | | | | |
| Complete compliers | 25.1 ± 3.76 (26) | 10 to 28 | | 25.0 ± 3.84 (26) | 11 to 28 | |
| Erratic compliers | 25.08 ± 4.28 (27) | 5 to 28 | 0.409 | 25.1 ± 4.22 (27) | 5 to 28 | 0.454 |
| N teeth at reevaluation | | | | | | |
| Complete compliers | 24.5 ± 4.12 (26) | 8 to 28 | | 24.4 ± 4.49 (26) | 6 to 28 | |
| Erratic compliers | 24.3 ± 4.95 (26) | 3 to 28 | 0.632 | 24.3 ± 4.76 (26) | 3 to 28 | 0.691 |
| DMFT | | | | | | |
| Complete compliers | 16.6 ± 6.04 (17) | 3 to 28 | | 16.1 ± 6.04 (17) | 2 to 28 | |
| Erratic compliers | 15.7 ± 6.20 (16) | 1 to 28 | 0.144 | 16.0 ± 6.21 (16) | 1 to 28 | 0.608 |
| Bleeding on probing (%) | | | | | | |
| Complete compliers | 38.1 ± 22.2 (36.6) | 1.8 to 100 | | 41.6 ± 24.9 (41.1) | 1.8 to 100 | |
| Erratic compliers | 42.6 ± 25.4 (40.1) | 0 to 100 | 0.088 | 40.8 ± 24.2 (38.0) | 0 to 100 | 0.734 |
| Plaque index (%) | | | | | | |
| Complete compliers | 41.6 ± 21.1 (38.1) | 7.1 to 100 | | 41.8 ± 23.2 (37.0) | 8.3 to 100 | |
| Erratic compliers | 44.5 ± 23.1 (41.7) | 0 to 100 | 0.245 | 44.3 ± 22.1 (41.7) | 0 to 100 | 0.182 |
| Percentage of sites with PD[†] <3 mm | | | | | | |
| Complete compliers | 79.1 ± 21.3 (85.1) | 3 to 100 | | 74.3 ± 24.4 (79.6) | 1 to 100 | |
| Erratic compliers | 72.8 ± 24.1 (78.7) | 1 to 100 | 0.008 | 75.4 ± 22.9 (83) | 2 to 100 | 0.994 |

\* $P$ values are based on Mann-Whitney U test.
† PD = probing depth.

to erratic compliers ($P = 0.173$). In addition, based on compliance 2, complete compliers showed no improvement in plaque scores and worsening DMFT compared to erratic compliers.

The percentage of sites with probing depth >3 mm within each subject was classified as improved if that percentage was reduced after 15 to 23 years. Based on both classifications of compliance, complete compliers showed no difference in the percentage of sites with reduction in significant periodontal pockets (i.e., improved percentage of sites with probing depth >3 mm) compared to erratic compliers. Interestingly, the percentage of patients with tooth loss over time was similar for complete compliers and erratic compliers according to both classifications of compliance. In both cases, complete compliers lost more teeth over time compared to erratic compliers, with the difference being statistically significant for compliance 1 ($P = 0.001$) and marginally significantly different for compliance 2 ($P = 0.087$) in the unadjusted model.

To further investigate the relationship of compliance to improvement or worsening in clinical parameters over time, multiple logistic regression models were constructed with adjustment for age, gender, smoking, maintenance period, and percentage of sites with probing depth >3 mm at baseline. The results for the final multiple logistic regression models constructed for improved or worsened clinical parameters

**Table 3.**

## Baseline Frequencies for Both Classifications for Compliance

| | Compliance 1 | | | Compliance 2 | | |
|---|---|---|---|---|---|---|
| | Complete Compliers | Erratic Compliers | P* | Complete Compliers | Erratic Compliers | P* |
| Gender | | | | | | |
| Male | 35.0% | 36.9% | | 33.5% | 37.5% | |
| Female | 65.0% | 63.1% | 0.181 | 66.5% | 62.5% | 0.381 |
| Bone level | | | | | | |
| Level 1 | 62.8% | 65.2% | | 59.8% | 66.6% | |
| Level 2 | 31.1% | 28.9% | 0.857 | 31.7% | 28.7% | 0.144 |
| Level 3 | 6.1% | 5.8% | | 8.5% | 4.7% | |
| Periodontal classification | | | | | | |
| Healthy | 0.6% | 0.3% | | 0.6% | 0.3% | |
| Gingivitis | 1.1% | 0.3% | | 0.6% | 0.6% | |
| Periodontitis | 75.0% | 83.4% | | 79.9% | 80.6% | |
| Periodontitis plus risk factor | 23.3% | 16.0% | 0.122 | 18.9% | 18.5% | 0.960 |

\* $P$ values are based on $\chi^2$ test of independence.

**Table 4.**

## Clinical Parameters Affected by Compliance (complete compliers versus erratic compliers) After 15 to 23 Years Based on Both Classifications for Compliance

| | Compliance 1 | | | Compliance 2 | | |
|---|---|---|---|---|---|---|
| | Complete Compliers | Erratic Compliers | P* | Complete Compliers | Erratic Compliers | P* |
| Plaque index | | | | | | |
| Improved | 71.7% | 65.3% | | 68.3% | 67.3% | |
| Worse | 28.3% | 34.7% | 0.145 | 31.7% | 32.7% | 0.817 |
| Bleeding on probing | | | | | | |
| Improved | 66.7% | 63.4% | | 60.4% | 66.6% | |
| Worse | 33.3% | 36.6% | 0.457 | 39.6% | 33.4% | 0.173 |
| Percentage of sites with PD† >3 mm | | | | | | |
| Improved | 58.3% | 58.5% | | 57.9% | 58.7% | |
| Worse | 41.7% | 41.5% | 0.969 | 42.1% | 41.3% | 0.869 |
| Tooth loss | | | | | | |
| No tooth loss | 44.4% | 59.7% | | 48.8% | 56.9% | |
| Tooth loss | 55.6% | 40.3% | 0.001 | 51.2% | 43.1% | 0.087 |
| DMFT | | | | | | |
| No change | 53.9% | 48.9% | | 50.3% | 50.9% | |
| Worse | 46.1% | 51.1% | 0.285 | 49.7% | 49.1% | 0.903 |

\* $P$ values are based on $\chi^2$ test of independence.
† PD = probing depth.

as well as for worsening of DMFT and for tooth loss according to compliance status at 15 to 23 years are given in Table 5. Complete compliers according

to compliance 1 were significantly more likely to experience tooth loss over time compared to erratic compliers. Also, complete compliers according to compliance 1 tended to exhibit improved plaque index, reduction in bleeding on probing, and a worsening of DMFT over time compared to erratic compliers. In contrast, complete compliers according to compliance 2 were only marginally more likely to experience tooth loss compared to erratic compliers. In addition, for compliance 2, no differences between complete compliers and erratic compliers were detected for the other clinical parameters, including worsening of DMFT.

## DISCUSSION

One limitation of any study of compliance is the method of classifying and quantifying a patient's compliance. The classification for assessing benefit of long-term compliance is inherently flawed and biased because no data are generally available for the true noncomplier, and the erratic complier over time is often more similar to the total complier than the total non-complier. Wilson et al.[9] classified compliance into three distinct groups: 1) complete compliance, 2) erratic compliance, and 3) noncompliance. They assigned patients to the erratic compliance group if patients failed to follow the maintenance visits as regularly as the complete compliers. Novaes et al.[13] classified compliance into the following categories: 1) regular, 2) irregular, and 3) non-regular compliance. In the scheme by Novaes et al.,[13] a patient was assigned to the irregular compliers if that patient missed one-third of recall visits, although it is unclear how long the period for evaluating patient absenteeism was. The strength of our

**Table 5.**

## Multiple Logistic Regression of Improved Clinical Parameters After 15 to 23 Years Based on Compliance (complete versus erratic) for Both Classifications of Compliance

| | Compliance 1 | | Compliance 2 | |
|---|---|---|---|---|
| | OR* | 95% CI† | OR | 95% CI |
| Reduction in plaque index | | | | |
|   Complete compliers | 1.00 | | 1.00 | |
|   Erratic compliers | 0.67 | (0.44; 1.01) | 0.90 | (0.59; 1.36) |
| Reduction in bleeding on probing | | | | |
|   Complete compliers | 1.00 | | 1.00 | |
|   Erratic compliers | 0.78 | (0.53; 1.17) | 0.98 | (0.67; 1.44) |
| Reduction in periodontal pockets | | | | |
|   Complete compliers | 1.00 | | 1.00 | |
|   Erratic compliers | 0.96 | (0.65; 1.40) | 1.20 | (0.81; 1.78) |
| No change in DMFT | | | | |
|   Complete compliers | 1.00 | | 1.00 | |
|   Erratic compliers | 0.81 | (0.56; 1.19) | 1.06 | (0.72; 1.56) |
| No tooth loss | | | | |
|   Complete compliers | 1.00 | | 1.00 | |
|   Erratic compliers | 0.58 | (0.39; 0.86) | 0.80 | (0.54; 1.19) |

\* OR =, odds ratio.
† CI = confidence interval.

study is that we clearly define our standard for classifying patients as erratic compliers. Hence, our study systematically quantified the minimum duration of missed appointments for an actual time range for erratic compliers (versus complete complier) compared to previous studies where this classification is not so well defined. Furthermore, our group used an additional compliance classification method similar to the classification of Novaes et al.[13] (absenteeism of >30% of prescribed maintenance visits classified as erratic compliance) to compare these two types of compliance (interval and regularity). In previous studies,[7,8,13-15] it has been shown that the percentage of patients classified as complete compliers of the three possible categories (complete complier, erratic complier, and total non-complier) is dependent on the study definition for classification of compliance, study design (i.e., period of follow-up), source of study population (private practice, student clinic, group, etc.), culture of study population (Japanese may tend to be more compliant), etc. Originally, Wilson et al.[15] reported that the proportion of complete compliers was 32.5% versus 67.5% erratic compliers in a private practice setting. In another study in a private practice setting, Novaes et al.[13] claimed that regular compliers

comprised 54% of subjects versus 46% erratic compliers. In our study, we found that complete compliers for the suggested maintenance comprised 35.6% of patients versus 64.4% erratic compliers in compliance 1 and 32.5% of patients versus 67.5% erratic compliers in compliance 2, which is a similar proportion of fully compliant patients in our population compared to all previous studies.

Another strength of this compliance study is the long observation period, which provides a strong basis for inference for the following reasons: 1) To understand the behavioral nature of a person in terms of good oral health consciousness and its effect on oral health, it is necessary to observe a patient over a long term to filter out those patients who are only complete compliers to an oral health regimen for a short period of time, as is often the case in clinical trials or short epidemiological studies. 2) Only with a long observation period are we able to observe enough tooth loss to evaluate the statistical differences of tooth loss between complete compliers and erratic compliers. The longer the observation period, the more powerful the study in terms of detecting any difference in tooth loss between the two groups because it allows for more events to take place. Although most of the compliance studies to date followed patients for 5 to 15 years, we observed both groups (complete compliers and erratic compliers) of patients for 15 to 23 years (average of 19 years) with a minimum of 10 years of maintenance therapy. Therefore, our study has the potential for detecting patients who become less compliant over time as well as allowing a longer period of time to detect a greater rate of tooth loss with greater power than previous studies of similar size with much shorter follow-up periods.

The relationship of baseline descriptive parameters to future compliance was previously analyzed by Ojima et al.[16] In their study, they used a survival analysis model to evaluate which baseline parameters are related to compliance for suggested maintenance. They concluded that age is the key factor, either alone or in combination with other baseline factors, in predicting which patients will comply with supportive maintenance therapy over time. Novaes and Novaes[14] analyzed the risk of non-compliance retrospectively in a private practice setting and suggested

that the relative risk for non-compliance was higher in younger subjects, not only alone but also with other factors, such as gender and type of periodontal therapy (surgical or non-surgical). When we evaluated baseline factors related to compliance, we found that the only factor significantly associated with patient compliance in both categories (compliance 1 and 2) was patient age. Hence, this result confirms results from previous studies which all indicated a greater likelihood for older patients to comply with suggested maintenance compared to young patients.

Furthermore, as we observed each individual category, our results also revealed that category 1 demonstrated the better probing depth for completely compliant patients, and category 2 showed more smokers among complete compliers. The results showing that complete compliers smoked more cigarettes at baseline than erratic compliers for compliance 2 can be due to several reasons: 1) The number of smokers in this sample population was small (total number of smokers = 129). 2) The method of assigning compliance based on a 2-year interval may not be appropriate because a subject may have been absent for this period because of serious illness or some other issue unrelated to a person's desire to comply with the recommendations of his/her dentist/periodontist.

Compliance and common clinical parameters, such as probing depth, bleeding on probing, tooth loss, and plaque index, have been studied previously. There is a general agreement that better compliance generally results in improved oral health as measured by these parameters. Novaes et al.[7] reported that there is a significant difference in bleeding index between patients who returned for SPT regularly and patients who returned irregularly or had discontinued for at least 1 year. Based on the classification according to compliance 1, which is a similar classification system to Novaes et al.,[7] our results demonstrated the following findings: 1) According to the multiple logistic regression model, erratic compliers were 22% less likely to show a reduction in bleeding on probing, which supports the finding by Novaes et al.[7] 2) Improvement in plaque index and changes of DMFT appeared somewhat better for the completely compliant patients, although neither achieved statistical significance. 3) Complete compliers were 42% more likely to experience tooth loss compared to erratic compliers, although complete compliers demonstrated almost the same level of reduction in probing depths. Konig et al.[8] reported that during SPT, mean probing depth and plaque index differed between compliers and non-compliers, but there did not appear to be a difference in tooth survival between the two groups. Our results are similar for the clinical parameters of plaque index and tooth loss, although our categoriza-

tion of compliance, study design, duration of follow-up, and, most importantly, the clinic setup (university practice versus private practice) are somewhat different.

With regard to tooth loss, the first study was conducted by Wilson et al.[9] The tooth loss of erratic compliers and complete compliers over a 5-year period after active periodontal treatment was compared. Their results showed that erratic compliers lost 0.06 teeth per patient per year and the complete compliers lost 0 teeth. Recently, Checchi et al.[17] published a retrospective study over 6.7 years that investigated the relationship of compliance to tooth loss in a university setting. Their results revealed that erratic compliers for SPT were 5.6 times more likely to lose a tooth compared to complete compliers. However, the results from other studies did not support the association between compliance (complete or erratic) and tooth loss. McGuire and Nunn[11] analyzed the association between tooth loss and commonly taught prognostic indicators, including the level of compliance, for 100 treated periodontal patients in maintenance for up to 15 years in a private practice setting. In this study, compliance was not associated with tooth loss. Furthermore, Konig et al.[8] also found that patient-based survival analysis of tooth loss during maintenance therapy of compliant and non-compliant patients showed that compliance is not related to tooth loss. Our results based on compliance 1 demonstrated that 55.6% of complete compliers lost teeth during maintenance periods, while 40.3% of erratic compliers lost teeth, which contradicts previous studies showing either a positive association or no association between compliance and tooth loss. Our data offer some support for the hypothesis that a greater frequency of patient visits to the dentist may result in more tooth loss, although the complete compliers have better improvement in plaque scores, bleeding on probing, and DMFT and no difference in probing depth improvement.

Current changes in treatment planning, better understanding of the prognosis of the dentition, and significant improvement in the success rate of dental implants may have played a role in this altered association between compliance and tooth loss because patients who are highly compliant to prescribed dental maintenance are likely to have a high rate of acceptance of proposed dental treatment.

Based on the classification of compliance 2, which is a new compliance classification system we developed using a 2-year interval of absenteeism, our results did not demonstrate any major differences in clinical parameters, including plaque index, DMFT, and probing depth, between complete compliers and erratic compliers. Bleeding on probing and tooth loss appeared somewhat better for the erratic

compliant patients, although neither achieved statistical significance. These results may suggest that this method of assigning compliance is simply not appropriate. However, the information from these results also demonstrates that as long as the patients have some continuity of maintenance therapy, despite a single 2-year interval between maintenance visits, many clinical parameters, such as plaque index, bleeding on probing, probing depth, DMFT, and tooth loss, can be maintained over the long term.

No previous studies on the association of compliance to DMFT were found. With respect to the impact of compliance on the risk of future dental caries in adult populations, information is fairly limited.[18] Based on compliance 1, compliance should be emphasized to prevent future caries since complete compliers tended to have less new caries over time, as indicated by no change in DMFT. In addition, previously identified risk factors for dental caries, such as uncontrolled diabetes, increased frequency of carbohydrate intake, etc., may be strongly influenced and altered by the reinforcement given to a patient who fully complies with regular maintenance visits.[19] Based on compliance 1, we demonstrated that the risk for new caries (DMFT) may be marginally improved in the long term by changing the compliance from erratic compliance to complete compliance. If we were able to assess truly non-compliant subjects, it is quite possible that a more substantial difference in DMFT would be detected.

Because this study was conducted in the private practice of a general dentist, the condition of the periodontium among all patients may be somewhat better than previous studies conducted in practices limited to periodontics where the majority of the patient population has a history of moderate to severe periodontal disease. Hence, some of the differences noted may be related to the differences in periodontal status between the current study and earlier studies. In addition, the number of the patients enrolled in this study is larger than many of the previous studies.

In summary, our long-term retrospective study of the relationship of compliance to clinical parameters and tooth loss using the classification system of compliance 1, where the patients who attended >70% of the expected maintenance visits were classified as complete compliers, revealed that oral health factors, such as bleeding index, plaque score, and DMFT, could be somewhat improved by changing erratic compliance to complete compliance. However, tangible patient benefits to the function of the dentition, such as minimizing tooth loss, could not be improved in the long term by changing compliance from erratic compliance to complete compliance. Furthermore, the classification system of compliance 2, which used a 2-year absence from maintenance therapy as a

means of classifying erratic compliers, might not be an optimum classification system for understanding the effect of compliance on oral health, since factors unrelated to a patient's willingness to comply with treatment may have affected that person's absence.

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Correspondence: Dr. Martha E. Nunn, Department of Health Policy and Health Services Research, Goldman School of Dental Medicine, Boston University, 715 Albany, 560, Boston, MA 02118. E-mail: nunn@bu.edu.