Commentary

# Prognosis Revisited: A System for Assigning Periodontal Prognosis

**Vivien Kwok*† and Jack G. Caton***

*Prognosis is an integral part of the periodontal practice because it directly influences treatment planning. However, there is limited direct evidence in the literature regarding the assignment of periodontal prognosis. There are several important concepts to consider in developing a system of periodontal prognosis. Traditional systems are based on tooth loss and may have limited use for patient management. On the other hand, prognosis can be based on stability of the periodontal supporting apparatus, which is influenced by more evidence-based factors and may be more useful for patient management. Other important concepts include the timing of the projection (short and long term) and the consideration of individual teeth versus the overall dentition. Historically, several authors have formulated and investigated their own prognostication systems. Results were variable, but they generally showed that systems based on tooth loss were unpredictable over the long term. Therefore, the purpose of this report is to review relevant literature and propose a new periodontal prognostication system.* J Periodontol 2007;78:2063-2071.

**KEY WORDS**

**Dentistry; diagnosis; periodontics; prognosis; treatment.**

Determination of periodontal prognosis is an integral part of periodontal practice, and it influences treatment planning directly. The etymologic origin of the term "prognosis" derives from Latin and literally means "foreknowledge." It is the prospect of recovery as anticipated from the usual course of disease or peculiarities of the case.[1] However, there is limited direct evidence in the literature regarding the assignment of periodontal prognosis. Traditional systems that are based on tooth loss (mortality) are not very useful for patient management. Conversely, prognosis can be based on the probability of obtaining stability of the periodontal supporting apparatus, which is influenced by more evidence-based factors. Therefore, the purpose of this report is to review relevant literature and propose a new periodontal prognostication system.

There are several important concepts in prognosis. One essential element of prognosis is the definition of the intended outcome. Prognostication systems traditionally are based on tooth mortality;[2-5] however, the periodontal status of retained teeth is variable and uncertain. Furthermore, most teeth can be retained until extraction by a dentist occurs. Prognosis also can be described in terms of the stability of supporting tissues. Periodontal stability can be evaluated continually by clinical attachment level and radiographic bone measurements.

The second essential element of prognosis is the timing of the projection. With regard to the length of the prediction, the definitions of "short term" and "long term" usually are arbitrary. Most importantly, periodontal prognostication is dynamic; therefore, it should be reevaluated periodically as treatment and maintenance progress.

The third essential element of prognosis is the consideration of individual teeth versus the overall dentition. Because there are many general factors, such as smoking or diabetes, that affect the whole dentition, and local factors, such as furcation or anatomic defects, that affect the individual teeth, prognosis needs to be considered at both levels.

* Division of Periodontics, Eastman Dental Center, University of Rochester, Rochester, NY.
† Private practice, Toronto, ON.

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Historically, several investigators have formulated and investigated their own prognostication systems.[2-5] Results were variable, but they generally showed that systems based on tooth loss were unreliable over the long term. Therefore, a system that uses periodontal stability as the primary outcome is needed to help clarify this important patient management determination.

## TOOTH MORTALITY VERSUS STABILITY OF THE PERIODONTAL SUPPORTING TISSUES

The intended outcome of the prediction has to be defined. Tooth retention is one of the endpoints used in assigning periodontal prognosis. However, survival and stability need to be considered separately. In a 5-year longitudinal study of patients treated without maintenance, Becker et al.[2] lost only 33.3% of teeth with a hopeless prognosis under compromising conditions such as >75% bone loss, probing depth ≥8 to 10 mm, Class III furcation involvement, hypermobility, poor crown/root ratio, severe root proximity with an adjacent tooth, and history of repeated periodontal abscess formation. However, these retained teeth were not necessarily stable, functional, or comfortable. On the other hand, teeth with advanced loss of periodontal support can be kept healthy in a strict program of maintenance care. In a 14-year longitudinal study on treated and well-maintained patients, Lindhe and Nyman[6] lost only 2.3% of teeth with >50% attachment loss. These results showed that the decision of retaining compromised teeth is complex, and it depends greatly on the practitioner's treatment philosophy and quality of therapy. With the evolution of implant dentistry and periodontal-systemic considerations influencing the treatment plan, the practitioner needs to develop a solid foundation to determine the treatment approach that best suits the needs of each patient.

Prognosis can be described in terms of the stability of the periodontal supporting tissues. Chronic periodontitis often is an episodic, chronic disorder with periods of exacerbation and remission. Because the etiology of periodontitis is multifactorial, patients are not equally at risk, and tooth surfaces are variably affected within the mouth.[7] Periodic examination of clinical attachment level measurements can help to identify periodontal breakdown resulting from disease activity. However, the reproducibility of clinical attachment level is affected by many factors, such as probing force,[8] status of soft tissue health,[9] and tooth anatomy. Moreover, the definition of disease activity varies with different investigators.[10-13]

Both outcomes (tooth mortality and morbidity) have their strengths and weaknesses. The observation of tooth loss is definitive, but the follow-up time can be lengthy. Most importantly, tooth loss usually does not occur naturally: it is merely the decision of the practitioner, and therefore, it can be influenced by factors other than periodontal, which makes it less useful for patient management. On the other hand, the observation of periodontal stability is dynamic and must be assessed periodically. It is influenced by many local and general factors that may be controlled. Therefore, it should be more useful to develop a prognostication system that is based on periodontal stability.

## PROGNOSTICATION: TEMPORAL ISSUES AND DYNAMICS

The temporal component of the prediction has to be defined. Prognosis usually is expressed in two parts: short term and long term. Although arbitrary, studies[14-18] usually were described as long term if the duration was >5 years. A study by McGuire and Nunn[3] showed a 5- to 8-year prediction accuracy of 80% overall; however, it decreased to ~50% or less when the teeth with a "good" prognosis were excluded. Therefore, it may be logical to define long term as ≥5 years and, subsequently, short term as <5 years.

The determination of prognosis is an evolving and dynamic process. Therefore, it is reasonable to try to predict long-term prognosis for 5 years, but reassessment is often needed for a prolonged period. Prognosis can change after treatment as well as after recurrent disease activity. Therefore, reprognostication occurs after each examination of the patient.

### *Prognosis for Individual Teeth and the Overall Dentition*

Finally, prognosis needs to be described at two levels: overall and individual tooth. This concept is extremely important because of several practical reasons. An overall description of prognosis facilitates communication between professionals and patients. Many general factors may affect the whole dentition, whereas local factors may affect only individual teeth. Second, periodontal disease does not progress uniformly throughout the dentition. Some sites, such as those with deep probing depth, molars, and posterior interproximal sites, may behave differently than anterior sites with single-rooted teeth.[19] Other local anatomic factors, such as palatal grooves, cervical enamel projections, enamel pearls, and overhanging restorations, are discussed later. Therefore, individual tooth prognosis has to be considered separately to develop a valid treatment plan. Finally, when general factors are considered, the individual tooth prognosis may need to be readjusted.

### *Previous Periodontal Prognostication Systems*

Historically, numerous studies proposed different classifications to describe or project long-term treatment outcome. Hirschfeld and Wasserman[15] observed 600 maintenance patients retrospectively for an average of 22 years and compared the prognosis assignment

with actual tooth loss. Most of the patients (76.5%) studied were classified initially as having advanced periodontal disease. There were only two levels of prognosis: favorable and questionable, and the number of teeth lost was used to classify patients as well-maintained (zero to three teeth lost), downhill (four to nine teeth lost), and extreme downhill (10 to 23 teeth lost). The criteria for assignment of a questionable prognosis were not highly specific and consisted of teeth with furcation involvement, deep pockets, extensive bone loss, and mobility (Table 1). A higher percentage of teeth (79.5%) with a questionable prognosis were lost in the well-maintained group compared to a lower percentage in downhill and extreme downhill groups (22.7% and 55.4%, respectively) (Table 2). This means that a questionable prognosis was most accurate in the well-maintained group, and many originally favorable teeth were lost in the downhill groups. Therefore, patients who tend to lose more teeth (downhill and extreme downhill groups) were less predictable in this system. A possible reason for this phenomenon was lack of consideration for systemic factors that can affect long-term outcome, such as smoking and diabetes, and local factors, such as palatal grooves, cervical enamel projections, enamel pearls, overhanging restorations, and pulpal lesions. If these factors were considered, many of the originally favorable teeth may have been classified as questionable, which would have increased the proportion of questionable teeth in the downhill groups. Moreover, this study also showed that the predictability of a correct prognosis became more variable over an extended period of time. The investigators explained that the longer follow-up period gave a greater opportunity for periodontal destruction to occur.

Becker et al.[2,4] followed two groups of post-treatment patients with and without maintenance therapy and studied tooth mortality. There were three prognostic categories used: good, questionable, and hopeless (Table 1). This system used more detailed criteria for classification, including bone level, probing depth, and furcation involvement. It also included criteria such as palatal grooves, extensive caries, and repeated abscesses. Results showed that this system predicted correctly most of the time during the study period in well-maintained patients. In an average of 6.5 years, 1.7% of originally good teeth were lost compared to 25.8% of questionable teeth and 80.4% of hopeless teeth. However, the system did not predict as well in poorly maintained patients. In poorly maintained patients after an average of 5.25 years, 3.0% of originally good teeth were lost compared to 37.2% of questionable teeth and 33.3% of hopeless teeth (Table 2). These results showed several important points in determining prognosis. First, the more detailed classification showed improved predictability in well-maintained patients. Second, it showed that prognosis can be determined effectively for the period of 5 to 6 years. Finally, poorly maintained patients were not as predictable. Moreover, it illustrated that lack of maintenance or poor patient compliance is one of the general factors that can influence long-term prognosis.

McGuire and Nunn[3,5] developed a prognostication system and followed 100 well-maintained patients for 5 and 8 years. This system contained a more detailed stratification for individual teeth: good, fair, poor, questionable, and hopeless (Table 1). Generally, prognostications on single-rooted teeth were more accurate than on multirooted teeth. The good prognosis category was the most predictable from baseline to 5 and 8 years, with ~85% of teeth remaining in the same category. More than half (~55%) of the teeth in the fair prognosis category improved to good, and about one-third remained fair. However, the poor and questionable categories were highly variable, with <20% remaining poor and none remaining questionable. The predictability of the hopeless category was quite reasonable, with 52.3% remaining hopeless at 5 years and 75% remaining hopeless at 8 years. Substantially greater percentages of lost teeth had a poor or worse prognosis than surviving teeth (Table 2). The mean follow-up time for lost teeth in the good to questionable categories was 5 to 6.61 years, whereas for hopeless teeth it was 2.68 years. Several conclusions can be drawn from these results. First, long-term prognosis was reasonably predictable in teeth with a good prognosis. Second, multiple stratifications may be redundant because the poor and questionable categories had high tendencies to change to other categories; therefore, they could be combined to improve predictability. Finally, because most teeth were lost before 5 to 6 years, it is reasonable to project long-term prognosis to ~5 years, but reassignment of prognosis is an ongoing process.

## PROPOSED CLASSIFICATION SYSTEM

Because tooth loss is influenced by natural and iatrogenic reasons, a periodontal prognostication system based on the probability of disease progression is hereby proposed. Individual tooth prognosis is based on the prediction of future stability of the periodontal supporting tissues. For the sake of simplicity, three primary classifications are proposed, with a fourth, hopeless, signifying a tooth that must be extracted.

### *Favorable*

The periodontal status of the tooth can be stabilized with comprehensive periodontal treatment and periodontal maintenance. Future loss of the periodontal supporting tissues is unlikely if these conditions are met (Fig. 1).

**Table 1.**

## Classification Schemes

| Study | Classification | | | | |
|---|---|---|---|---|---|
| | Good | Fair | Poor | Questionable | Hopeless |
| Hirschfeld and Wasserman, 1978[15] | | | | 1. Furcation involvement.<br>2. A deep, non-eradicable pocket.<br>3. Extensive alveolar bone loss.<br>4. Marked mobility in conjunction with probing depth (2 or 2.5 degrees on a scale of three). | |
| Becker et al., 1984[2,4] | | | | Teeth with more than one of the following problems:<br>1. Bone loss close to 50% of the root length.<br>2. Probing depths of 6 to 8 mm.<br>3. Class II furcation involvement with minimal interadicular space.<br>4. Presence of deep vertical groove on palatal aspect of maxillary incisors.<br>5. Mesial furcation involvement of maxillary first bicuspids. | Teeth with more than one of the following problems:<br>1. Loss >75% of the supporting bone.<br>2. Probing depths >8 mm.<br>3. Class III furcation involvement.<br>4. Class III mobility with tooth movement in mesial-distal and vertical directions.<br>5. Poor crown/root ratios.<br>6. Root proximity with minimal interproximal bone and evidence of horizontal bone loss. History of repeated periodontal abscess formation. |
| McGuire and Nunn, 1996[3] | Control of the etiologic factors and adequate periodontal support as measured clinically and radiographically to ensure the tooth would be relatively easy to maintain by the patient and clinician assuming proper maintenance. | Approximately 25% attachment loss as measured clinically and radiographically and/or Class I furcation involvement. The location and depth of the furcation would allow proper maintenance with good patient compliance. | 50% attachment loss and Class II furcations. The location and depth of the furcations would allow proper maintenance, but with difficulty. | >50% attachment loss resulting in a poor crown/root ratio. Poor root form. Class II furcations not easily accessible to maintenance care, or Class III furcations. ≥2+ mobility. Significant root proximity. | Inadequate attachment to maintain the tooth in health, comfort, and function. Extraction was performed or suggested. |

### *Questionable*

The periodontal status of the tooth is influenced by local and/or systemic factors that may or may not be able to be controlled. The periodontium can be stabilized with comprehensive periodontal treatment and periodontal maintenance if these factors are controlled; otherwise, future periodontal breakdown may occur (Fig. 1).

**Table 2.**

## Percentage of Tooth Loss

| Study | Length of Study (mean) | Teeth Involved (N) | Classification | | | | |
|---|---|---|---|---|---|---|---|
| | | | Good* | Fair | Poor | Questionable | Hopeless |
| Hirschfeld and Wasserman, 1978[15] (well-maintained)† | 22 years | 342 | 20.5% | | | 79.5% | |
| Hirschfeld and Wasserman, 1978[15] (downhill)† | 22 years | 435 | 77.3% | | | 22.7% | |
| Hirschfeld and Wasserman, 1978[15] (extreme downhill)† | 22 years | 333 | 44.6% | | | 55.4% | |
| Becker et al., 1984[4] (well-maintained)‡ | 6.58 years | 2,414 | 1.7% (37/2,192) | | | 25.8% (31/120) | 80.4% (82/102) |
| Becker et al., 1984[2] (not maintained)‡ | 5.25 years | 1,117 | 3.0% (31/1,015) | | | 37.2% (19/51) | 33.3% (17/51) |
| McGuire and Nunn, 1996[3‡] | 9.97 years | 2,509 | 2.07% (37/1,787) | 7.87% (40/508) | 13.38% (21/157) | 50.56% (20/36) | 61.90% (13/21) |

* Classified as "favorable" in Hirschfeld and Wasserman.[15]
† Percentage of tooth loss of total tooth loss.
‡ Percentage of tooth loss of total tooth loss in each class.

### *Unfavorable*

The periodontal status of the tooth is influenced by local and/or systemic factors that cannot be controlled. Periodontal breakdown is likely to occur even with comprehensive periodontal treatment and maintenance (Fig. 1).

### *Hopeless*

The tooth must be extracted (Fig. 1).

## FACTORS THAT MAY AFFECT PROGNOSIS

Many general and local factors can affect the stability of the periodontal attachment apparatus. Although longitudinal studies[14-16,18,20] have indicated that non-surgical and surgical treatments generally were maintainable, long-term stability is still subject to many variables.

### *General factors*

**Patient compliance in an effective maintenance program.** The major etiologic factor for periodontal disease is plaque-induced infection and inflammation. Therefore, stability of the periodontium depends greatly on the patient's ability and willingness to adhere to a professional maintenance program. Studies[21-24] showed that lack of maintenance can result in disease recurrence, even after years of periodontal health, and periodontal instability was more pronounced as time progressed. In the study of periodontal surgery in plaque-infected dentitions by Nyman et al.,[25] plaque accumulation after different kinds of pocket-reduction surgery resulted in the recurrence of destructive periodontitis. Even in patients receiving non-surgical therapy, discontinuous maintenance led to an increase in tooth loss.[26]

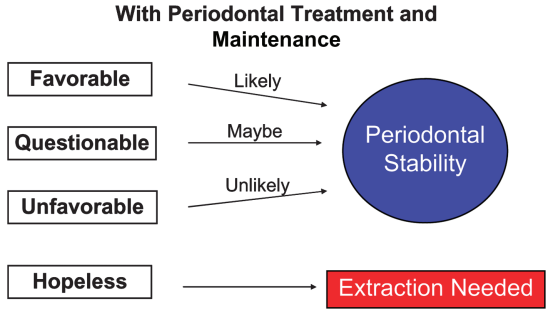


***Figure 1.***
*For teeth with a favorable prognosis, the local or systemic factors can be controlled and the periodontal status of the tooth can be stabilized with comprehensive periodontal treatment and maintenance. For teeth with a questionable prognosis, the local or systemic factors may or may not be controlled. However, the periodontium can be stabilized with comprehensive periodontal treatment and periodontal maintenance if these factors are controlled; otherwise, future periodontal breakdown may occur. For teeth with an unfavorable prognosis, the local or systemic factors cannot be controlled, and periodontal breakdown is likely to occur even with comprehensive periodontal treatment and maintenance. For teeth with a hopeless prognosis, extractions are indicated.*

**Cigarette smoking.** In many studies,[27-29] smokers had a greater prevalence of periodontal disease and bone loss, even after adjustment for different plaque levels. Cigarette smoking affects the periodontium at many levels. Microbiologically, smokers harbor increased levels of periodontal pathogens compared to non-smokers, even after periodontal treatment.[30,31] Systemically, smoking can affect the host response by impairing the immune defense against pathogens[32,33] and interfering with collagen metabolism.[34] Locally, nicotine binds to the root surface, affecting fibroblast attachment.[35] Studies[36-39] showed negative effects on the results of non-surgical and surgical treatments, especially regenerative procedures. If smoking is not controlled, it worsens the long-term prognosis.[3] Moreover, it takes a certain period of discontinued use to relieve its effect on the periodontium. In former smokers, the odds of having periodontitis decreased to those of never smokers after ≥11 years of cessation.[40] Although smoking cessation cannot reverse the past effects of smoking, former smokers can have a similar response to periodontal therapy as never smokers.[41]

**Diabetes mellitus.** The relationship between type 1 and 2 diabetes and periodontal diseases has been known for many years. Diabetic patients have a higher prevalence of periodontal disease and greater attachment and bone loss.[42,43] Patients who have poorly controlled diabetes also have more severe disease than patients whose diabetes is well controlled.[44] Diabetes affects the host response by decreasing polymorphonuclear leukocyte function[45] and affects collagen metabolism by decreasing collagen production and increasing collagenase activity.[46] Hyperglycemia can cause the formation of advanced glycation end products with other extracellular proteins. These end products result in reduced solubility and a decreased turnover rate of collagen. They also thicken the basement membrane, impeding oxygen diffusion, metabolic waste product elimination, and immune defense. As a result, wound healing is compromised in patients who have uncontrolled diabetes.[47] Diabetes was also shown to worsen the long-term periodontal prognosis.[3] Fortunately, studies[48,49] showed that the results of periodontal treatment in patients with controlled diabetes can be comparable to healthy patients after surgical and non-surgical therapy; however, patients with poorly controlled diabetes have more rapid recurrence of deep pockets and a less favorable long-term outcome.

**Other systemic factors.** Many systemic conditions affect the periodontium markedly. Neutrophil dysfunction usually manifests with severe aggressive periodontal breakdown, and this is associated with Chediak-Higashi syndrome, chronic granulomatous disease, chronic neutropenias, leukocyte adhesion deficiency, Papillon-Lefèvre syndrome, and Down syndrome, among others. The periodontal treatment for patients with periodontitis related to neutrophil disorders has been empirical and without consistent success. Unfortunately, for those systemic conditions most associated with neutrophil disorders and periodontitis, the end result usually is tooth loss.[50-52] Other acquired immunologic dysfunctions, including acquired immunodeficiency syndrome and leukemia, also can predispose to periodontal breakdown.[53-55] The periodontium also can be influenced by medications like phenytoin, nifedipine, and cyclosporin, resulting in gingival overgrowth. Although not related directly to periodontal breakdown, the overgrowing tissues create deep pockets and interfere with plaque control. Treatment includes a vigorous preventive program and surgical removal of the overgrowth; however, recurrence is likely if the medication cannot be changed.[56,57] Other systemic factors that may affect periodontal stability include interleukin-1 genotype, stress, nutrition, hormones, obesity, osteoporosis, and alcohol. More evidence is needed in these areas to verify the relationship with periodontal stability.[53,58-62]

### *Local factors*

**Deep probing depth and attachment loss.** Numerous studies[7,63,64] showed that deep probing depths and attachment loss are associated with future periodontal breakdown. Possible reasons include limited access for maintenance and opportunistic changes in the environment to favor periodontal pathogens.[65] Probing depths >5 mm were difficult to maintain as healthy and had more residual plaque and calculus.[66-68] Microbiologically, deep pockets were associated with virulent periodontal pathogens.[69]

**Other anatomic plaque-retentive factors.** Furcation involvement favors plaque retention, and furcation-involved teeth also had a poorer long-term prognosis and suffered continued attachment loss, even after treatment.[3,15,16,70] The situation can be aggravated by developmental aberrations like enamel pearls and cervical enamel projections.[71,72] Other possible aberrations include palato-gingival and other root grooves that may affect maintenance severely.[73,74] Tooth position (crowding, root proximity, or open contacts) also can interfere with maintenance. Crowding and root proximity can render some tooth surfaces inaccessible for oral hygiene.[75] Open contacts that cause food impaction were associated with deeper probing depth.[76] Finally, overhanging restorations are plaque retentive and were associated with microbiologic changes, attachment, and bone loss.[77-79]

**Trauma from occlusion and parafunctional habits.** Tissue changes and injury within the attachment apparatus can occur as a result of occlusal forces and parafunctional movements of the mandible.[80] These injuries may result in mobility, wear

facets, and enlargement of the periodontal ligament space.[81] Under experimental conditions in animals, traumatic forces combined with inflammation can cause increased bone loss and attachment loss.[82,83] However, signs of trauma in humans, such as mobility and a widened periodontal ligament, are often the result of periodontal disease and not the cause.[81] Despite the controversies, one study[84] showed that occlusal adjustments improved attachment gains after surgical and non-surgical treatments. Moreover, patients who had parafunction without a night guard were more likely to lose teeth over the long term.[64]

**Mobility.** Increased tooth mobility signifies alteration of the periodontal tissues that may result from occlusal trauma, inflammation, or loss of periodontal support.[85] Although the relationship between mobility and periodontal prognosis is still unclear, studies[3,19,63] suggested that mobility was associated with increased periodontal breakdown and a poorer long-term prognosis. This may reflect just the mobility resulting from severe periodontal destruction. Fortunately, periodontal treatment resulting in decreased inflammation and bone regeneration is associated with decreased mobility.[85]

## DISCUSSION

The determination of prognosis involves prediction of the future; therefore, it can be viewed from different perspectives. Traditional prognostication systems are based on tooth mortality. This is useful in epidemiologic studies, but less useful in patient management. In societies that have access to dental care, the reason for tooth loss usually is iatrogenic and may not even be periodontally related. The decision about tooth removal is based on many non-periodontal factors, such as restorative needs, clinician philosophy, and patient-centered issues. Therefore, it is not as useful in determining periodontal prognosis. On the other hand, using periodontal stability as the endpoint of periodontal prognosis has more practical and clinical advantages. Periodontal stability is monitored routinely by clinical examinations and radiographs. It is more useful for making treatment decisions in patient management. Moreover, the determination of prognosis can become more scientific by incorporating evidence-based modification factors on disease progression.

Many general and local factors can influence periodontal stability. As more evidence accumulates in the future, the list of influencing factors will change. However, the concept remains the same. A periodontal prognostication system that is based on stability can evolve with the current evidence. Clinicians can use this system to make decisions about treatment planning and patient management.

Periodontal prognosis is a dynamic entity. Because the periodontium is highly dynamic, the timing of prognostication is extremely important. In clinical practice, patients are evaluated at several phases of their therapy. At the initial examination, prognosis is determined according to the initial status, expected treatment results, and the uncertainty of controlling the modifying factors. Patients are educated on factors that can be changed, such as plaque control, diabetic control, and smoking cessation. At the re-evaluation visit after initial therapy, prognosis is determined again because some factors may have changed or new findings may have emerged during therapy. The clinician will be better acquainted with the patient's compliance level as well as possible new findings from the medical consultations, like uncontrolled diabetes and other undisclosed conditions and medications. Therefore, definitive treatment plans may be reviewed along with further patient education as needed. Finally, after comprehensive periodontal treatment, prognosis is reviewed again based on the results, and the outlook for future treatment needs can be discussed.

## CONCLUSIONS

The determination of periodontal prognosis has been arbitrary. The results of this analysis showed that systems using tooth loss as an endpoint may not be predictable or useful in patient management. This suggests that the proposed prognostication system, based on stability and evidence-based modification factors, may be more predictable and facilitate communication between clinicians and patients. The adaptation of this prognostication system into clinical practice is needed to verify long-term efficacy and usefulness.

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Correspondence: Dr. Jack G. Caton, Division of Periodontics, Eastman Dental Center, University of Rochester, 625 Elmwood Ave., Rochester, NY 14620. Fax: 585/473-5254; e-mail: jack_caton@urmc.rochester.edu.

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