Saliva and the Clinical Laboratory: A Data Driven Model for Periodontics and Implant Dentistry

A Peer-Reviewed Publication
Written by Thomas W. Nabors, DDS, FACD

Abstract
Periodontitis is a disease that is more serious from a health perspective than previously known. Peri-implant diseases are prevalent: They not only present risk for implant failure but may also present systemic risk. The doctor's ability to determine an accurate diagnosis for both of these diseases is critical. Ideally, the diagnostic capacity should be able to accomplish five important goals:

- To determine if the risk for disease is present in any given patient
- To determine if this risk is high or low in each patient
- To determine if actual disease is present at any level of disease (early, moderate, or late stages)
- To define which treatment is most advisable for the specific patient.
- To determine if co-management is appropriate for each patient.

Historically, oral medicine (dentists) has utilized a model that can only identify disease after it has become clinically apparent by the loss of or damage to anatomical structures. (BOP, pocket depth, radiographic images, etc.) While this legacy model can determine a history of past disease, it does not fill any specific goal of an ideal diagnostic model for the two diseases in question. Today, clinical lab tests that utilize saliva provide information for accomplishing the important goals of diagnosis, risk assessment, treatment planning, and monitoring for periodontal and peri-implant diseases.

Learning Objectives:
After completion of this course, the clinician will be able to:
1. Apply the scientific data that underscores the need for more accurate diagnosis for periodontitis and peri-implant diseases.
2. Understand the clinical utility of saliva to identify patients at risk for periodontal disease and peri-implant diseases.
3. Understand the shift in concentration of specific oral pathogens, and a specific genetic trait, that provide important biological information regarding these two diseases.
4. Understand that patients may display similar clinical profiles but have different diseases.
5. Utilize a saliva sample to personalize treatment of periodontitis and peri-implant diseases.

Author Profile
Thomas W. Nabors, DDS, FACD
Dr. Nabors received his degree from the University Of Tennessee College Of Dentistry. He served in the U.S. Navy as a dentist and rotate through all of the dental specialties including oral, periodontal surgery, endodontic therapy, prosthodontic dentistry and general dentistry. During his tenure in private practice, he served on the medical staff of Baptist Memorial Hospital in the Oral Surgery and Dental Division for approximately 25 years.

In 2004, he co-founded and served as CEO for Advanced Dental Diagnostics, LLC. In 2009, Dr. Nabors worked with a dedicated team to validate saliva as a suitable molecular assay for detection of HPV in the oral cavity.

Dr. Nabors is a frequent lecturer for both dental and medical groups on the subject of molecular genetics in the field of oral medicine: Including the role that periodontal disease contributes to systemic inflammation and this relationship to heart disease, stroke and diabetes. He lectures also inclusive the role that HPV plays in the development of certain forms of oropharyngeal cancer.

Today, Dr. Nabors serves as president and founder of Integrated HealthCare Consultants, LLC. He has published numerous articles within a variety of peer reviewed publications. He is a Life Member of the American Dental Association, an associate member of the AAP, a Fellow of the American College of Dentists, a member of the Penne Pauchard Honorary Society, and serves within numerous dental associations.

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The author of this course has no commercial ties with the sponsors or providers of the unrestricted educational grant for this course. The author serves as executive consultant to Advanced Dentals labs.

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Historically, oral medicine (dentists) has utilized a model that can only identify disease after it has become clinically apparent by the loss of or damage to anatomical structures. (BOP, pocket depth, radiographic images, etc.) While this legacy model can determine a history of past disease, it does not fill any specific goal of an ideal diagnostic model for the two diseases in question. Today, clinical lab tests that utilize saliva provide information for accomplishing the important goals of diagnosis, risk assessment, treatment planning, and monitoring for periodontal and peri-implant diseases.

The Medical Model
General medicine has for decades utilized a different model for diagnosis and treatment of disease than has oral medicine / dentistry. This model is oft referred to as the “Medical Model”: “the traditional approach to the diagnosis and treatment of illness as practiced by physicians in the Western world since the time of Koch and Pasteur.” The clinical decisions made by the physician are based upon an accurate diagnosis that requires the clinical exam, medical history, and the results from specific lab tests.1,2

Clinical lab tests and lab values become the cornerstone of the medical exam and record. These tests represent the majority of clinical data for each patient. Physicians rely heavily on this information and interpretations to make critical decisions that govern patient diagnosis and treatment. To put the value of lab tests in perspective, laboratory findings affect 60 to 70 percent of all clinical decisions in medicine.3

Current data supports the benefits for using saliva within the clinical lab model for both periodontal and implant dentistry for several reasons:
- Improved diagnosis and risk assessment
- Genetic risk assessment
- Improved patient treatment outcomes
- Monitoring patient improvement post-treatment
- Assessing the potential need for systemic antibiotics
- Risk for bacterial contamination of implant and bone grafting procedures.

Saliva as an important analyte within periodontics and implant dentistry
“Saliva, the most accessible and noninvasive biofluid of our body, harbors a wide spectrum of biological analytes informative for clinical diagnostic applications.”4 Saliva contains gingival crevicular fluid (GCF), sloughed oral epithelial cells, and pathogenic bacteria and their products among other elements.5 Saliva is a representative diagnostic specimen for an overall view of the oral microbiota since bacteria from various sites and surfaces of the oral cavity are found in saliva and mouth rinse samples. Salivary sampling and polymerase chain reaction (PCR) technique allow rapid and accurate identification of pathogenic bacteria and viruses, as well as human mucosal cells. The detection of multiple pathogenic bacterial species in saliva is closely associated with periodontal infections.5

Traditional clinical data vs. The clinical laboratory using saliva in conjunction with clinical data
In 2009, Giannobile, et al. stated the following: “In periodontics and implant dentistry, traditionally clinical criteria are often insufficient for determining sites of active disease, for monitoring quantitatively the response to therapy or for measuring the degree of susceptibility to future disease progression. Saliva as a mirror of oral and systemic health is a valuable source for clinically relevant information because it contains biomarkers specific for the unique physiological aspects of periodontal / peri-implant disease, and qualitative changes in the composition of these biomarkers could have diagnostic value by identifying patients with enhanced disease susceptibility, identifying sites with active disease, predicting sites that will have active disease in the future and/ or serving as surrogate end points for monitoring the effectiveness of therapy.”7

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The authors continued to state that, “[today, the principal focus on both periodontal disease and peri-implant disease is directed toward late stage or end-stage disease. Thus, there is a need for earlier disease detection. Having predictable biomarkers that can be measured within saliva can provide a valuable dimension to preventing both of these diseases as well as a more targeted strategy in the treatment of these diseases.”)

Aimetti et al. recently published data to show that the desirability to measure clinical signs plus the resident bacteria before periodontal treatment and after treatment provided valuable information regarding treatment objectives as well as treatment success or failure in the One Stage Full Mouth Disinfection model of therapy.9

A recent article by Zia, et al., stated that “clinical measurements used in diagnosis of periodontal disease are often of limited usefulness in that they are indications of previous periodontal diseases rather than the present disease activity. Biochemical mediators in oral fluids such as saliva and gingival crevicular fluid (GCF) are highly beneficial in the determination of current periodontal status.”

It is important especially for the general practitioner to understand the pathogenic potential of specific bacterial species that may reside within the biofilm community at the earliest time, and that different infections within different individuals tend to vary significantly based on bacterial specificity and dose. When defining periodontal disease within 774 subjects using six known periodontal pathogens, Beikler, et al., discovered 46 different combinations or “Pathogen Complexes.”10

While the mouth contains hundreds of different bacterial species and millions of individual bacteria, destruction of the periodontal tissues is a complex interaction between specific pathogenic bacteria, dose/concentration, and the host immune response. Due to unique pathogenic properties, some oral bacteria possess well established differences in their ability to excite the host immune response. It is also known that these specific bacteria that proliferate within the biofilm community exhibit a higher pathogenic potential than health related bacteria.8-22 It is the virulence or pathogenic potential of these specific bacterial species that increases the host response toward attachment loss and inflammation.9-14 The initiation and progression of both chronic periodontitis, as well as peri-implantitis, have well documented references to support that when these specific bacteria increase in volume, a clear and present danger exists within the host with an inflammatory movement toward disease and bone loss.13,14 The events associated include the bacterial infection, genetic response, metabolic response with eventual anatomical destruction. The time lag will be different in individuals based on these events as well as well documented risk factors.

Paju et al., found that saliva testing supported the role of specific bacteria and the traditional clinical signs of periodontal disease. Per this article, the pathogens that are considered to create the greatest pathogenic potential for chronic inflammatory periodontal diseases are Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, Prevotella intermedia, Tannerella forsythia, Campylobacter rectus, and Treponema denticola. Others, such as Fusobacterium nucleatum, Eubacterium nodatum, Eikenella corrodenes, and Micromonas micros (Peptostreptococcus micros) also exhibit virulent potential and are often found in large numbers within the saliva of those with periodontal diseases.25

In the Paju, et al. study referenced above, bacterial DNA from 1,198 subjects from saliva samples was extracted and PCR detection was performed using species-specific primers for A. actinomycetemcomitans, P. gingivalis, P. intermedia, T. forsythia, C. rectus, and T. denticola.

Their findings are as stated: “We investigated whether certain bacterial species and their combinations in saliva can be used as markers for periodontitis. In 1,198 subjects, the detection of multiple species, rather than the presence of a certain pathogen in saliva was associated with periodontitis as determined by the number of teeth with deepened periodontal pockets.”

Kononen, et al published a population based study of salivary carriage rates of periodontal pathogens in 2007. In this study, the authors stated that “… saliva is an easily obtainable and noninvasively collected microbiological specimen, containing the microbes which detach from various oral surfaces. It is a suitable sample material for large-scale oral microbiological studies utilizing PCR-based assays, which offer a labor-minimizing technique. In oral microbiological studies, culture has been appreciated as the gold standard despite its relatively low sensitivity. Due to the development of molecular biological methods, which do not need viable cells for detection, more accurate data on the presence of target bacteria in the specimen can be expected.”26

In the discussion, the authors stated: “Periodontitis-associated organisms colonize not only subgingival sites, but also supragingival sites, and appear in saliva. According to Umeda et al.,27 whole saliva was even superior to pooled subgingival samples to detect P. gingivalis, P. intermedia, and T. denticola in the oral cavity, and reasonably good detection rates were obtained also for A. actinomycetemcomitans and T. forsythiae.”

Umeda, et al., made a significant statement regarding the presence or absence of specific pathogens. While carriage rates were high within their study population (88.2%), subjects without any pathogens were typically female, young, with higher education, married, non-smoking, and having full dentition, and no pockets around teeth.
This is a significant finding and is also consistent with other laboratory findings. Subjects with clinical signs of attachment loss tend to carry multiple pathogenic species in higher concentration than those within healthy subjects. However, subjects without clinical signs of disease (healthy subjects), do not tend to have pathogenic species. Or if present, they are at very low concentration.

In concluding remarks, the authors stated “There is abundant evidence that the prevalence of major periodontal pathogens in oral (saliva) specimens varies between individuals due to differences in their periodontal health status. In pathogen carriers, the proportion of pathogens increases in saliva due to deteriorating periodontal status, an indication that a subject with advanced periodontitis can serve as a potential source of pathogens to his/her close contacts. Monitoring the carriage pattern of periodontal pathogens at the general population level may help in designing preventive strategies to attempt to control the acquisition of less beneficial members of the human oral microbiota.”

Boutaga, et al. studied the comparison of subgingival bacterial detection with oral mouth wash samples (oral lavage) to detect and quantify periodontal pathogens. The study was used to compare saliva with site specific testing via subgingival detection and also the abilities of anaerobic culture technique compared to the use of real-time PCR technique to detect and quantify bacterial pathogens.

The aim of the study was to compare the presence and numbers of Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, Tannerella forsythia, Prevotella intermedia, and Micromonas micros in subgingival plaque and mouth wash samples.

The conclusions included: Both qualitatively and quantitatively, saliva detected Aa, Pg, Tf, Pi, & Mm more successfully than subgingival samples. The highest detection frequencies were found in mouth wash samples with real-time PCR.

Rapid detection and quantification of periodontal pathogens in mouth wash samples are possible by real-time PCR. The procedure is significantly less time-consuming than subgingival sampling with paper points. This approach to detect major periodontal pathogens in mouth wash samples may simplify microbial diagnosis in periodontitis patients and may be used to monitor periodontal treatment.

Per a host of literary reviews, the diagnosis of periodontal disease as well as the progression of periodontal destruction cannot be predicted by traditional clinical signs of disease. However, the progression of chronic periodontal disease can be predicted by the levels of specific bacterial pathogens that can be accurately measured within a salivary sample.

Saliva testing and genetics
The role of genetic susceptibility to periodontal infections has been a topic of much research during the past decade.29-31

“Periodontitis is considered as a complex genetic disease whose phenotype is determined by both the genetic makeup and the environmental influences on the affected individual.”29

Clinical studies have demonstrated that cytokine neutralization was able to inhibit alveolar bone loss. There are several reasons to believe IL-1β is an important mediator of connective tissue destruction in the gingiva and periodontal ligament and in the resorption of alveolar bone. IL-1β is a potent stimulator of bone resorption in vitro and in vivo as well as a potent stimulator of matrix metalloproteinase expression. It is also the most potent stimulator of bone resorption in vitro of all the cytokines and hormones and a strong stimulator of prostaglandin E2 formation which fosters bone resorption mediated by RANKL expression in perio tissues.

Along with periodontal disease, there are clinical studies showing the importance of IL-1β for joint inflammation and destruction in RA and osteoarthritis.

Saliva, Implants and bone grafts
Infections are a significant concern for both the time of surgical placement of osseointegrated dental implants as well as their long term survivability. Both the optimal placement time as well as survivability may be predicted more effectively by knowing specific oral bacterial presence and concentration than by observation of clinical signs. Increased occurrence of Porphyromonas gingivalis, Prevotella intermedia, Treponema denticola, and Aggregatibacter actinomycetemcomitans are considered risk factors for further attachment loss around implants and bone grafts.35-38

Charalampakis et al., from July, 2011, clearly demonstrates that a history of periodontitis increases the risk for mucositis and peri-implantitis.37 This study included the following:

- Cohort study from 1996-2006
  - N=736 subjects
  - Mean follow-up 35.6 months
- Severe chronic inflammation status turned out to be a significant risk factor for implant failure after 50 months
  - HR=8.06 (Greater risk than smoking)
- Smoking indicates a significant effect after 50 months
  - HR=2.76
- Periodontal status and smoking are significant risk factors for late implant failures.

Since most implant beneficiaries have a history of periodontitis, it would be helpful to know how significant this is on a patient to patient basis. When observ-
ing the findings, chronic inflammation around remaining teeth resulted in a significantly greater risk factor for implant failure after 50 months than smoking.

With respect to surgical grafts and contamination with saliva:

Verdugo et al., recently published an article entitled: “Periodontopathogen and Epstein-Barr Virus Contamination Affects Transplanted Bone Volume in Sinus Augmentation.” The odds ratio (OR) of having bone microbial contamination in patients with a history of periodontitis was 37.5 times higher than in individuals without periodontitis.

Additionally, the likelihood of having moderate to pronounced bone volume loss 6 months post augmentation was 7.5 times greater in those patients presenting with ≥3 specific pathogens (Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Tannerella forsythia, or Prevotella intermedia) versus those with only one (P <0.05).

The following are the salient features of this article:

• **Background:**
Bone microbial contamination can impair osteogenesis. Human herpes viruses-associated vasculitis can cause vascular damage within the osseous graft and host.

This study was conducted to substantiate specific contamination and assess the impact 6 months after sinus augmentation.

• **Methods:**
Culture and PCR-based identification were performed on harvested bone particles and unstimulated whole saliva in a group of 30 patients undergoing maxillary sinus augmentation.

Thirty patients were divided into two groups: those with and those without a history of periodontitis.

Radiographic evaluation was done to assess and compare bone healing and volume gain at baseline and 6 months post-transplantation.

• **Results:**
Seventeen patients had a history of periodontitis, and 13 did not.

Ten showed culture- and PCR-negative results and belonged to the periodontally healthy group.

The 17 patients with periodontitis showed culture or PCR-positive results for the targeted periodontal pathogens.

Patients with periodontitis were 2.3 times more likely to have positive salivary Epstein-Barr virus type 1 (EBV-1) than those with no history of periodontitis.

• **Results:**
The likelihood of having moderate to pronounced bone volume loss 6 months post augmentation was 16.3 times higher in those patients contaminated with a combination of salivary EBV-1 and ≥3 of the previously mentioned species versus only EBV-1 (P <0.05).

Individuals showing positive salivary EBV-1 had bone bacterial contamination associated 57% of the time.

The odds ratio (OR) of having bone microbial contamination in patients with a history of periodontitis was 37.5 times higher than in individuals without periodontitis.

**Conclusions**
The medical model of utilization of clinical lab tests has proven for the past 100 years the value of biological information in patient care. Periodontal diseases are serious infections that deserve the same degree of urgency that is provided for the prevention and treatment of all human diseases and infections. If each periodontal infection was the same, then the treatment of all infections the same way would make sense. However, since periodontal infections differ widely based on etiological agents, genetic factors, and additional risk factors, the use of clinical lab tests has significant value for both diagnosis and therapy. Perhaps, the greatest value lies within the general dentist office as the widest variety of periodontal diseases may be expected. Upon identification of specific infections and consideration of risk elements, the GP may choose to treat the disease, refer the patient to a specialist, or co-manage the patient based on additional information received from saliva testing.

The etiological agents of periodontal disease are well established with a multitude of scientific articles that clearly state the relationship between specific bacteria and concentration are related to both periodontitis and peri-implant infections. Plus, the ability to detect a specific genetic variation appears to make significant differences in certain individuals as to their risk for disease as well as the severity of their disease.
The referenced articles within this course support the use of specific bacteria and specific genetics to more accurately define both periodontal infections and peri-implant diseases. The use of saliva as a valuable, predictable, and accurate analyte in conjunction with clinical signs is proving to add great value to periodontal and implant dentistry for diagnosis, treatment and monitoring of periodontal disease.

Today, saliva and the clinical lab model exist for everyday use. The future, really, is today.

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Author Profile

Thomas W. Nabors, DDS, FACD

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Questions

1. The “Medical Model” is defined by making clinical decisions using which of the following:
   a. Medical history
   b. Clinical exam
   c. Specific lab tests
   d. All of the above

2. Current data supports the use of saliva within oral diagnosis that will impact which of the following:
   a. Genetic risk assessment
   b. Improved diagnosis
   c. Specific pathogenic species
   d. All of the above

3. Traditional clinical criteria are often insufficient for determining which of the following:
   a. Sites of active disease
   b. For monitoring response to therapy
   c. Genetic susceptibility
   d. All of the above

4. The detection of multiple pathogenic bacteria species in saliva is …
   a. Closely associated with periodontal infections.
   b. Not significant
   c. Causes halitosis
   d. Is found in all humans

5. Saliva as a mirror of oral and systemic health is a valuable source for clinically relevant information because …
   a. It contains biomarkers unique to periodontal and peri-implant disease
   b. Quality changes in these biomarkers have diagnostic value
   c. It can serve as surrogate end points for monitoring effectiveness of therapy
   d. All of the above

6. Clinical measurements used in diagnosis today …
   a. Has limited usefulness
   b. Is the best that we have
   c. Are indications of previous disease rather than present disease activity
   d. Both a and c

7. Specific bacteria within biofilm infections are important because …
   a. Some bacteria possess virulent properties that initiate immune responses more than others
   b. Concentration of pathogenic species must be taken into consideration
   c. Knowing which bacteria are present helps to determine how to treat
   d. All of the above

8. Specific bacteria species contained within saliva can be used as markers for
   a. Periodontal disease & peri-implant disease
   b. Increased risk for disease
   c. Potential risk for both diseases
   d. All of the above

9. Some reasons that patients tend to “refract” after perio therapy include which of the following:
   a. Major perio pathogens in saliva varies between individuals
   b. Subjects with periodontitis can serve as a carrier to close contacts
   c. Treatment procedures in themselves do not guarantee that “end-point” of therapy has been reached
   d. All of the above

10. Saliva samples to detect pathogen groups and quantify them have been shown to be
    a. More successful than subgingival samples.
    b. Less successful than subgingival samples
    c. A relevant risk assessment model
    d. Both a & c

11. All people that have periodontal infections have …
    a. An equal degree of susceptibility to infections.
    b. Susceptibility may vary based on the IL-1 genotype
    c. No need to know this
    d. Should brush and floss more

12. Periodontitis is considered to be a complex disease and differences in disease activity and appearance is determined by which of the following …
    a. Genetic makeup
    b. Environmental influences
    c. Specific bacteria and concentration
    d. All of the above

13. Interleukin B (IL-8) is …
    a. An important mediator of connective tissue destruction
    b. A strong stimulator of prostaglandin E2 and bone resorption
    c. Is found only in patients with RA and joint inflammation
    d. Found at increased levels in IL-1 genotype individuals
    e. Both a and b
    f. A, B, and D

14. Increased occurrence of Pg, Pi, Td, and Az are considered risk factors for
    a. Attachment loss around implants and bone grafts.
    b. Found in all adults
    c. Not relative to risk management
    d. Dental caries

15. Charalampakis et al. demonstrated that a history of periodontitis presents
    a. No increased risk for implant infections.
    b. Significant risk for implant infections
    c. Should not matter as implants are very successful
    d. Patients that want implants don’t care

16. As clinical signs are not good predictors of potential risk of infection, and since a history of periodontitis increases risk for implant infections, it seems reasonable
    a. To determine the potential risk for implant failure or infections prior to the placement of an implant.
    b. To probe all patients prior to placing implants
    c. To determine the potential risk for implant disease over time
    d. All of the above

17. Saliva samples in parallel with clinical signs to help determine disease or risk for disease, based on these studies, appears
    a. To offer significant improvement in diagnosing periodontal diseases and peri-implant risk over the traditional model of clinical signs only.
    b. Don’t improve risk assessment
    c. Are becoming standard of care issues
    d. Are not available today

18. Saliva contamination of surgical sites can impair osteogenesis
    a. Based on the presence of specific bacterial and viral species.
    b. Based on surgical expertise
    c. Doesn’t make significant difference in surgical outcomes
    d. Based on patient home-care

19. Saliva has become an important biofluid due the fact that it harbors a wide spectrum of
    a. Salivary proteins
    b. Elements that can be used to detect cancers
    c. Biological analytes with information that is clinically relevant and important.
    d. Buffers

20. Laboratory tests and lab values are the cornerstone of the medical exam and record. Dentists are the main source of determining oral disease activity and genetic susceptibility and lab tests have become an important addition to the clinical exam.
    a. Adopting the “Medical Model” is an important advancement in patient care.
    b. Saliva tests are improving diagnosis and risk management
    c. Clinical lab tests for improved patient care are using saliva are available today
    d. All of the above
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Educational Objectives
1. Apply the scientific data that underscores the need for more accurate diagnosis for periodontitis and peri-implant diseases.
2. Understand the clinical utility of saliva to identify patients at risk for periodontal disease and peri-implant diseases.
3. Understand the shift in concentration of specific oral pathogens, and a specific genetic trait, that provide important biological information regarding these two diseases.
4. Understand that patients may display similar clinical profiles but have different diseases.
5. Utilize a saliva sample to personalize treatment of periodontitis and peri-implant diseases.

Course Evaluation
1. Were the individual course objectives met?  
   Objective #1: Yes No  
   Objective #2: Yes No  
   Objective #3: Yes No

2. To what extent were the course objectives accomplished overall?  
   5 4 3 2 1 0

3. Please rate your personal mastery of the course objectives.  
   5 4 3 2 1 0

4. How would you rate the objectives and educational methods?  
   5 4 3 2 1 0

5. How do you rate the instructor’s effectiveness?  
   5 4 3 2 1 0

6. Please rate the instructor’s effectiveness.  
   5 4 3 2 1 0

7. Was the overall administration of the course effective?  
   5 4 3 2 1 0

8. Please rate the usefulness and clinical applicability of this course.  
   5 4 3 2 1 0

9. Please rate the usefulness of the supplemental webliography.  
   5 4 3 2 1 0

10. Do you feel that the references were adequate?  
    Yes No

11. Would you participate in a similar program on a different topic?  
    Yes No

12. If any of the continuing education questions were unclear or ambiguous, please list them.

13. Was there any subject matter you found confusing? Please describe.

14. How long did it take you to complete this course?

15. What additional continuing dental education topics would you like to see?

Requirements for successful completion of the course and to obtain dental continuing education credits: 1) Read the entire course. 2) Complete all information above. 3) Complete answer sheets in either pen or pencil. 4) Mark only one answer for each question. 5) A score of 70% on this test will earn you 2 CE credits. 6) Complete the Course Evaluation below. 7) Make check payable to PennWell Corp. For Questions Call 216.398.7822

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