CALIBRATION OF PERIODONTAL DIAGNOSIS AMONG PARTICIPANTS OF VARIOUS DENTAL EDUCATION LEVELS

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ORTHODONTICS

ABSTRACT

The purpose of this project is to assess the level of calibration among dental students of two different education levels and postgraduate students of two different dental specialties during diagnosis and treatment planning of clinical cases with various levels of periodontal involvement, using the 2018 Classification of Periodontal and Peri-implant Diseases and Conditions.

Fifty-seven second year dental students (D2), 45 fourth year dental students (D4), 17 orthodontic postgraduate students (OS) and 12 postgraduate periodontology (PS) students were presented with an anonymous survey of 10 different cases, each with 5 choices of diagnosis and 7 therapeutic approaches. Consensus diagnosis was established through a discussion between 2 experienced periodontists, and used as the gold standard. Diagnosis and treatment choices for each case were compared across educational groups using Fisher's exact test. The level of agreement for diagnoses and treatments among educational groups was assessed using a multirater kappa coefficient.

The levels of agreement for all participants for diagnosis was fair (0.24). The PS showed moderate agreement for diagnosis (0.55) whereas the D2, D4 and OS had lower

levels of agreement (0.24, 0.26 and 0.30 respectively). Fair levels of agreement were registered for diagnosis when comparing all predoctoral students (0.23) and all postdoctoral (0.34) for diagnosis. There were tendencies to over-diagnose the severity of periodontitis as well as gingivitis as incipient periodontitis by the D2, D4 and OS groups, and to under-diagnose incipient periodontitis as gingivitis by all groups. All participants showed substantial agreement for scaling and root planing as a choice of treatment (0.63), and moderate agreement for periodontal maintenance therapy (0.44). The postgraduate group showed substantial level of agreement for scaling and root planing therapy (0.63) and extraction (0.63). The distribution of responses per case and per level of education indicates that PS have a higher frequency of responses agreeing with the gold standard than any other group.

Treatment planning agreement was higher than diagnostic agreement. Clinical exposure and continuous reinforcement refine learning pathways. Distinguishing between health, gingivitis and periodontitis is a crucial step for all levels of education. For D2 and D4, an increase of case-based learning and more integration of diagnosis and treatment planning in the clinic could be beneficial. Continuous reinforcements of concepts for all students through calibration exercises is recommended for improved communication and planning of interdisciplinary treatments.

Keywords: Calibration, Periodontology, Orthodontics, Diagnosis, Treatment planning.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table *Page*

LIST OF FIGURES

Figure *page*

CHAPTER 1

INTRODUCTION

According to the National Health and Nutrition Examination Survey in 2009-10, half of American adults suffer from periodontal disease.[1] Also, one in four patients who seek orthodontic treatment is an adult, as reported by the American Association of Orthodontists [2] This simple equation explains the need to identify periodontal conditions prior to the initiation of orthodontic treatment, particularly in adults.

Unless they are dedicated to a pediatric population, most dental students and dentists happen to provide dental treatment to adults. Therefore, it is crucial that dental pre- and postgraduate students are educated to properly conduct clinical exams. Adequate medical and dental history recording, periodontal chartings, radiograph reading and interpretation are essential to formulate and deliver proper treatment plans for a given patient.[3] This concept highlights the importance of calibration among the dental team that encompasses educators, students, residents and clinicians in private practice.

In addition, there may be a "language barrier" between new dental graduates and earlier graduates as the classification of periodontal diseases has recently been revised. [4] As a consequence, there is a need to educate all dental practitioners on the newly adopted classification to be able to facilitate communication as well as to unify the therapeutic approach. The purpose of this project is to assess the level of calibration among dental students of two different education levels and postgraduate students of two

different dental specialties during diagnosis and treatment planning of clinical cases with various levels of periodontal involvement, using the 2018 Classification of Periodontal and Peri-implant Diseases and Conditions.

Calibration

Calibration is a concept used in education to ensure that a cluster of assessors evaluate the same situation in a reliable and valid way, usually using a rubric.[5] Calibration ensures standardization of results, as it trains individuals who are faced by the same set of information to go through the same thought process and objectively assign a grade (or a diagnosis) to a particular situation. [6] The rationale is that an accurate diagnosis leads to better health outcome as treatment objectives are clearly defined.[7]

In 2015, The National Academies of Sciences, Engineering and Medicine published a report entitled: Improving Diagnosis in Health Care.[8] This report highlights three important areas in diagnosis: diagnosis error by the clinician, diagnostic error from the patient's perspective, and the importance of diagnosis in a team approach to healthcare. The first and third areas are very relevant for the current project, as they emphasize the need for clinicians to reliably reach a correct diagnosis, communicate with peers and use the health care system to the patient's advantage. In their report, the authors use a calibration loop to depict the importance of feedback in order to improve diagnostic accuracy. This loop is adapted below based on the original publication.[8]

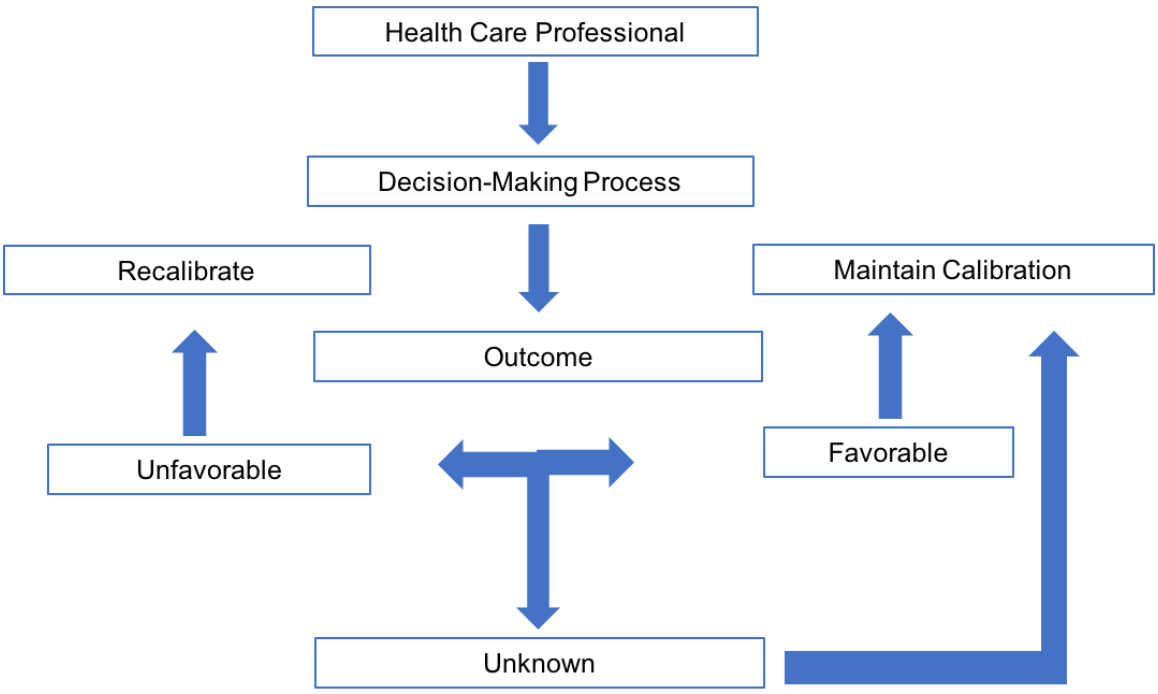

Figure 1. Calibration loop depicting the calibration process. Feedback is necessary to evaluate the outcome quality and improve clinician calibration.

This diagram emphasizes the importance of a feedback mechanism, to put clinicians in a continuous learning mode. In other words, in order to successfully identify a condition and therefore implement successful treatment, clinicians need to continuously calibrate their decision-making process on peers and as well as against a gold standard for validity purposes.[5]

Haj-Ali and Feil tested a calibration gold standard, which is a benchmark established by experts in a field, over a period of 10 weeks.[9] Their investigation focused on Class II amalgam preparation, but the thought process applies for any type of independent grading using specific standards. Their results indicate that calibrating against a gold standard seems to carry a longevity factor as it establishes clear criteria, benchmarks and requirements in order to meet high quality and high reliability. They also

advocate continuous standardization in order to maintain calibration over extended periods of time.

Variation among educators is well documented [10-12] To counteract this trend, dental school administrators usually hold seminars and training days to ensure that all educators in a particular field use the same evaluation criteria and are able to communicate the information in a similar fashion to their students. Many calibration studies in the field of Dentistry have been published, usually using caries risk assessment, caries identification and periodontal disease diagnosis as the variables they are studying. [9, 12-15] They all advocate the implementation of faculty development sessions during which there is a continuous calibration of educators to ensure a clear and unified message delivery to students.

Of interest to the current project are three studies investigating the diagnosis and treatment planning of periodontal disease. It is important to note that all three works used the 1999 Periodontal classification by Armitage as a common language [16] and that this classification has been revised in 2017. [17] The new periodontal disease classification will be presented later in this introduction.

First is a publication by Lanning that investigates periodontal diagnosis and treatment planning calibration among dental school clinical instructors.[12] This group included periodontists, general practitioners, dental hygiene providers, and periodontology residents, as they all teach on the clinic floor. The participants were presented with three clinical scenarios and were asked to offer a diagnosis and treatment plan for each. Their findings indicate considerable variation among the groups when it came to periodontal diagnosis, radiographic interpretation and prospective treatment

plans. A greater consistency among periodontology postgraduate students was noted when compared to the other groups, and was tentatively attributed to the fact that these students often have treatment planning seminars together which could be acting as informal calibration sessions.

The second study by John et al. takes a closer look at consensus training in periodontal diagnosis and treatment planning among dental faculty and students.[14] Periodontology educators (faculty members and postgraduate residents), third year and fourth year dental students were presented with a web-based survey of 9 documented clinical cases and asked to formulate a diagnosis and treatment plan for each. The gold standard diagnosis and treatment plan for each case was established by three of the authors. Their results showed high variability in diagnoses of extent and severity of the disease as well as therapeutic approaches.

The third study by Lane et al. is entitled: Assessment of the Calibration of Periodontal Diagnosis and Treatment Planning Among Dental Students at Three Dental Schools.[15] In this publication, third and fourth year dental students of three different dental schools were presented with 11 documented cases and asked to formulate a diagnosis and treatment plan for each. Their results indicate that the levels of agreement on diagnosis between the students differed from one school to the other. Students and schools agreed more on treatment plan strategies. Their conclusions advocate for reorganizing the predoctoral curriculum with an emphasis on continuous calibration.

Development of A New Classification of Periodontal and Peri-Implant Diseases Conditions

The World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions held in November 2017 by the American Academy of Periodontology and the European Federation of Periodontology presented a new classification model after reviewing the strongest available scientific evidence.[18] Among the significant changes, periodontitis is no longer classified as chronic or aggressive as its diagnosis has acquired a multidimensional approach. Similar to cancer, periodontitis is assigned a stage based on severity and a grade based on rate of progression. Staging and grading also incorporate the complexity of disease management and the influence of known risk factors on disease progression, respectively. This new approach in diagnosing one of the most prevalent oral diseases, i.e. periodontitis, interfaces greatly with precision medicine as it allows for individualized treatment based on the patient's presentation and associated systemic risk factors. Challenges in implementing the new classification relate to dissemination among the dental community and clinicians' calibration.

New Classification Categories

Caton et al.'s publication highlights the differences between the 2019 and the previously used 1999 classification. Three types of periodontal diseases and conditions are defined.[17]

1. Periodontal Health, Gingival Diseases and Conditions
2. Periodontitis

3. Other Conditions Affecting the Periodontium. This category includes periodontal disease linked to systemic diseases or mixed with local aggravating factors such as endodontic lesions, periodontal abscesses, traumatic occlusion, and prosthetic-related complications.

In order to correctly diagnose the periodontal status of a patient, the American Association of Periodontology recommends starting with a clinical examination which includes counting the teeth, a periodontal charting and radiographic images. This initial screening allows clinicians to diagnose the patient's condition and decide whether they are healthy, have gingivitis or have periodontitis. The allocation of a specific stage and grade are measures of extent, severity and complexity of the diagnosed periodontitis. Stages are based on the severity of the periodontitis, as evaluated by the amount of Clinical Attachment Loss (CAL), the Radiographic Bone Loss (RBL- evaluated on periapical radiographs) and the number of teeth lost due to periodontitis. The complexity of the disease is determined by the depth and pattern of bone loss, whereas the extent and distribution describe the extent of the disease.

Staging Criteria

Stages I through IV therefore describe mild, moderate, severe and very severe periodontitis. Grading criteria are presented in Table 1.[4]

PERIODONTITIS: STAGING

Staging intends to classify the severity and extent of a patient's disease based on the measurable amount of destroyed and/or damaged tissue as a result of periodontitis and to assess the specific factors that may attribute to the complexity of long-term case management.

Initial staging should be determined using clinical attachment loss (CAL). If CAL is not available, radiographic bone loss(RBL) should be used. Tooth loss due to periodontitis may modify stage definition. One or more complexity factors may shift the stage to a higher level. See **perio.org/2017wwdc** for additional information.

	Periodontitis	**Stage I**	**Stage II**	**Stage III**	**Stage IV**
Severity	**Interdental CAL** (at site of greatest loss)	1-2mm	3-4mm	≥5mm	≥5mm
	RBL	Coronal third (<15%)	Coronal third (<15%-33%)	Extending to middle third of root and beyond	Extending to middle third of root and beyond
	Tooth loss (due to periodontitis)	No tooth loss		≤4 teeth	≥5 teeth
Complexity	**Local**	• Max. probing depth ≤4mm • Mostly horizontal bone loss	• Max. probing depth ≤5mm •Mostly horizontal bone loss	In addition to stage II complexity: • Probing depths ≥6mm • Vertical bone loss ≥3mm • Furcation involvement class II or III • Moderate ridge defects	In addition to stage III complexity: Need for complex rehabilitation due to: - masticatory dysfunction - secondary occlusal trauma (tooth mobility degree ≥2) - severe ridge defects - bite collapse, drifting, flaring - <20 remaining teeth (10 opposing pairs)
Extend and distribution	**Add to stage as descriptor**	For each stage, described extent as: • Localized (< 30% of teeth involved); • Generalized; or • Moral/incisor pattern			

Table 1. Staging criteria for Periodontitis.

Grading Criteria

Grading describes disease progression. Four grades have also been proposed, and are based on CAL, the percentage of bone loss in regards to age, the amount of plaque on the teeth, as well as modifiers such as such as smoking and diabetes.

Grading criteria are presented in Table 2. [4]

PERIODONTITIS: GRADING **Grading aims to indicate the rate of periodontitis progression, responsiveness to standard therapy, and potential impact on systemic health.** Clinicians should initially assume grade B disease and seek specific evidence to shift to grade A or C. See **perio.org/2017wwdc** for additional information.					
	Progression		**Grade A:** **Slow rate**	**Grade B:** **Moderate rate**	**Grade C:** **Rapid rate**
Primary Criteria *Whenever available, direct evidence should be used.*	Direct evidence of progression	Radiographic bone loss or CAL	No loss over 5 years	<2mm over 5 years	≥2 mm over 5 years
	Indirect evidence of progression	% bone loss/ age	<0.25	0.25 to 1.0	>1.0
		Case phenotype	Heavy biofilm deposits with low levels of destruction	Destruction commensurate with biofilm deposits	Destruction exceeds expectations given biofilm deposits; specific clinical patterns suggestive of periods of rapid progression and/or early onset disease
Grade modifiers	Risk factors	Smoking	Non-smoker	<10 cigarettes/day	≥ 10 cigarettes/day
		diabetes	Normoglycemic/no diagnosis of diabetes	HbA1c<7.0% in patients with diabetes	HbA1c≥ 7.0% in patients with diabetes

Table 2. Grading criteria for Periodontitis.

The oral systemic link

Systemic interactions act as modulators for periodontal disease. The importance of recording a thorough medical history has long been known to dentists. At the initial dental exam, dentists will complete a medical history questionnaire in order to record past health history, list of medications and evaluate current status of organs and systems. They will also record habits such as drinking and smoking and offer advice regarding addiction, diet, and mental health. At the same visit, a blood pressure recording is made and an oral cancer screening is conducted.[3] The aim is to understand the systemic-dental interactions that could potentially impact the dental intervention.

A review by Genco and Borgnakke offers a comprehensive overview of the risk factors for periodontal disease.[19] The following conditions are listed as individual risk factors:

- Gender, smoking, and alcohol (lifestyle)
- Diabetes
- Obesity and metabolic syndrome
- Osteoporosis, dietary calcium, and vitamin D
- Stress
- Genetic factors.

Recognizing and recording these factors allows for the fine tuning of the grade of periodontal disease. In particular, smoking and diabetes are listed as grade modifiers, and will be described in more detail below.

Smoking

According to the Center for Disease Control (CDC), around 14% of the adult population in the US smokes cigarettes. While this percentage has been slowly decreasing over time, cigarette smoking accounts for 1 in 5 deaths and impacts 16 million Americans with smoking-related diseases.[20] Smoking has been linked to alveolar bone loss and increase in periodontal disease progression. It has been shown that the effect of smoking accumulates over time leading to an increased severity of periodontal destruction. Smokers seem to have lower bleeding scores and less gingival erythema. Smoking has been reported to be a modulating factor and not an etiological factor of periodontal disease. From a treatment standpoint, smokers seem to have less favorable results than non-smokers in regards to non-surgical and surgical periodontal therapy. Implant placement is less successful in smokers compared to non-smokers, particularly in the maxilla. It is recommended to offer smoking cessation advice to smoking patients as studies have shown increased success and decreased complications when smoking is avoided.[21]

Diabetes

The CDC reports that 34.2 million Americans have diabetes.[22] Diabetes is an endocrine disease that manifests as either Type I (insulin deficient), Type II (insulin resistant) or gestational diabetes.[23] Regardless of the type, the oral complications of diabetes include: increased severity of periodontal disease, salivary dysfunction, dysphagia and candidiasis. Poor glycemic control leads to an increased severity of periodontal disease, in the presence of plaque. Patients with diabetes tend to have longer

healing times following injury, and this is also observed in regards to periodontal disease therapy.[21] The grading criteria shown in Table 2 indicates that poorly controlled diabetes as measured by HbA1c $\geq$ 7.0% directly contributes to a rapid progression of periodontal disease.

Microbiology of Periodontal Disease

Researchers in the fields of Periodontology have made great progress in the last decades trying to identify the microbiological basis of periodontal disease, as well as the elements that modulate the host's response. The microbiology of periodontal disease is actually fascinating. Dental plaque is the principal etiology of periodontal disease in a susceptible individual. Listgarten defines plaque as "A non-mineralized accumulation that adheres tenaciously to tooth surface, restorations, and prosthetic appliances, shows structural organization with predominance of filamentous forms, is composed of an organic matrix derived from salivary glycoproteins and extracellular microbial products and cannot be removed by rinsing or water spray". [24]

The current consensus is that periodontal disease is multifactorial, and it that results from the interaction between the microbial biofilm, and the environmental and genetic factors that modulate the host's immunological response.[25] The work of Socransky and Haffajee has allowed the dental community to understand the multiple and complex phases that come into play to form dental plaque.[26] The very early stage is the formation of the dental pellicle, which is defined as a bacteria-free, amorphous, membranous layer which covers the enamel surface. Salivary glycoproteins are

selectively adsorbed by the tooth surface, and provide the substrate onto which initial bacterial colonization occurs. This initial colonization is reversible and often starts around irregularity of the tooth and around gingival margins. Plaque maturation corresponds to microbial growth in amount and complexity.[27-29] The shift in the environment (from aerobe to anaerobe) as well as in bacterial composition (gram-positive cocci facultative anaerobic rods and cocci to gram-negative obligate anaerobic rods) is sequence-specific. According to Socransky and Haffajjee, the initial colonizers adhere directly to the pellicle.[26] They mainly consist of Streptococci and Actinomyces, and have been grouped in color-coded complexes (Yellow, Green, Purple and Blue). The next colonizers are grouped in the Orange complex, of which *Fusobacteria* species seem to be the bridging species between the early and late colonizers. The Orange complex has been linked to clinical signs of inflammation such as erythema and bleeding. The most virulent group is the Red complex, which comprises *Porphyromonas gingivalis, Tanneralla forsythia* and *Treponema denticola* and has the ability to invade the periodontium and colonize subgingival tissues while releasing toxins that elicit an immune response that leads to further bone loss. This cycle can be broken by diagnosing properly the clinical presentation at hand, and applying the therapeutic procedures.[30] Disease control is thus the first step for any dental treatment particularly in adults seeking orthodontic treatment.

The Periodontal-Orthodontic Interaction

Orthodontics and Periodontology are currently two different dental specialties. The former focuses on occlusion and dental alignment while delivering esthetic results whereas the latter focuses of maintaining and regenerating health to the supporting tissues of a tooth. Their common denominator is the periodontal ligament. Without a healthy periodontium, tooth movement cannot occur. This simple realization stresses the importance of sharing the same language with other dental practioners when it comes to identifying, diagnosing and treating periodontal conditions, particularly in adult patients seeking multidisciplinary treatment.

At the root of this project is the deep belief that disease control should be the first stage of any dental treatment, including orthodontic treatment.[31] A commonly used analogy compares restoring a tooth or a number of teeth with building a house, and laying its foundation. A strong foundation keeps the house safe by distributing the load on the surface of the ground. Similarly, a healthy periodontal ligament acts like the foundation of a tooth, anchors that tooth to the bone and transfers the forces of mastication evenly to the supporting bone. It is therefore important to be able to differentiate health from disease, and to formulate a deliver an adequate treatment plan that aims at maintaining or restoring health. This is particularly relevant to orthodontics, as indicated by the theories of tooth movement.

Orthodontic Tooth Movement

Orthodontic tooth movement often considered to be an aseptic inflammation. The most popular theory of tooth movement is the pressure-tension theory. In this theory, the amount of force has a direct effect on the blood vessels and on the PDL. The application of a light consistent force results in a nearly continuous tooth movement from frontal resorption. In contrast, the application of a heavy continuous force results in interrupted tooth movement delayed by undermining resorption. Heavy forces can be destructive to the tooth and PDL, and requires time for regeneration and repair. It is important to note that some undermining resorption probably occurs in every case. [31] An optimal force is meant to achieve frontal resorption and avoid undermining resorption, as undermining resorption results in less efficient tooth movement. [32] Optimal force levels are high enough to stimulate cellular activity, low enough to allow for proper blood flow, and are determined by the force by unit area of the PDL. [33]

Key Elements In The Orthodontic And Periodontal Outcomes

The American Association of Orthodontists regularly disseminates educational materials aimed at the public. One of them, currently found on the Association's website, specifically addresses orthodontic treatment in adult patients. As the title indicates, it recommends a team approach for adult treatment. Seven points are presented to advocate for orthodontic treatment for adults, and 4 out of the seven are directly linked to periodontal status, as listed below:

- Help improve periodontal problems

- Help prevent or reduce further bone loss around the teeth
- Improve the ability of the dentist to restore missing teeth
- Improves oral health

It is important to understand the periodontal-orthodontic interactions as they go both ways: the periodontal status has an impact on orthodontic treatment outcome and orthodontic tooth movement has an impact on periodontal status. Initial diagnosis is therefore crucial in order to preserve health and improve the overall dental condition.[30]

Disease control in the first step of any dental treatment.[34] A precise periodontal assessment will help detect any active disease. Patients with deep probing depth, bleeding on probing and plaque should be treated and stabilized prior to any application of orthodontic forces. Moreover, the pattern and pace of bone loss should be taken into consideration. A decision tree for the management of periodontal disease has been proposed and outlines the required steps prior to initiation to orthodontic therapy and after treatment completion. In every scenario involving periodontitis, maintenance therapy is always the final step to insure health preservation over time.[35]

Orthodontic forces have been shown to accelerate bone loss when plaque-induced disease is not controlled.[36, 37] Conversely, orthodontic therapy can help level the bone in areas of plaque induced infrabony pockets if the active disease is stopped. This has been shown with intrusion, extrusion and uprighting of severely tipped teeth.[34, 38-40]

The key concept is to maintain a plaque-free environment throughout orthodontic treatment. Malocclusion itself has been shown to increase plaque levels.[41] Orthodontic attachments also have the potential to accumulate plaque and encroach on the gingival

tissues.[42] There is a transient increase in towards a more pathogenic biofilm during the first six months of orthodontic therapy in adults. With good oral hygiene throughout treatment after appliance removal, clinical periodontal parameters as well as bacterial counts tend to go back to pre-orthodontic treatment levels.[30, 43]

CHAPTER 2

MATERIALS AND METHODS

This study's aim in to assess the level of calibration among dental students of two different education levels and postgraduate students of two different dental specialties during diagnosis and treatment planning of clinical cases with various levels of periodontal involvement. This protocol has been approved by the UAB Institutional Review Board (IRB-300000090).

The specific aims of this study are to:

1. Evaluate the frequency of responses of diagnosis and treatment per group
2. Evaluate the degree of agreement of diagnosis and treatment within groups
3. Evaluate the degree of agreement of diagnosis and treatment between groups

The Null Hypothesis is that there are no disagreements among UAB predoctoral and dental students and postgraduate students in diagnosis and treatment planning of periodontal disease.

Population

There are four groups of participants in this study, all students at University of Alabama at Birmingham's the School of Dentistry

- **Group 1**: Second year predoctoral dental students (D2), N=57
- **Group 2**: Fourth year predoctoral students (D4), N=45

- **Group 3**: Orthodontics postgraduate students, N=17
- **Group 4**: Periodontology postgraduate students N=12

The 2018 Periodontal Disease classification will be presented by the same educator to 4 groups of dental students and postgraduate students (RVA) in a lecture format, supported by power point slides.

Methods

Ten de-identified clinical cases, each with 5 choices of diagnoses and 7 choices of therapeutic approaches were prepared by the investigators. The diagnoses choices varied from case to case but the 7 therapeutic options were the same for all the cases, and are listed below:

- Diagnosis
- Prophylaxis
- Scaling and root planing
- Periodontal respective surgery
- Extraction
- Periodontal maintenance therapy
- Complex multidisciplinary treatment

Consensus diagnosis was established though a discussion between two experienced periodontists (RVA and MK), and used as the gold standard. Participants were invited through email to participate in an anonymous survey. If they agreed to participate, they were invited to sign a consent form and directed to access the survey link on the Research

Electronic Data Capture (REDcap) software. This software is a secure web application for collecting and managing online surveys and databases, and is HIPAA compliant. Participants were free to drop out of the study without any effect on their grades or class standing. They received no financial compensation for their participation.

The survey consisted of demographic questions about the participants' status at the University of Alabama at Birmingham and their year of education, as well as 10 documented clinical cases. Participants viewed the selected cases, each on a page, and were asked to choose the most adequate diagnosis and treatment(s) for each. The information they received consisted of medical history, dental history, social history (if any), intraoral photographs, radiographs (full mouth series), periodontal charting, which included probing depths (PD), clinical attachment loss (CAL), gingival recession, furcation involvement, and mobility. All answers were collected using REDcap.

Statistical Methods

Diagnosis and treatment choices for each case were compared across educational groups using Fisher's exact test. The level of agreement for diagnoses and treatments among educational groups was assessed using a multirater kappa coefficient. All statistical analyses were completed using SAS Version 9.4 (SAS Institute, Cary, NC) and R Version 3.4.0. A p-value of <0.05 was considered statistically significant.

Table 3 summarizes the presentation, diagnoses and the treatment plans for the 10 selected cases.

Case	Presentation	Gold Standard Diagnosis	Gold standard Treatment Plan
1	75yo Caucasian Female Type 2 Diabetes (HbA1c=8%) Lack of routine dental care Probing depth = 2-8 mm CAL= 2-9 mm BOP= 62% PI= 87% Furcation Grade 1 (#2,3,19,30,31) Grade 2 (#14, 15, 18) Class 1 Mobility (anterior teeth)	Generalized Stage 3 Grade C Periodontitis	Scaling and root planing therapy Periodontal resective surgery Extraction Periodontal maintenance therapy
2	30yo Caucasian Female Systemically healthy Lack of routine dental care Probing depth = 1-8 mm CAL= 1-8 mm BOP= 17% PI= 4% No Furcation involvement No Mobility	Localized Stage 3 Grade C Periodontitis	Scaling and root planing therapy Periodontal regenerative surgery Periodontal maintenance therapy
3	18yo AA Female Systemically healthy Lack of routine dental care Probing depth = 4-13 mm BOP= 100% PI= 100% No missing teeth	Generalized Stage 4 Grade C Periodontitis	Extraction Complex multidisciplinary treatment
4	41yo Caucasian Male Smoking (1pack/day-22 years) Probing depth = 2-5mm CAL=3-5mm BOP= 15% PI= 23% No mobility No missing teeth No furcation involvement	Localized Stage 2 Grade C Periodontitis	Scaling and root planing therapy Periodontal maintenance therapy
5	37yo Caucasian Female Systemically Healthy Regular dental care History of orthodontic treatment Probing depth = 1-3 mm	Plaque-induced gingivitis on an intact periodontium	Prophylaxis

	BOP= 27% PI= 25% No missing teeth No mobility No Furcation involvement		
6	65yo Caucasian Female Osteoporosis Hypothyroidism Rheumatoid Arthritis Lack of routine dental care Probing depth = 2-11 mm CAL= 2-12 mm BOP= 71% PI= 84% 1 missing tooth Class 2 mobility (#4, 5, 17) Furcation Grade 2 (#2, 14, 15)	Generalized Stage 4 Grade C Periodontitis	Scaling and root planing therapy Periodontal resective surgery Periodontal regenerative surgery Extraction Periodontal maintenance therapy Complex multidisciplinary treatment
7	65yo Caucasian Female Osteoporosis Hypothyroidism Rheumatoid Arthritis History of active periodontal therapy followed by maintenance Probing depth = 2-3 mm CAL= 2-7 mm BOP= 1% PI= 9% Class 1 mobility (#4 and 5) 1 missing tooth + 3rd molars	Clinical health on a reduced periodontium	Periodontal maintenance therapy
8	61yo AA Female Hypertension Hypothyroidism Type 2 Diabetes (HbA1c=5.9%) Lost Maxillary anterior teeth in motor vehicle accident Probing depth = 2-4 mm BOP= 32% PI= 17% Furcation Grade 1 (#2, 14, 15)	Generalized Stage 1 Grade A Periodontitis	Scaling and root planing therapy Periodontal maintenance therapy
9	18yo AA Male Systemically healthy Lack of routine dental care Probing depth = 2-12 mm CAL = 2-13 mm BOP= 41%	Molar/incisor pattern Stage 3 Grade C Periodontitis	Scaling and root planing therapy Periodontal regenerative surgery Periodontal maintenance therapy

	PI= 83%		
10	26yo Asian Female Systemically healthy Probing depth = 1-3 mm BOP= 0% PI= 5%	Clinical health on an intact periodontium	Prophylaxis

Table 3. Summary of the presented cases with their diagnosis and treatment plan options used as the gold standard.

CHAPTER 3

RESULTS

Fifty-seven D2 students, forty-five D4 students, 17 orthodontic postgraduate students and 12 periodontology postgraduate students participated in the survey. Their responses distributions and their levels of agreement were examined.

Levels of Agreement

The kappa statistic is used to determine interexaminer level of agreement. Traditionally the scale is as follows: values ≤ 0 as show no agreement, 0.01–0.20 show slight agreement, 0.21–0.40 shows fair agreement, 0.41– 0.60 shows moderate agreement, 0.61–0.80 shows substantial agreement, and 0.81–1.00 shows almost perfect agreement.[44]

Table 4 presents the multi-rater kappa coefficient for periodontal disease diagnosis and treatment classifications among various dental education levels. The levels of agreement for all participants for diagnosis was fair (0.24). The Periodontology postgraduate students showed moderate agreement for diagnosis (0.55) whereas the D2, D4 and Orthodontic postgraduate students had lower levels of agreement (0.24, 0.26 and 0.30 respectively). All participants showed substantial agreement for scaling and root planing as a choice of treatment (0.63), and moderate agreement for periodontal maintenance therapy (0.44).

In general, the periodontology postgraduate students have substantial levels of agreement for the following procedures: Prophylaxis (0.79), scaling and root planing (0.73), periodontal regenerative surgery (0.67) and extraction (0.72).

Table 5 presents agreement results for periodontal disease diagnosis and treatment classifications within dental student and postgraduate student groups. When dental students (combined D2 and D4) were compared to all postgraduate students (Periodontology and Orthodontics combined) on diagnosis, fair levels of agreement were registered for both groups (0.23 for the predoctoral students and 0.34 for postgraduate students). The postgraduate students generally have substantial agreement for scaling and root planing therapy and extraction, whereas the dental student pooled group kappa scores indicate substantial agreement for scaling and root planing therapy and moderate agreement for periodontal maintenance therapy.

Table 6 divided the levels of agreement further by looking at postgraduate students of each specialty (Periodontology and Orthodontics) by year. Overall, the periodontology postgraduate students have higher levels of agreement per year than the Orthodontic postgraduate students for diagnosis (0.57, 0.44 and 0.60 versus 0.28, 0.37 and 0.23 for years 1, 2 and 3 of each program respectively). As for treatment options, the periodontology postgraduate students register higher kappa scores than the orthodontic postgraduate students, except for the third year orthodontic postgraduate students whose kappa scores for scaling and root planing is similar to the first and second year periodontology postgraduate students (0.7, 0.75 and 0.75 respectively).

Distribution of Responses

The responses were divided per level of education for each case. Cases 1 through 10 results are presented in Tables 7.1 to 7.10 respectively. There was a significant variation in the frequency of responses between D2, D4, orthodontic and periodontology students. The periodontology postgraduate students were the most consistent in choosing the same diagnosis and treatment options across all the cases except case 4. Their most frequent responses also corresponded to the gold standard. The D2 participants were often slit on the diagnosis and treatment plan choices.

Case 4 has the most diverse distribution of responses: All participants were divided on diagnosis. There was no statistically significant difference between the participants' responses for diagnosis in this example. Treatment planning was less controversial, as 82% of the D2 participants, 86.67 of the D4 participants 70% of the orthodontic postgraduate students and 75% of the periodontology postgraduate students choose scaling and root planing; and 78.95%, 84.44%, 76.47% and 75% of the same groups chose periodontal maintenance as well. These two treatments correspond to the gold standard of treatment for this particular case.

In contrast, case 10 registered the highest frequency of responses for the same diagnosis: Clinical health on an intact periodontium was chosen by 80.70% of the D2 participants, 77.78 of the D4 respondents, 82.35% of the orthodontic postgraduate students and 100% of the periodontology postgraduate students. High response frequency was also noted for Prophylaxis as it was chosen by 96.49% of the D2 participants, 95.56% of the D4 participants, 94.12 % of the orthodontic postgraduate students and

100% of the periodontology postgraduate students. Both diagnosis and treatment plan were in agreement with the gold standard.

Cases 5 and 8 offer interesting findings, detailed below:

In case 5 the correct diagnosis was plaque induced gingivitis on an intact periodontium. 77.19 of the D2 participants, 80% of the D4 participants and 91.67 of the periodontology postgraduate students chose the correct diagnosis. The correct treatment was prophylaxis, and was chosen by 98.25% of the D2 students, 95.56% of the D4 students 82.35% of the orthodontic postgraduate students and 91.67% of the periodontology postgraduate students. However, in the clinical pictures and periodontal charting, the lower right central incisor presented a gingival recession that prompted 47.06% of the orthodontic postgraduate students and 41.67 of the periodontology postgraduate students to choose periodontal maintenance therapy as an additional treatment modality, probably to treat this isolated recession with a free gingival graft.

Case 8 presented a 61-year-old African American Female with listed medical conditions of hypertension, hypothyroidism and Type 2 Diabetes (HbA1c=5.9%). She lost Maxillary anterior teeth in motor vehicle accident. The diagnosis for this case was Generalized Stage 1 Grade A Periodontitis. Seventy five percent of the periodontology postgraduate student chose the gold standard diagnosis, while 70% of the orthodontic postgraduate students chose Generalized stage 3 Grade B Periodontitis. Treatment plan choices were scaling and root planing therapy (82.46% of D2 students, 82.22% of D4 students, 94.12% of orthodontic postgraduate students and 91.67% of periodontology residents and periodontal maintenance therapy (87.72%, 77.78%, 82.35% and 91.67% of

D2 students, D4 students, orthodontic postgraduate students and periodontology postgraduate students respectively).

	D2 (N=57)		D4 (N=45)		Perio (N=12)		Ortho (N=17)		All Participants (N=131)	
	Kappa	P-value	Kappa	P-value	Kappa	P-value	Kappa	P-value	Kappa	P-value
Diagnosis	0.24	<.0001	0.26	<.0001	0.55	<.0001	0.30	<.0001	0.24	<.0001
Prophylaxis	0.11	<.0001	0.39	<.0001	0.79	<.0001	0.26	<.0001	0.23	<.0001
Scaling and root planing therapy	0.63	<.0001	0.67	<.0001	0.73	<.0001	0.52	<.0001	0.63	<.0001
Periodontal resective surgery	0.36	<.0001	0.34	<.0001	0.50	<.0001	0.31	<.0001	0.33	<.0001
Periodontal regenerative surgery	0.15	<.0001	0.25	<.0001	0.67	<.0001	0.42	<.0001	0.20	<.0001
Extraction	0.24	<.0001	0.40	<.0001	0.72	<.0001	0.56	<.0001	0.36	<.0001
Periodontal maintenance therapy	0.52	<.0001	0.46	<.0001	0.43	<.0001	0.28	<.0001	0.44	<.0001
Complex multidisciplinary treatment	0.17	<.0001	0.29	<.0001	0.39	<.0001	0.27	<.0001	0.23	<.0001

Table 4. Multirater kappa coefficient for periodontal disease diagnosis and treatment classifications among various dental education levels.

	All Dental Students (N=102)		All postgraduate students (N= 29)	
Diagnosis	0.23	<.0001	0.34	<.0001
Prophylaxis	0.20	<.0001	0.42	<.0001
Scaling and root planing therapy	0.64	<.0001	0.60	<.0001
Periodontal resective surgery	0.34	<.0001	0.32	<.0001
Periodontal regenerative surgery	0.15	<.0001	0.48	<.0001
Extraction	0.30	<.0001	0.63	<.0001
Periodontal maintenance therapy	0.47	<.0001	0.33	<.0001
Complex multidisciplinary treatment	0.22	<.0001	0.32	<.0001

Table 5. Multirater kappa coefficient for periodontal disease diagnosis and treatment classifications within dental student and postgraduate student groups.

	Perio Y1 (N=4)		Perio Y2 (N=4)		Perio Y3 (N=4)		Ortho Y1 (N=5)		Ortho Y2 (N=6)		Ortho Y3 (N=6)	
	Kappa	P-value	Kappa	P-value	Kappa	P-value	Kappa	P-value	Kappa	P-value	Kappa	P-value
Diagnosis	0.57	<.0001	0.44	<.0001	0.60	<.0001	0.28	<.0001	0.37	<.0001	0.23	<.0001
Prophylaxis	0.86	<.0001	0.67	<.0001	0.86	<.0001	0.22	0.0138	0.08	0.1667	0.34	<.0001
Scaling and root planing therapy	0.75	<.0001	0.75	<.0001	0.66	<.0001	0.24	0.0077	0.52	<.0001	0.70	<.0001
Periodontal resective surgery	0.56	<.0001	0.29	0.0126	0.51	<.0001	-0.04	0.6615	0.52	<.0001	0.39	<.0001
Periodontal regenerative surgery	0.89	<.0001	0.54	<.0001	0.56	<.0001	0.57	<.0001	0.27	0.0004	0.43	<.0001
Extraction	0.67	<.0001	0.89	<.0001	0.60	<.0001	0.46	<.0001	0.63	<.0001	0.48	<.0001
Periodontal maintenance therapy	0.38	0.0017	0.58	<.0001	0.44	0.0003	0.19	0.0304	0.16	0.0284	0.34	<.0001
Complex multidisciplinary treatment	0.48	<.0001	0.01	0.4706	0.79	<.0001	0.56	<.0001	0.31	<.0001	0.04	0.3121

Table 6. Multirater kappa coefficient for periodontal disease diagnosis and treatment classifications within postgraduate student groups per year. Y1, Y2 and Y3 stand for first year, second year and third year respectively.

Tables 7.1 to 7.10 compare diagnosis and treatment responses across education groups.

Case 1	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					<.0001
Generalized Stage 3 Grade C Periodontitis	45(78.95%)	17(37.78%)	7(41.18%)	11(91.67%)	
Generalized Stage 2 Grade B Periodontitis	0	11(24.44%)	0	1(8.33%)	
Localized Stage 3 Grade C Periodontitis	2(3.51%)	3(6.67%)	8(47.06%)	0	
Generalized Stage 4 Grade B Periodontitis	10(17.54%)	14(31.11%)	2(11.76%)	0	
Clinical health on a reduced periodontium	0	0	0	0	
Treatment plan					
Prophylaxis	29(50.88%)	8(17.78%)	3(17.65%)	0	<.0001
Scaling and root planing therapy	57(100%)	44(97.78%)	17(100%)	12(100%)	0.5879
Periodontal resective surgery	31(54.39%)	31(68.89%)	8(47.06%)	9(75.00%)	0.2081
Periodontal regenerative surgery	13(22.81%)	7(15.56%)	8(47.06%)	3(25.00%)	0.0777
Extraction	25(43.86%)	18(40.00%)	10(58.82%)	8(66.67%)	0.2699
Periodontal maintenance therapy	53(92.98%)	37(82.22%)	15(88.24%)	12(100.00%)	0.2009
Complex multidisciplinary treatment	9(15.79%)	4(8.89%)	1(5.88%)	0	0.3138

Table 7. 1. Case 1 diagnosis and treatment responses compared across education groups.

Case 2	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.0038
Localized Stage 3 Grade C Periodontitis	11 (19.30%)	15 (33.33%)	10 (58.82%)	9 (75.00%)	
Localized Stage 4 Grade C Periodontitis	6 (10.53%)	7 (15.56%)	3 (17.65%)	0	
Generalized Stage 3 Grade B Periodontitis	32 (56.14%)	16 (35.56%)	2 (11.76%)	3 (25.00%)	
Localized Stage 2 Grade C Periodontitis	6 (10.53%)	2 (4.44%)	1 (5.88%)	0	
Generalized Stage 2 Grade C Periodontitis	2 (3.51%)	5 (11.11%)	1 (5.88%)	0	
Treatment plan					
Prophylaxis	32(56.14%)	8 (17.78%)	3 (17.65%)	0	<.0001
Scaling and root planing therapy	56(98.25%)	45 (100.00%)	16 (94.12%)	12(100.00%)	0.3842
Periodontal resective surgery	16(28.07%)	16 (35.56%)	3 (17.65%)	8 (66.67%)	0.0329
Periodontal regenerative surgery	16(28.07%)	32 (71.11%)	14 (82.35%)	12 (100.00%)	<.0001
Extraction	1(1.75%)	1(2.22%)	1 (5.88%)	0	0.7207
Periodontal maintenance therapy	55(96.49%)	41 (91.11%)	15 (88.24%)	12 (100.00%)	0.3904
Complex multidisciplinary treatment	6(10.53%)	3 (6.67%)	0	0	0.3431

Table 7. 2. Case 2 diagnosis and treatment responses compared across education groups.

Case 3	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.0217
Generalized Stage 4 Grade C Periodontitis	28 (49.12%)	32(71.11%)	15 (88.24%)	12 (100.00%)	
Localized Stage 4 Grade C Periodontitis	1 (1.75%)	3 (6.67%)	0	0	
Generalized Stage 3 Grade C Periodontitis	13 (22.81%)	5 (11.11%)	2 (11.76%)	0	
Generalized Stage 4 Grade B Periodontitis	12 (21.05%)	5 (11.11%)	0	0	
Generalized Stage 2 Grade C Periodontitis	3 (5.26%)	0	0	0	
Treatment plan					
Prophylaxis	32(56.14%)	6 (13.33%)	3 (17.65%)	0	<.0001
Scaling and root planing therapy	56(98.25%)	34 (75.56%)	15 (88.24%)	8 (66.67%)	0.0017
Periodontal resective surgery	45(78.95%)	26 (57.78%)	12 (70.59%)	4 (33.33%)	0.0091
Periodontal regenerative surgery	35(61.40%)	13(28.89%)	6 (35.29%)	2 (16.67%)	0.0015
Extraction	22(38.60%)	32(71.11%)	15 (88.24%)	12 (100.00%)	<.0001
Periodontal maintenance therapy	55(96.49%)	24 (53.33%)	16 (94.12%)	7 (58.33%)	<.0001
Complex multidisciplinary treatment	30(52.63%)	29 (64.44%)	11 (64.71%)	10 (83.33%)	0.2106

Table 7. 3. Case 3 diagnosis and treatment responses compared across education groups.

Case 4	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.2133
Localized Stage 2 Grade C Periodontitis	20 (35.09%)	6 (13.33%)	5 (29.41%)	3 (25.00%)	
Localized Stage 1 Grade C Periodontitis	8 (14.04%)	9 (20.00%)	4 (23.53%)	4 (33.33%)	
Localized Stage 1 Grade C Periodontitis	6 (10.53%)	13 (28.89%)	2 (11.76%)	1 (8.33%)	
Generalized Stage 2 Grade B Periodontitis	15 (26.32%)	11 (24.44%)	4 (23.53%)	1 (8.33%)	
Plaque-induced gingivitis on an intact periodontium	8 (14.04%)	6 (13.33%)	2 (11.76%)	3 (25.00%)	
Treatment plan					
Prophylaxis	37 (64.91%)	18 (40.00%)	9 (52.94%)	3 (25.00%)	0.0197
Scaling and root planing therapy	47 (82.46%)	39 (86.67%)	12 (70.59%)	9(75.00%)	0.4706
Periodontal resective surgery	1 (1.75%)	3 (6.67%)	1 (5.88%)	0	0.5068
Periodontal regenerative surgery	4(7.02%)	3 (6.67%)	1 (5.88%)	1 (8.33%)	0.9951
Extraction	1 (1.75%)	0	0	0	0.7272
Periodontal maintenance therapy	45 (78.95%)	38 (84.44%)	13 (76.47%)	9 (75.00%)	0.821
Complex multidisciplinary treatment	1 (1.75%)	0	0	0	0.7272

Table 7. 4. Case 4 diagnosis and treatment responses compared across education groups.

Case 5	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.0259
Localized Stage 2 Grade A Periodontitis	3 (5.26%)	6(13.33%)	5 (29.41%)	0	
Localized Stage 1 Grade A Periodontitis	5 (8.77%)	3 (6.67%)	4 (23.53%)	1 (8.33%)	
Generalized Stage 1 Grade A Periodontitis	3 (5.26%)	0	0	0	
Generalized Stage 2 Grade B Periodontitis	2 (3.51%)	0	1 (5.88%)	0	
Plaque-induced gingivitis on an intact periodontium	44 (77.19%)	36(80.00%)	7 (41.18%)	11 (91.67%)	
Treatment plan					
Prophylaxis	56 (98.25%)	43 (95.56%)	14 (82.35%)	11 (91.67%)	0.0777
Scaling and root planing therapy	8 (14.04%)	1 (2.22%)	4(23.53%)	0	0.0306
Periodontal resective surgery	1 (1.75%)	1 (2.22%)	2 (11.76%)	0	0.16
Periodontal regenerative surgery	11 (19.30%)	17 (37.78%)	9 (52.94%)	4 (33.33%)	0.038
Extraction	11 (19.30%)	2 (4.44%)	0	0	0.64
Periodontal maintenance therapy	12 (21.05%)	2 (4.44%)	8 (47.06%)	5 (41.67%)	0.0005
Complex multidisciplinary treatment	2 (3.51%)	1 (2.22%)	1 (5.88%)	0	0.8055

Table 7. 5. Case 5 diagnosis and treatment responses compared across education groups.

Case 6	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.1243
Generalized Stage 3 Grade C Periodontitis	16 (28.07%)	8 (17.78%)	4 (23.53%)	2 (16.67%)	
Generalized Stage 4 Grade C Periodontitis	23 (40.35%)	22 (%)48.89	8 (47.06%)	2 (16.67%)	
Generalized Stage 3 Grade A Periodontitis	3 (5.26%)	1 (2.22%)	0	0	
Generalized Stage 2 Grade C Periodontitis	0	4 (8.89%)	1 (5.88%)	0	
Generalized Stage 3 Grade B Periodontitis	15 (26.32%)	10 (%)22.22	4 (23.53%)	8 (66.67%)	
Treatment plan					
Prophylaxis	30 (52.63%)	7 (15.56%)	5 (29.41%)	0	<.0001
Scaling and root planing therapy	57 (100.00%)	44 (97.78%)	14 (82.35%)	12 (100.00%)	0.0023
Periodontal resective surgery	34 (59.65%)	33 (73.33%)	12 (70.59%)	11 (91.67%)	0.1332
Periodontal regenerative surgery	25 (43.86%)	18 (40.00%)	5(29.41%)	11 (91.67%)	0.0053
Extraction	33 (57.89%)	31 (68.89%)	11(64.71%)	11 (91.67%)	0.1487
Periodontal maintenance therapy	53 (92.98%)	39 (86.67%)	15 (88.24%)	12 (100.00%)	0.4566
Complex multidisciplinary treatment	18 (31.58%)	9 (20.00%)	7 (41.18%)	6 (50.00%)	0.1426

Table 7. 6. Case 6 diagnosis and treatment responses compared across education groups.

Case 7	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.1923
Generalized Stage 3 Grade C Periodontitis	10 (17.54%)	5 (11.11%)	1 (5.88%)	1 (8.33%)	
Generalized Stage 4 Grade B Periodontitis	2 (3.51%)	1 (2.22%)	2 (11.76%)	0	
Generalized Stage 3 Grade A Periodontitis	9 (15.79%)	1 (2.22%)	0	1 (8.33%)	
Generalized Stage 2 Grade C Periodontitis	3 (5.26%)	4 (8.89%)	0	0	
Clinical health on a reduced periodontium	33 (57.89%)	34 (75.56%)	14 (82.35%)	10 (83.33%)	
Treatment plan					
Prophylaxis	37 (64.91%)	14 (31.11%)	7 (41.18%)	0	<.0001
Scaling and root planing therapy	25 (43.86%)	8 (17.78%)	3 (17.65%)	1 (8.33%)	0.0056
Periodontal resective surgery	10 (17.54%)	3 (6.67%)	0	1 (8.33%)	0.1286
Periodontal regenerative surgery	12 (21.05%)	5 (11.11%)	0	0	0.0514
Extraction	10 (17.54%)	3 (6.67%)	2 (11.76%)	1 (8.33%)	0.3957
Periodontal maintenance therapy	48 (84.21%)	40 (88.89%)	15 (88.24%)	12 (100.00%)	0.493
Complex multidisciplinary treatment	3 (5.26%)	1 (2.22%)	1 (5.88%)	4 (33.33%)	0.0019

Table 7. 7. Case 7 diagnosis and treatment responses compared across education groups.

Case 8	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.0068
Generalized Stage 1 Grade A Periodontitis	17 (29.82%)	18 (40.00%)	2 (11.76%)	9(75.00%)	
Generalized Stage 3 Grade B Periodontitis	17 (29.82%)	13 (28.89%)	12 (70.59%)	2 (16.67%)	
Generalized Stage 1 Grade C Periodontitis	5 (8.77%)	7 (15.56%)	0	1 (8.33%)	
Generalized Stage 2 Grade C Periodontitis	16 (28.07%)	5 (11.11%)	3 (17.65%)	0	
Generalized Stage 3 Grade A Periodontitis	2 (3.51%)	2 (4.44%)	0	0	
Treatment plan					
Prophylaxis	35 (61.40%)	10 (22.22%)	3 (17.65%)	1 (8.33%)	<.0001
Scaling and root planing therapy	47 (82.46%)	37 (82.22%)	16 (94.12%)	11 (91.67%)	0.5619
Periodontal resective surgery	5 (8.77%)	3 (6.67%)	4 (23.53%)	0	0.1231
Periodontal regenerative surgery	7 (12.28%)	4 (8.89%)	3 (17.65%)	0	0.457
Extraction	3 (5.26%)	2 (4.44%)	0	0	0.6768
Periodontal maintenance therapy	50 (87.72%)	35 (77.78%)	14 (82.35%)	11 (91.67%)	0.4866
Complex multidisciplinary treatment	7 (12.28%)	3 (6.67%)	3 (17.65%)	6 (50.00%)	0.002

Table 7. 8. Case 8 diagnosis and treatment responses compared across education groups.

Case 9	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					<.0001
Molar/incisor pattern Stage 3 Grade C Periodontitis	14 (24.56%)	16 (35.56%)	11(64.71%)	11 (91.67%)	
Molar/incisor pattern Stage 2 Grade C Periodontitis	4 (7.02%)	0	0	0	
Molar/incisor pattern Stage 4 Grade C Periodontitis	19 (33.33%)	25 (55.56%)	5(29.41%)	1 (8.33%)	
Generalized Stage 3 Grade B Periodontitis	5 (8.77%)	1 (2.22%)	0	0	
Molar/incisor pattern Stage 3 Grade A Periodontitis	15 (26.32%)	3 (6.67%)	1 (5.88%)	0	
Treatment plan					
Prophylaxis	31 (54.39%)	7 (15.56%)	4 (23.53%)	0	<.0001
Scaling and root planing therapy	57 (100.00%)	43 (95.56%)	16 (94.12%)	12 (100.00%)	0.3168
Periodontal resective surgery	34 (59.65%)	18 (40.00%)	2 (11.76%)	7 (58.33%)	0.0034
Periodontal regenerative surgery	22 (38.60%)	29 (64.44%)	17 (100.00%)	12 (100.00%)	<.0001
Extraction	12 (21.05%)	17 (37.78%)	0	2 (16.67%)	0.013
Periodontal maintenance therapy	55 (96.49%)	39 (86.67%)	15 (88.24%)	12 (100.00%)	0.183
Complex multidisciplinary treatment	10 (17.54%)	14 (31.11%)	2 (11.76%)	2 (16.67%)	0.2479

Table 7. 9. Case 9 diagnosis and treatment responses compared across education groups.

Case 10	D2 (N=57)	D4 (N=45)	Ortho (N=17)	Perio (N= 12)	P-value
Diagnosis					0.5977
Generalized Stage 1 Grade A Periodontitis	2 (3.51%)	2 (4.44%)	0	0	
Plaque-induced gingivitis on a reduced periodontium	2 (3.51%)	1 (2.22%)	0	0	
Plaque-induced gingivitis on an intact periodontium	7 (12.28%)	4 (8.89%)	1 (5.88%)	0	
Clinical health on an intact periodontium	46 (80.70%)	35 (77.78%)	14 (82.35%)	12 (100.00%)	
Clinical health on a reduced periodontium	0	3 (6.67%)	2 (11.76%)	0	
Treatment plan					
Prophylaxis	55 (96.49%)	43 (95.56%)	16 (94.12%)	12 (100.00%)	0.8645
Scaling and root planing therapy	2 (3.51%)	1 (2.22%)	1 (5.88%)	0	0.8055
Periodontal resective surgery	0	1 (2.22%)	0	0	0.5879
Periodontal regenerative surgery	0	0	0	0	0
Extraction	0	0	0	0	0
Periodontal maintenance therapy	4 (7.02%)	2 (4.44%)	2 (11.76%)	2 (16.67%)	0.4789
Complex multidisciplinary treatment	0	0	0	0	0

Table 7. 10. Case 10 diagnosis and treatment responses compared across education groups.

CHAPTER 4

DISCUSSION

This study's aim was to investigate the levels of calibration between dental students and postgraduate dental students of various educational levels to diagnosing periodontal conditions and choosing the most appropriate treatment for each situation, using the 2018 Classification of Periodontal Disease and Conditions. Levels of agreement as well as frequencies of responses were calculated in order to evaluate whether standardization of didactic teaching would lead to standardization of clinical evaluation and therapeutic choices.

The target audience was D2 students, exposed to didactic teaching only; D4 students, exposed to didactic teaching and clinical teaching; orthodontic postgraduate students, and the periodontology postgraduate students at the University of Alabama at Birmingham. It is important to note that the D4 participants learned the 1999 classification of Periodontal diseases and used it during their third year of dental school which corresponds to their first clinical year. All postgraduate students were taught and used the 1999 Periodontal disease classification during their dental school education years. Their learning of the 2018 classification was therefore necessary to keep unified standards and to be able to communicate with younger graduates at the School of Dentistry and with future colleagues after graduation.[45]

The nature of the kappa statistics dictates using specific categories of answers to be able to be analyzed. The reverse is also true: the kappa statistics does not capture nuances that could be recognized by using open-ended questions. There is a high level of subjective interpretation when it comes to reading radiographs.[46] Disagreements between clinicians result from a difference in attention to details as well as previous experiences.[47] Therefore, achieving a fair level of agreement is more expected than a substantial level of agreement. Ultimately, the practical application of this work will result in refining the teaching message, increasing clinical applications, and making sure that all students know to diagnose periodontal disease properly in order to build the foundation for future dental work.

In this study, the new classification was presented to all participants by the same educator (RVA), using the same presentation format prior to survey administration. All 10 cases representing health, gingivitis and periodontitis were selected and their corresponding diagnoses and most appropriate treatment plans decided by two experienced periodontists (RVA and MK), and used as the gold standard. The gold standard is advocated by many authors as it sets clear criteria in order to meet high quality and high reliability.[5] It has been reported that increased faculty calibration results in better student learning and clinical performance. [10] Faculty members have been shown to lack calibration as their thought process if often anchored in opinions they formed over their years of practice.[47] In this situation, this variable was eliminated by using one educator to present the new classification and administer the survey.

Clinical skills are refined with clinical exposure, and the pathway of clinical integration of didactic knowledge is not mature enough preclinical dental students.[48]

The results of this study indicate that the D2 students' agreement on overall diagnoses and treatment plan was generally lower than that of the D4 students, the orthodontic postgraduate students and the periodontology postgraduate students. This observation regarding less experienced dental students has been reported in previous calibration studies.[14, 15] In addition, the least experienced group (D2 students) frequently conflated prophylaxis with scaling/root planing or with maintenance therapy in several of the periodontitis cases. This is expected as clinical practice reinforces concepts and clarifies thinking pathways.[49] On the other hand, it appears that the D4 students tend to under or over-diagnose disease severity, as seen in case 1, which is also an indication of a need to refine diagnostic skills. Finally, looking at cases 2 and 3, it appears that D2 and D4 students tend to formulate their diagnoses based on stage and extent, and that grade is a lee influencing factor in their decision-making process. These examples illustrate the importance of using teaching techniques that reinforce feedback loops to insure a better calibration of students.

Prior to assigning a stage and a grade to a clinical situation, it is important to recognize health, gingivitis and periodontitis as broad categories. Clinical health on either an intact periodontium (case 10) or on a reduced periodontium in a stable periodontitis patient (case 7) are newly introduced diagnoses in the 2018 classification.[50] A large number of adult patients may present to the dentist or orthodontist with stable periodontal health following active therapy and maintenance by a periodontist. It was encouraging in both cases, and particularly in Case 7, that the overwhelming majority of students and postgraduate students were able to properly diagnose and treatment plan these healthy clinical conditions. Case 5, on the other hand, presented plaque-induced gingivitis an

intact periodontium, and most second year students, fourth year students and periodontal postgraduate students were able to identify the diagnosis correctly. More than half of the postgraduate orthodontic students over-diagnosed gingivitis as Grade A periodontitis. Recognizing reversible situations such as gingivitis (case 5) and identifying health situations ensures that future dental treatment will not induce additional bone loss, particularly in the case of orthodontic treatment.[30]

When all cases and participants were considered, there was a fair level of agreement on the diagnosis (kappa=0.24). Interestingly, when treatment options were considered, there was a moderate to substantial level of agreement for some therapies, i.e. scaling and root planing (kappa=0.63) and periodontal maintenance (kappa=0.44). This finding suggests that while the overall agreement on the diagnosis was suboptimal, students and postgraduate students seemed to agree on treatment planning non-surgical periodontal therapies irrespective of their level of training. A higher agreement on treatment rather than on diagnosis has also been reported by Lane et al.[15]

An advanced training seemed to positively influence the level of agreement on diagnosis and treatment options. When combined, orthodontic and periodontology postgraduate students showed a greater level of agreement comparatively to all dental students (D2 and D4). Previous calibration studies compared predoctoral students to a group of clinical instructors that combined faculty and postgraduate students [12, 14, 15]

Case 8 is of particular interest because it presents a Generalized stage 1 grade A periodontitis diagnosis. This is one of the most challenging situations to recognize, as it marks the onset of periodontal disease. An inability to identify this diagnosis leads to an inability to apply the proper treatment. Some authors have proposed that accuracy of

diagnosis might not always be necessary if the chosen treatment does not vary.[51] This thought process was applicable in Case 8, as scaling and root planing followed by maintenance would be required rather than prophylaxis. In contrast, the same could not be demonstrated in another patient with localized stage 2 periodontitis (case 4) where a majority of students and postgraduate students underdiagnosed the case as stage 1 periodontitis or even as gingivitis. Hence, their proposed therapy was not in full agreement with the gold standard. Furthermore, failure to diagnose incipient periodontitis could have significant consequences with disease progression to more advanced stages.

The postgraduate students learned to diagnose periodontal condition using the 1999 classification that divided periodontitis into mild, moderate, severe, and chronic or aggressive. The shift to the staging and grading nomenclature brings its own challenges, as seen in the agreement results, particularly for the orthodontic postgraduate students who are trained to use the previous nomenclature for diagnostic purposes. The fact that the periodontology postgraduate students consistently have higher levels of agreement for diagnosis and treatment planning compared to the other study groups is an indication of the refinement of learning that happens when the studied material is embedded in daily practice. Treatment planning is also more accurate as the clinical application of didactic teaching is much more frequent in the periodontology clinic than in the general dentistry and orthodontic clinics.

It can be argued that orthodontic postgraduate students are not required to know the exact diagnosis for a particular case. In fact, when looking at case 1, the periodontology residents agree with the gold standard whereas the orthodontic postgraduate students are split on diagnosis. A closer look ultimately reveals that the

orthodontic residents are in fact not split on the diagnosis per se, but on the extent (localized versus generalized) of the condition rather than its presence and severity. This is in agreement with John et al. who found that when categories are polled together, there is a higher level of agreement between participants.[14] From the clinical standpoint, this type of split has mild impact on treatment modalities and/or referral. Cases 5 illustrates this concept, showing how a particular focus of education (example, orthodontics) leads dentists to focus on issues that directly impact their daily practice: in this case, regenerative therapy was chosen in part because proclination of lower incisors during orthodontic treatment can lead to gingival recession, and grafting this area prior to treatment would prevent this adverse effect from happening.

The study results demonstrated an elevated proportion of students and residents of all groups who correctly identified the presence of vertical bone defects (Cases 2 and 9) and accurately proposed the appropriate treatment plan including periodontal regeneration of those defects. This is an interesting finding as those 2 cases included an adolescent patient as well as a young adult presenting with severe periodontitis on select teeth (previously known as aggressive periodontitis). The recognition of such conditions is crucial especially in patients seeking orthodontic treatment as failure to diagnose this level of disease could be catastrophic for a number of teeth in these patients.

Finally, the distinction between periodontitis stages 3 and 4 was not consistent for any of the student groups. This result may bear little importance as these two disease stages represent severe and very severe levels respectively. Even though treatment of stage 4 periodontitis is typically more complex than that of stage 3 periodontitis by involving a complex multidisciplinary approach, the recognition of an advanced severity

of the disease by clinicians would be sufficient to warrant the necessary collaboration on proper patient management.

CHAPTER 5

CONCLUSIONS

- Treatment planning agreement was higher than diagnostic agreement.
- Clinical exposure and continuous reinforcement refine learning pathways.
- Distinguishing between health, gingivitis and periodontitis is a crucial step for all levels of education.
- For D2 and D4, an increase of case-based learning and more integration of diagnosis and treatment planning in the clinic could be beneficial.
- Continuous reinforcements of concepts for all students through calibration exercises is recommended for improved communication and planning of interdisciplinary treatments.

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APPENDIX A

IRB APPROVAL FORM

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
Office of the Institutional Review Board for Human Use

470 Administration Building
701 20th Street South
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205.934.3789 | Fax 205.934.1301 |
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APPROVAL LETTER

TO: Souccar, Nada M

FROM: University of Alabama at Birmingham Institutional Review Board
Federalwide Assurance # FWA00005960
IORG Registration # IRB00000196 (IRB 01)
IORG Registration # IRB00000726 (IRB 02)

DATE: 31-May-2019

RE: IRB-300000090
Calibration of Periodontal Diagnosis Among Participants of Various Dental Education Levels

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The IRB reviewed and approved the Revision/Amendment submitted on 06-May-2019 for the above referenced project. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services.

Type of Review: Exempt
Exempt Categories: 2
Determination: Exempt
Approval Date: 31-May-2019

Please note: Approval for removing personnel (Colson Smith); adding personnel (Shadi Alkhoury [thesis], Thomas Swain, & Patrick Young)

Documents Included in Review:

- praf.190502.doc