Students' Approaches to The Formulation of a Periodontal Diagnosis and Treatment Plan for Pediatric Patients: A Mixed - Method Study

by

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Abstract

Background and Objectives: Gingivitis affects almost all children and adolescents. The prevalence of periodontal disease in children while extremely low can lead to severe dental consequences if left untreated. Dental students should be competent in diagnosing, treating, and referring to such cases. At the School of Dentistry, University of Alberta, there is an acknowledged gap between the didactic and clinical experience of the students for diagnosing and treating pediatric periodontal problems. Thus, the objective of this study was to examine the effectiveness of third- and fourth-year dental students' training on periodontal diagnosis and treatment planning in pediatric patients.

Methods: An explanatory sequential mixed-method study was conducted in two phases. The clinical reasoning skills were compared using the Script concordance test (SCT) followed by investigations at individual levels using semi-structured interviews and think-aloud protocols. The participants were the periodontists and the pediatric dentists in Edmonton, Alberta, and the third- and fourth-year dental students at the School of Dentistry, University of Alberta. The quantitative data was collected using an online survey to explore the dental students' knowledge, confidence and compare their clinical reasoning about periodontal diagnosis in pediatric patients. The verbal analysis of the interview data was performed.

Results: While there was no difference in the knowledge and the confidence level between the students, they differed from the experts for some questions on confidence. As measured using the SCT, no significant difference was found between the students or the students and the experts in their clinical reasoning. The verbal analysis of the interview data showed that the students used three different patterns for searching through the problem space. Most of the students used the

forward pattern of search and reported low confidence in diagnosing and treating pediatric periodontal diseases.

Conclusion: The third-year undergraduate dental students at the University of Alberta were as competent as fourth year in terms of knowledge, confidence, and clinical reasoning for periodontal diagnosis in pediatric patients. The students' reasoning process was close to the experts. However, the students reported low confidence in diagnosing periodontal disease in pediatric patients. This study highlights the need for efforts to improve the confidence of undergraduate dental students in diagnosing and treating periodontal disease.

Preface

This thesis is an original work by Disha Nagpal. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, project name "*Students' approaches to the formulation of a periodontal diagnosis and treatment plan of pediatric patients: examining the effectiveness of didactic and clinical experiences from a mixed methods perspective*", No: Pro00083394, July 27'2018.

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"**Gratitude is born in hearts that take time to count up past mercies" and so comes the time to look back and thank the souls behind this endeavor with a sense of gratitude.**

First and foremost, I bow my head and fold my hands in faith, to the supreme sculptor of our destiny and every existence **"GOD ALMIGHTY"**. I sincerely thank God for giving me the strength and to keep going in all my difficult times.

It is my proud privilege and honor to express my sincere, heartfelt, and deep sense of gratitude to my esteemed and revered teachers, my mentors and my supervisors, **Dr. Ida Kornerup and Dr. Monica Prasad Gibson.** Their constant motivation and tireless pursuit for academic excellence has made me pave my way to completion of my thesis without which, such an endeavor would never have materialized. I express my heartfelt thanks to **Dr. Hollis Lai** for guiding with study design as well as the statistical analysis of my study and **Dr. Arnaldo Garcia** for providing me his expertise in qualitative research and guiding me throughout the study.

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Abbreviations

- SCT - Script Concordance Test
- AAP - American Academy of Periodontology
- WWP -World Workshop of Periodontology
- EFP - European Federation of Periodontology
- BPE - Basic periodontal examination
- PGE2 - Prostaglandin E2
- SPSS - Statistical Product for the Social Sciences
- RedCAP - Research Electronic Data Capture
- ICC – Inter-Class Correlation Coefficient
- Hx - History
- Dx - Diagnosis
- Tx - Treatment
- S vs RP - Scaling versus Root Planing
- PBL - Problem Based Learning

Chapter One: Introduction

Gingivitis is defined as the inflammation of the gingiva, and periodontitis is defined as the inflammation of the supporting structures of the teeth (Papapanou et al., 2018). The global burden of disease report shows that periodontitis is the 6th most prevalent disease worldwide, with an overall prevalence of 11.2%. From 1990 to 2010, there has been an increase of 57.3% in the global burden of periodontal disease, including gingivitis and periodontitis (Tonetti et al., 2017). Untreated or inadequately treated periodontal disease leads to increased chances of tooth loss (Tonetti et al., 2017). In turn, complete and partial edentulism negatively impacts an affected individual's nutrition status, quality of life, and self-confidence. This poses a considerable burden financially on both the individual and the global level (Petersen & Ogawa, 2012). The annual loss of productivity due to severe periodontitis has been reported to be 54 billion USD worldwide. However, the gross economic effect of periodontal diseases (including gingivitis and periodontitis) accounts for a significant portion of the 442 billion USD direct and indirect cost of oral diseases in 2010 (Tonetti et al., 2017). All age groups are affected by periodontal disease (gingivitis and periodontitis); however, the destructive forms of periodontal disease are less common in children and adolescents. Despite its low prevalence, it is more destructive in children (Califano, 2003). Therefore, it should be detected at an early age, and appropriate treatment should be rendered. These facts show how the important it is to formulate an appropriate diagnosis and treatment plan.

A general practitioner should be well trained and confident enough to diagnose and treat primary gingival and periodontal diseases in adults and children. Whenever needed, they should be able to make a referral to the specialist. To achieve this goal, education at the undergraduate level should make the students competent. Hence, the student should know the anatomy of the periodontal structures, etiology and pathogenesis of the disease and the treatment options available for a patient with periodontal disease, including the referral to the specialist. Moreover, they can apply this knowledge to diagnose and treat the disease using their interpretation and clinical reasoning skills. It is also important that they have confidence in their clinical judgement. The theoretical framework by Newell and Simon (1972) put forth the idea that the novices can be distinguished from the experts in the way of their 'problem representation.' This includes an understanding phase based on their knowledge and the search phase, which includes the step-by-step approach to arrive at a diagnosis and treatment plan.

It has been found that the students and the recent graduates are generally not confident enough in treating periodontal disease, and the reason attributed is the lack of periodontal education (Chandrasekaran et al., 2017; Lee et al., 2009). Because of the low prevalence of the disease, periodontal education in pediatric patients is not much explored. No study has been done to explore the knowledge, confidence and clinical reasoning/decision making of the students for periodontal diagnosis in pediatric patients.

At the School of Dentistry, there is a perceived gap between what is occurring withi[i]n the classroom with little or no emphasis and lack of clinical experience in periodontal problems in pediatric patients. This adversely affects students' performance in clinical practice. Hence, this mixed-method study was undertaken with the research objective to examine the effectiveness of third- and fourth-year dental students' training on the periodontal diagnosis and treatment planning in pediatric patients.

We aim to address the following research questions in this study:

1. Is there a difference in knowledge and confidence of third- and fourth-year undergraduate dental students in formulating a periodontal diagnosis, treatment planning, and maintenance phases?

2. What is the clinical reasoning of dental students when developing periodontal diagnosis and treatment plan for pediatric patients among dental students at the School of Dentistry, University of Alberta?

Chapter Two: Literature Review

Periodontal Disease (Gingivitis and Periodontitis)

The Glossary of the Periodontal Terms defines periodontal diseases as the pathologic processes affecting the periodontium, most often the gingiva and periodontium. Gingivitis is defined as the inflammation of the gingiva and periodontitis is defined as the inflammation of the periodontal tissues resulting in clinical attachment loss, alveolar bone loss, and periodontal pocketing (American Academy of Periodontology, 2001).

Periodontal disease is a multifactorial, inflammatory disease, primarily microbial in origin, involving dental plaque and inflammation (Genco & Borgnakke, 2013). Apart from the microbial plaque, there are several different other factors including genetic susceptibility, host immune responses resulting in the breakdown of the periodontal structures (Tatakis & Kumar, 2005).

Prevalence and Burden of Gingivitis and Periodontitis

The worldwide prevalence of gingivitis in children and adolescents is high. Gingival inflammation (mild and moderate) is an almost universal finding in all children. (Albandar et al., 2002; Gjermo et al., 2002). However, the occurrence of periodontal destruction is low in children aged 5-11 years. but increases in adolescents aged 12-17 years (Califano, 2003). Studies show that in the US, while the prevalence of periodontitis in children is around 0.2-0.5% (Löe & Brown, 1991), it is more severe as compared to the adult population (Alrayyes & Hart, 2011). The prevalence rates of early-onset aggressive periodontitis in the children of the age 13-15 years were found to be 0.4-0.8% and the prevalence of chronic periodontitis was 2.75%. The prevalence of gingivitis among adolescents in the United States, reported by Albandar et al. (1996) was 82.1% (Albandar et al., 1996). Albandar et al. (2002) in another study, assessed the prevalence of early-onset forms of periodontitis among the group of US adolescents and reported that 0.6% of the subjects were having juvenile periodontitis at the age of 13–15, and 2.75% of the subjects were having chronic periodontitis at the age of 16-17 (Albandar et al., 2002). In adolescents, necrotizing ulcerative gingivitis and periodontal attachment loss were associated with poor Quality of Life (López & Baelum, 2007). The annual loss of productivity due to severe periodontitis has been reported to be 54 billion USD worldwide. Although the gross economic effect of periodontal

diseases (including gingivitis and periodontitis) accounts for a significant portion of the 442 billion USD direct and indirect cost of oral diseases in 2010 (Tonetti et al., 2017).

The available literature on the frequency of periodontal disease in children is limited. To complicate the situation further, the criteria used in these studies are not uniform, hence the prevalence data for periodontal diseases in children vary significantly (Albandar & Tinoco, 2002).

Comprehensive Periodontal Evaluation and Periodontal Disease Diagnosis

Gingival and Periodontal Examination

A complete periodontal exam is needed to form a periodontal diagnosis and treatment plan. The complete periodontal exam starts with assessing the gingiva for the presence/ absence of gingival inflammation. Noticing the gingival features like redness, swelling, bleeding on probing, and /or suppuration confirms that the gingival inflammation is present. The damage to the periodontium is assessed by recording the periodontal probing depth, recession, mobility, furcation, mucogingival deformities, and plaque. Radiographic assessment is done to assess the horizontal and vertical bone levels around teeth and implants (Armitage, 2004a).

Based on the exam findings and following the diagnostic system, an appropriate periodontal diagnosis is established. Periodontal diagnosis relies on the classification of periodontal disease (gingivitis and periodontitis). A periodontal diagnosis is a crucial label assigned to a patient's periodontal disease by the clinicians (Armitage, 2004b). The treatment plan is further presented to the patient based on the diagnosis. It is important to discuss with the patient various treatment options available and the success of each.

Diagnostic Classification of Periodontal Disease

The continuous evolution in the understanding of periodontal disease has led to different classification systems to be used over time for the diagnosis of periodontal disease. The most recent is the 2018 American Academy of Periodontology (AAP) classification of Periodontal and Peri-Implant diseases (Caton et al., 2018) and the one before that as the 1999 International Workshop for the Classification of the Periodontal Diseases organized by the AAP.

Though the emphasis is on using the new classification system for periodontal diseases, however, since this is recent, the 1999 Classification system is also used by many clinicians.

As per the latter, the following seven categories of periodontal disease were identified (Armitage, 1999).

1. Gingival Diseases
   I. Plaque-induced gingival diseases
   II. Non-plaque-induced gingival lesions

2. Chronic Periodontitis

   I. Localized
   II. Generalized

3. Aggressive Periodontitis

   I. Localized
   II. Generalized

4. Periodontitis as a Manifestation of Systemic Diseases

5. Necrotizing Periodontal Diseases

   I. Necrotizing ulcerative gingivitis (NUG)
   II. Necrotizing ulcerative periodontitis (NUP)

6. Abscesses of the Periodontium

   I. Gingival abscess
   II. Periodontal abscess
   III. Pericoronal abscess

7. Periodontitis associated with Endodontic Lesions

   I. Endodontic-periodontal lesion
   II. Periodontal-endodontic lesion
   III. Combined lesion

8. Developmental or Acquired Deformities and Conditions

I. Localized tooth-related factors that predispose to plaque-induced gingival disease or periodontitis
II. Mucogingival deformities and conditions around teeth
III. Mucogingival deformities and conditions on edentulous ridges
IV. Occlusal trauma

The prevalence of gingival and periodontal disease in children varies. The predominant form of the plaque-induced disease in children and adolescents is gingivitis (Modéer & Wondimu, 2000). Gingival inflammation, both mild and moderate, is almost common in young people. Various forms of periodontal diseases affect children, adolescents, and young adults. Clinical symptoms of inflammation confined to the gingiva with no associated periodontal tissue damage characterize the gingival diseases. Aggressive periodontitis is the destructive form of periodontal disease affecting children and adolescents (Albandar & Tinoco, 2002). They are described here in detail:

Gingivitis.

Gingivitis is defined as the inflammation of the gingiva (Glossary of Periodontal Terms, 2011)**.** The universal features of gingivitis (Mariotti, 1999):

- Signs and symptoms that are confined to the gingiva
- The presence of dental plaque to initiate and/or exacerbate the severity of the lesion
- Clinical signs of inflammation (enlarged gingival contours due to edema or fibrosis, color transition to a red and/or bluish-red hue, elevated sulcular temperature, bleeding upon stimulation, increased gingival exudate)
- Clinical signs and symptoms associated with stable attachment levels on a periodontium with no loss of attachment or on a stable but reduced periodontium
- Reversibility of the disease by removing the etiology(ies)
- Possible role as a precursor to attachment loss around teeth

Aggressive Periodontitis. (Armitage, 1999)

Affects children and adolescents. The common characteristics of an otherwise clinically healthy patient are:

- Rapid attachment loss and bone destruction.
- Amount of microbial deposits inconsistent with disease severity.
- Familial aggregation of diseased individuals.
- In addition, the diseased sites infected with *Actinobacillus actinomycetemcomitans,* abnormalities in phagocyte function, and hyper-responsive macrophages producing increased prostaglandin E2 (PGE2) and interleukin-1B.

Aggressive periodontitis may be further classified into localized and generalized forms with the following features:

Localized form.

- The circumpubertal onset of disease.
- Localized first molar or incisor disease with proximal attachment loss on at least two permanent teeth, one of which is the first molar.
- Robust serum antibody response to infecting agents.

Generalized form.

- Usually affecting persons under 30 years. of age (however, may be older).
- Generalized proximal attachment loss affecting at least three teeth other than first molars and incisors.
- Pronounced episodic nature of periodontal destruction.
- Poor serum antibody response to infecting agent.

Since this classification was introduced, there has been a lot of new research and thus, new information that emerged from the understanding of the risk factors (environmental and systemic) addressing the difference between the presence of gingival inflammation at some sites and a gingivitis case, the need for distinction between periodontal health and inflammation in a reduced

periodontium, gradual blurring of the distinctive features of the aggressive and the chronic periodontitis (Caton et al., 2018). After careful consideration, major changes were introduced in the existing system by the task force of the World Workshop of Periodontology, and a new classification was adopted and published in 2018. The previous types of "chronic" or "aggressive" were then grouped under a single category "periodontitis". Periodontitis was classified predicated on a multidimensional staging and grading system. Staging mainly described the disease severity at presentation and the complexity of its management. Grading, on the other hand, provides information about biological features of the disease including a history-based analysis of the rate of periodontitis progression, analyzing the risk for disease progression, assessing possible poor outcomes of treatment; and assessment of the risk that the disease or its treatment may negatively affect the general health of the patient (Papapanou et al., 2018).

The staging and grading criteria of periodontitis used in the new classification system are shown in Table1 and 2 (Tonetti et al., 2018).

Table 1.

Periodontitis Staging

Periodontal Stage		Stage I	Stage II	Stage III	Stage IV
Severity	*Interdental CAL at site of greater loss*	1 to 2 mm	3 to 4 mm	≥ 5 mm	≥ 5 mm
	Radiographic Bone Loss	Coronal third (<15%)	Coronal third (15% to 33%)	Extending to mid-third of root and beyond	Extending to mid-third of root and beyond
	Tooth Loss	No tooth loss due to periodontitis		Tooth loss due to periodontitis ≤ 4 teeth	Tooth loss due to periodontitis ≥ 5 teeth
Complexity	*Local*	Maximum probing depth ≤ 4 mm Mostly horizontal bone loss	Maximum probing depth ≤ 5 mm Mostly horizontal bone loss	In addition to Stage II complexity: Probing ≥ 6mm Vertical bone loss ≥ 3mm Furcation involvement Class II or III Moderate ridge defect	In addition to Stage III: Need for complex rehabilitation due to: Masticatory dysfunction Secondary occlusal trauma (Tooth mobility degree ≥ 2 mm) Severe ridge defect Bite collapse, drifting, flaring Less than 20 remaining teeth (10 opposing pair)
Extent and Distribution	*Add to the stage as a descriptor*	For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern			

Note. The table shows the criteria for staging periodontitis. This table Adapted from: "Staging and grading of periodontitis: Framework and proposal of a new classification and case definition", by M.S. Tonetti, H. Greenwell, K.S. Kornman, 2018 J Periodontol,89(Suppl 1): S159–S172.

Table 2.

Periodontitis Grading

Periodontitis Grade			Grade A: Slow rate of progression	Grade B: Moderate rate of progression	Grade C: Rapid rate of progression
Primary criteria	Direct evidence of progression	*Longitudinal data (radiographic bone loss or CAL)*	Evidence of no loss over 5 years	< 2 mm over 5 years	≥ 2mm over 5 years
		% Bone loss/age	< 0.25	0.25 to 1	> 1
	Indirect evidence of progression	*Case phenotype*	Heavy biofilm deposits with low level of destruction	Destruction commensurate with biofilm deposit	Destruction exceeds expectation given biofilm deposits; specific clinical patterns suggestive of periods of rapid progression and/or early onset disease (e.g., molar/ incisor pattern; lack of expected response to standard bacterial control therapies)
Grade Modifier	Risk Factors	*Smoking*	Non-smoker	Smoker < 10 cigarettes/day	Smoker > 10 cigarettes/day
		Diabetes	Normoglycemic/ No diagnosis of diabetes	HbA1c <7% in patient with diabetes	HbA1c >7% in patient with diabetes

Note. The table shows the criteria for grading periodontitis. Adapted from: "Staging and grading of periodontitis: Framework and proposal of a new classification and case definition", by M.S. Tonetti, H. Greenwell, K.S. Kornman, 2018 J Periodontol,89(Suppl 1): S159–S172.

Gingival and Periodontal Disease Diagnosis in Children

The diagnosis is based on the current classification system (Kinane & Hodge, 2001).To arrive at a diagnosis, the information from medical and dental history along with the patient's chief complaint should be considered. Like adults, the clinical examination is needed, however, while examining a child there are behavioral, anatomical, and risk factors to consider. For a patient of young age, cooperation is a limiting factor, so the examination should be quick. When the incisors and the first molars have erupted, simplified basic periodontal examination (BPE) can be conducted around the index teeth 16, 11, 26, 36, 31, and 46 using the WHO 621 probe. During mixed dentition, the teeth are at different stages of eruption in the child, hence increasing the chances of pseudo pockets. For this reason, it is recommended that codes of 0, 1, 2 should be followed during the mixed dentition stage, as shown in Table 3. As soon as a child is in the permanent dentition, a complete periodontal examination should be done (Clerehugh & Tugnait, 2001; Cole et al., 2014). The steps in the periodontal examination of a child patient are shown in Figure 1 (Clerehugh & Tugnait, 2001).

The use of radiographs is only done if they significantly affect the treatment plan and prognosis of the disease. Panoramic radiographs can be of advantage in pediatric patients to see if there are any missing teeth. It may also give an idea if there is bone loss. Bitewing and periapical radiographs can then be done (Clerehugh & Tugnait, 2001; Corbet, 1998).

Table 3.

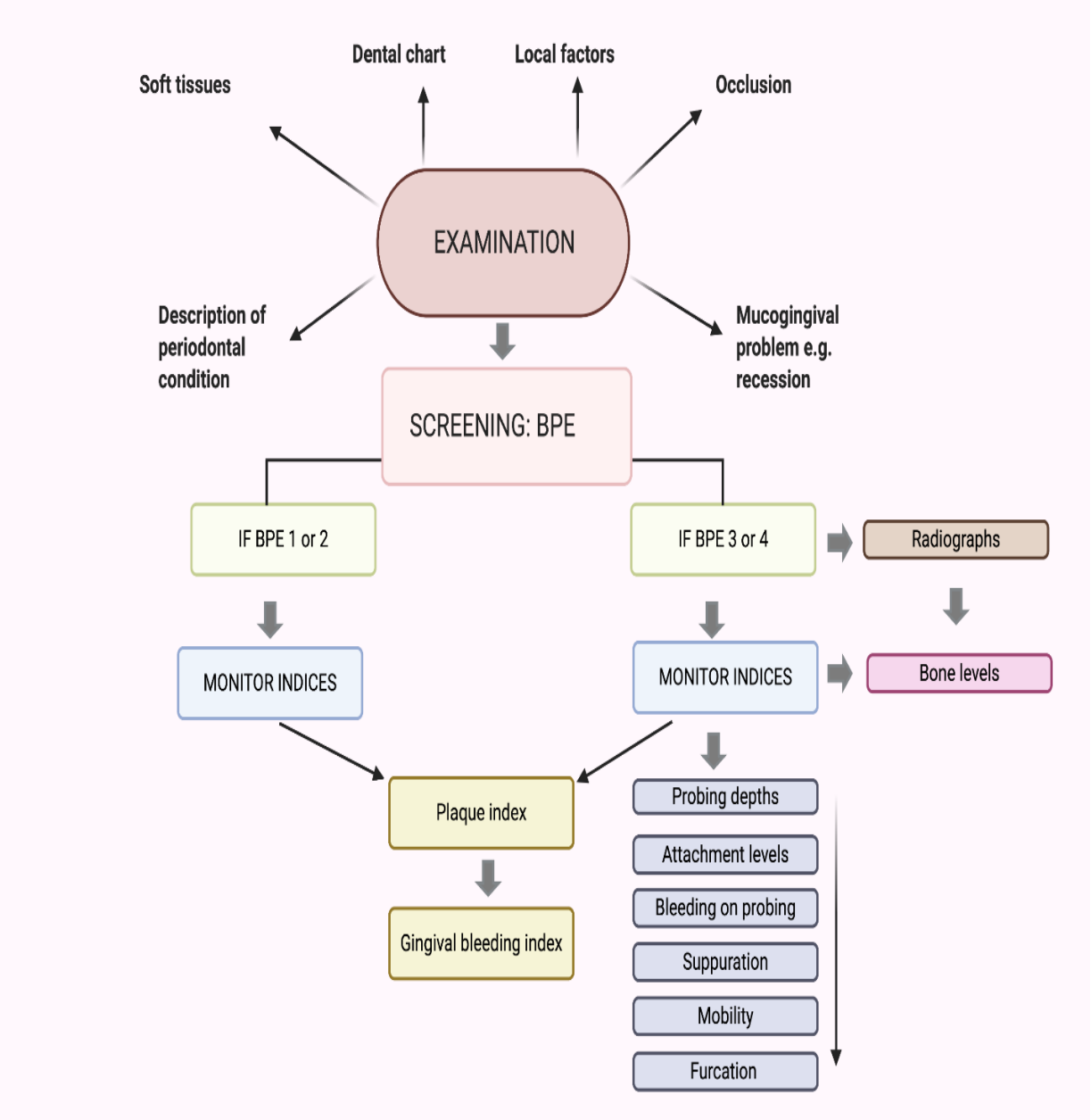
Scoring criteria for Basic Periodontal Examination for use in children

Codes	Status
Code 0	Healthy
Code 1	Bleeding on probing. NO plaque retention factors or pockets greater than 3.5mm
Code 2	Presence of calculus or plaque retention factor. No pockets greater than 3.5mm.
Code 3	Pockets of 3.5 to 5.5mm
Code 4	Pockets greater than 5.5mm
*	Furcation Involvement

Note. The table represents the scores for BPE. Adapted from: "Simplified basic periodontal examination (BPE) in children and adolescents: a guide for general dental practitioners", by Cole E, A.R. Chaudhuri, M. Vaidyanathan, J. Johnson, S. Sood, 2014 Dent Update.,41(4): 332–334.

Figure 1.

General steps for periodontal examination in children



Note. The figure represents the step-by-step approach for conducting a periodontal examination in children. Adapted from: "Diagnosis and management of periodontal diseases in children and adolescents.", by V. Clerehugh, A. Tugnait. 2001, Periodontol 2000,26(1): 146–168.

Adverse Outcomes of Periodontal Disease

Periodontal disease, if left untreated, can have adverse outcomes. These include receding gums, mobile teeth, discomfort, and oral infections that adversely impacts the overall health and quality of life of patients(Tonetti et al., 2018). Ultimately, it can lead to the loss of teeth and affect the systemic health of an individual.

This further emphasizes the importance of early diagnosis, prevention, and treatment of periodontal disease, especially if it occurs at a younger age.

Prevention and Treatment of Periodontal Disease

The primary goal of periodontal therapy is the elimination of gingival inflammation and correction of the conditions that cause and perpetuate the disease (Carranza et al., 2006).

Periodontal therapy begins with home care. It is of utmost importance to review the home care instructions with the patient like toothbrushing technique, use of interdental aids, use of mouthwashes, etc. Periodontal treatment cannot be successful until the patient is motivated. Along with this, the practitioner should also make sure that systemic diseases like diabetes are well controlled. These may adversely affect the outcome of periodontal therapy. Any emergency conditions like teeth with a hopeless prognosis should be extracted at the beginning of the therapy. Conditions like abscesses should also be addressed at the beginning (Carranza et al., 2006).

In a motivated patient with adequate home care, scaling, and root planning should be started. This is done using the hand as well as ultrasonic instruments. For root planning, adequate anesthesia of the area should be achieved. Occlusal adjustment may also be needed to relieve the fremitus, reduce excessive mobility on certain teeth. To make sure that all the subgingival calculus has been removed, 11/12 explorer, as well as post-operative radiographs, are used. Systemic antibiotics are indicated in certain situations like aggressive periodontitis (Stage III, Grade C periodontitis), acute periodontal diseases resulting from the systemically uncontrolled conditions, refractory periodontitis, and as an adjunct to non-surgical and surgical therapies. Apart from their systemic use, antibiotics (minocycline microspheres), can also be applied locally in a periodontal pocket (Carranza et al., 2006).

The non-surgical phase is followed by periodontal re-evaluation after 4-6 weeks. During this time, periodontal charting is done again, and the areas of improvement are discussed with the patient. This stage is an important point to check patient compliance. Depending on the improvement, a further treatment plan is decided. In a compliant patient with no more deep pockets (>5mm) and no vertical bone loss, maintenance therapy (scaling and root planing) is done. For a compliant patient with persistent deep pockets and/ or vertical and horizontal bone defects, surgical treatment like bone grafting and osseous resective surgeries are carried out respectively. However, for a noncompliant patient, with no significant improvement, initial therapy is repeated. The maintenance phase follows every surgical and/or non-surgical treatment (Carranza et al., 2006).

Once the periodontal disease is controlled, the restorative phase including the placement of implants to replace the missing teeth can be carried out depending on the specific indications and patient's preference (Carranza et al., 2006; Kwon et al., 2020).

Integrating Diagnosis and Treatment Plan

A carefully considered periodontal diagnosis is of the utmost importance in the subsequent management of a patient's periodontal disease. An accurate diagnosis is often a first step towards the development of a well-designed and appropriate treatment plan that when implemented leads to the resolution of the patient's periodontal infection. The diagnosis is based on the patient's signs and symptoms. An incorrect diagnosis often leads to an ill-conceived treatment approach that ultimately fails to address resolve the patient's periodontal problem. The use of available literature, that is, evidence-based dentistry, clinician's expertise, and patient factors like socioeconomic factors, culture, perception of health are important factors that influence the treatment plan for a patient. Of this, the clinician's experience impacts the decision-making most considerably (Kalsi & Hemmings, 2013). It is always considered good practice to establish a diagnosis and discuss its implication with the patient before starting any therapeutic procedures (Armitage, 2004b). An accurate diagnosis is also important for communication among clinicians, between clinicians and patients, and between clinicians and insurance companies (Lane et al., 2015).

Dental and Periodontal Education

Dentistry is a profession where an individual needs to have an understanding not only of oral health but also of overall health as well as the basic anatomy and physiology. To make a well-informed, skillful, caring and proficient general dentist, the education and training in dentistry must assure that dental students acquire the necessary competence - Knowledge, Skills, and Attitudes (Sanz & Meyle, 2010).

Levels of undergraduate training

Bloom's Taxonomy, often known as the Taxonomy of Educational Objectives, is one of the most well-known learning theories in education. Bloom's Taxonomy is frequently used by educators to create learning outcomes (Bloom et al., 1956).

It defines learning into three domains: cognitive, affective, and psychomotor, and assigns a hierarchy to each of these areas, corresponding to different levels of learning. It's worth noting that the various levels of thinking outlined within each area of the taxonomy are arranged in a hierarchical order (Anderson & Bloom, 2001). The levels are:

1. Remember

   Definition: retrieve, recall, or recognize relevant knowledge from long-term memory Appropriate learning outcome verbs for this level include: cite, define, describe, identify, label, list, match, name, outline, quote, recall, report, reproduce, retrieve, show, state, tabulate, and tell.

2. Understand

   Definition: demonstrate comprehension through one or more forms of explanation. Appropriate learning outcome verbs for this level include: abstract, arrange, articulate, associate, categorize, clarify, classify, compare, compute, conclude, contrast, defend, diagram, differentiate, discuss, distinguish, estimate, exemplify, explain, extend, extrapolate, generalize, give examples of, illustrate, infer, interpolate, interpret, match, outline, paraphrase, predict, rearrange, reorder, rephrase, represent, restate, summarize, transform, and translate.

3. Apply

   Definition: use information or skill in a new. Appropriate learning outcome verbs for this level include: apply, calculate, carry out, classify, complete, compute, demonstrate, dramatize, employ, examine, execute, experiment, generalize, illustrate, implement, infer, interpret, manipulate, modify, operate, organize, outline, predict, solve, transfer, translate, and use.

4. Analyze

   Definition: break material into its constituent parts and determine how the parts relate to one another and/or to an overall structure or purpose. Appropriate learning outcome verbs for this level include analyze, arrange, break down, categorize, classify, compare, connect, contrast, deconstruct, detect, diagram, differentiate, discriminate, distinguish, divide, explain, identify, integrate, inventory, order, organize, relate, separate, and structure.

5. Evaluate

   Definition: make judgments based on criteria and standards. Appropriate learning outcome verbs for this level include: appraise, argue, assess, compare, conclude, consider, contrast, convince, criticize, critique, decide, determine, discriminate, evaluate, grade, judge, justify, measure, rank, rate, recommend, review, score, select, standardize, support, test, and validate.

6. Create

   Definitions: put elements together to form a new coherent or functional whole; reorganizing elements into a new pattern or structure (design a new set for a theater production, write a thesis, develop an alternative hypothesis based on criteria, invent a product, compose a piece of music, write a play). Appropriate learning outcome verbs for this level include: arrange, assemble, build, collect, combine, compile, compose, constitute, construct, create, design, develop, devise, formulate, generate, hypothesize, integrate, invent, make, manage, modify, organize, perform, plan, prepare, produce, propose, rearrange, reconstruct, reorganize, revise, rewrite, specify, synthesize, and write (Anderson & Bloom, 2001).

   At the School of Dentistry, the University of Alberta, these levels have been used to design a rubric to assess the students' progress through their training. For both periodontal and pediatric

dentistry, it is expected that the students at the beginning of their third year should be able to understand and as they progress through their training, they should be able to apply, analyze and create.

Periodontal and Pediatric Training at the University of Alberta

At the University of Alberta, the different aspects of training in periodontics and pediatric dentistry are covered as the students progress through the years. In the first years, the students are expected to recognize and understand the structures and functions of the periodontium in health and disease. In their second year, they must conduct a periodontal assessment for a mild periodontal disease patient, diagnose a disease and formulate a treatment plan. In the third and the final year, the students are required to do the periodontal assessment, diagnosis, and treatment plan for moderate and severe periodontal cases, respectively. The students receive a lecture on periodontal disease in pediatric patients. If periodontal involvement in a pediatric patient is suspected, the patient is managed under the supervision of a pediatric dentist and periodontist. If deemed necessary, a referral to the periodontics department is made.

Competencies in Periodontal Education at Undergraduate Level

Competencies have been described as the combination of expertise, abilities, and attitudes, suitable to the individual requirements of the profession. It is usually denoted as the minimum applicable level of overall performance for a graduating dentist. Competency for that reason implies the behavior anticipated of unbiased practitioners beginning their profession (Sanz & Meyle, 2010).

Competency is defined as a global statement of the complex knowledge, skills, and attitudes required of a beginning general dentist (Charbonneau et al., 2019). To improve undergraduate education, it is important to understand the present curriculum. According to the Association of Canadian Faculties of Dentistry (ACFD) educational framework for the development of competency in Canadian dental programs, for a beginning general dentist to be competent, they should successfully integrate the understanding, skills, and values inherent in each of the following five competencies:

Competency 1 – Patient-centered care which includes the application of professional knowledge, skills, and values in the provision of patient-centered care. The application of the knowledge refers to the ability of the student to evaluate the scientific literature and support the recommendations, interpret the findings from the patient's chief complaint, form a treatment plan based on the evaluation of the available data, and recognize the relationship between the systemic and oral health of the patient. The other components of this competency are to be able to perform a complete and appropriate assessment of the patient, demonstrate appropriate diagnostic and treatment planning skills as well as the appropriate therapeutic and preventive skills. The management of the conditions and diseases of the periodontium is one such example. The graduating student should also be able to recognize their limits and seek appropriate consultation from other health professionals where needed.

Competency 2 – Professionalism includes the commitment to the oral health and well-being of individuals and society through ethical practice, reflective learning, self-regulation, and high personal standards of behavior.

Competency 3 – Communication and Collaboration encompasses the effective facilitation, both individually and as part of a healthcare team, of the dentist-patient relationship and the dynamic exchanges that occur before, during, and after a patient interaction. This also includes being able to make an appropriate referral to provide the best possible care for ~~the~~ patients regarding the conditions which are beyond the competency of an individual.

Competency 4 – Practice and Information Management incorporates the assessment of information and the management of a general dental practice to facilitate patient-centered care.

Competency 5 – Health Promotion covers the responsible use of professional expertise and influence to advance the health and well-being of individual patients, communities, and populations (Charbonneau et al., 2019).

The European workshop on periodontal education, 2010 also highlighted similar criteria. These include professionalism which encompasses a broader range of skills like planning, communication, team building, and leadership skills; knowledge and information handling with critical thinking, which means that the student should be able to apply the knowledge to differentiate between the normal and the diseased tissues; and diagnosis and treatment planning in

periodontics, which means that the student should be competent in clinical reasoning and decision-making to develop a diagnosis and implementation of available data to arrive at the treatment plan that meets the needs and demands of patients. A dentist should recognize those treatments that are beyond their skills and need to be referred for a specialist's opinion and treatment. Therefore, the students should be competent in the establishment and maintenance of oral health as well as health promotion (Sanz & Meyle, 2010).

Considering all these competencies, it can be deduced that to be competent, a student should not only have the basic knowledge of the structures in periodontal health and disease, etiology and pathogenesis of periodontal and peri-implant diseases but also should be able to apply this knowledge to know the diseases as well as formulate a diagnosis and treatment plan for the patient using their clinical reasoning and judgment (Sanz & Meyle, 2010).

The theoretical framework put forth by Newell and Simon (1972) proposed a theoretical framework to distinguish the experts from the novices in the way they search through "problem spaces''. A problem space consists of elements and, operators including the way these operators work through these elements. Those are all possible or permissible strategies to help search through the problem spaces. As such, a problem representation is a model of the search performance of a solver on a specific problem (Newell, 1972). A "problem representation'' consists of two phases: An Understanding Phase and a Search Phase. The former is comprised of the knowledge about the starting state, the goal state, the permissible operators, and the constraints, while the latter consist of a step-by-step search path which could have different patterns like depth-first vs breadth-first and, backward search vs forward search (Ericsson, 2006). Bader and Shugars (1992) proposed that the clinical decision making process in dentistry can be divided into three separate phases: diagnosis or the "detection phase"; the decision about the appropriate intervention (treatment plan); and the selection of the treatment (Bader & Shugars, 1992). Differences can occur in any of these phases (Courts, 1997).

Clinical Reasoning and its Relevance in Undergraduate Education

Clinical reasoning is the ability to incorporate and apply various types of information, weigh facts, critically think about claims, and dwell on the diagnostic process (Linn et al., 2012). It leads to a meaningful interpretation of the patient's concerns and formulation of an appropriate treatment strategy to manage the clinical condition (Modi et al., 2015). Clinical reasoning is therefore a skill that needs to be learned as one progresses through their educational training to be a competent clinician (Linn et al., 2012). This impact is usually recommended to persist through the dentist's life affecting decision-making (Nafea & Dennick, 2018).

There are various ways to study clinical reasoning. These can be grouped into those that study the outcome (quantitative) and those that aim to explore the process of reasoning (qualitative) (Higgs et al., 2008). Quantitative methods are used to compare between the groups with different levels of expertise. Some examples of the quantitative methods are Script Concordance Test (SCT), Repertory Grid Technique, Neuro Imaging methods, and Eye-tracking(Higgs et al., 2008).

SCT is primarily based on the precept that it is possible to test a couple of decisions made in these clinical reasoning strategies and compare their concordance with the ones of a reference panel of professionals. Therefore, this can be used as a device for the evaluation of clinical thinking (Fournier et al., 2008). SCT stems from a cognitive concept of clinical knowledge improvement. The professional and qualified practitioners of clinical medicine range from less-skilled to skilled practitioners due to the fact they have got significant knowledge networks tailor-made to their daily tasks (Charlin et al., 2000). In keeping with script theory, structured knowledge networks, referred to as "scripts," are mobilized through physicians to manage the data and strengthen the direction of answers to clinical issues. Those scripts consist of links among conditions, clinical features, and management alternatives (Charlin et al., 2000).

Qualitative methods, on the other hand, are used to assess individual reasoning. The verbal protocol is one such method where the participants are asked to verbalize their thinking about a sample problem without theorizing their thinking. This verbalization is used as data. There is also the think-aloud protocol and analysis, which is used extensively to explain clinical reasoning, especially in situations where extensive cognitive theories underlie the decision-making processes

that are difficult to investigate (Higgs et al., 2008). Lastly, video data collection and analysis are useful for the study of behavior and cognition (Someren, 1994).

The qualitative data collection is done through think-aloud interviews (Someren, 1994). There are two types: concurrent and retrospective. The former is mostly used in studying cognitive processes between novices and experts. During a concurrent think-aloud interview, the participant verbalizes their thoughts while solving problems. This, in principle, does not lead to much disturbance of the thought process. The subject solves a problem while the talking is executed almost automatically. The data gathered are very direct and there is no delay. The subject does not give an interpretation of their thoughts, nor are they required to bring them into a predefined form as in structured techniques. The subject renders thoughts just as they come to mind. Another advantage of using the think-aloud method is that it is easy for subjects because they are allowed to use their language(Someren, 1994). However, a drawback of this technique may be that a subject may verbalize only part of his thoughts, but this can be overcome with practice. As such, while designing such interviews, it is important to include a practice task that is somewhat like the target task.

Rationale for the Study

Performance in Periodontics

Dental Students.

There have been reports in the literature that dental students may not be satisfied with their performance in periodontics. Chandrasekaran et al. (2017) analyzed dental students' descriptions of and reflections on the periodontal care they provided to their patients in dental school clinics. Almost two-thirds (63.1%) of these students felt that the periodontal care they provided for their patients was inadequate. The reasons for this were broadly divided into two broad categories: student/school-dependent (student oversight, limited operator session, and patients) and patient dependent (e.g., scheduling compliance) (Chandrasekaran et al., 2017).

Similarly, John et al. (2013); Lane et al. (2015) found that dental students performed poorly in diagnosing and managing periodontal diseases after comparing their performances with those of calibrated instructors (John et al., 2013; Lane et al., 2015). This poor performance was partially attributed to their limited clinical exposure and hence a more limited integration between their didactic knowledge and the clinical application was found (Lee et al., 2009).

General Dentists.

An inadequate periodontal education can negatively impact the performance of students, and practitioners, as their practice depends on what they learn in school. Therefore, if students are skilled in the diagnosis and treatment of periodontal disease at preliminary stages, they should also be able to treat it at the advanced stage. This will, in turn, be beneficial for the patients. However, the study by Darby et al (2005) investigating the confidence of general dentists in the treatment of periodontitis found that nearly one-third- of the general dentists surveyed did not have confidence in the treatment of advanced periodontitis and more than half were not comfortable in handling severe periodontal cases (Darby et al., 2005). Several dentists who participated in this study were interested in further periodontal education, which suggests that the previous education they had received in this area was insufficient (Darby et al., 2005). Cobb et al. (2003) found that the changes in the education system with less time devoted to the training in periodontics and less interaction with the periodontists as instructors were the reasons for the student's lack of confidence in managing periodontal cases as well as making appropriate referrals (Cobb et al., 2003). Similarly,

Linden et al. (1998) found that the diagnosis, treatment, and referral decisions continued to present significant challenges to the general dentists working in Northern Ireland, regardless of their experience level. There was a significant variation in the referral patterns to periodontists by the general dentists with 37% of the respondents stating that the lack of training to treat periodontal diseases is the reason for referral (Linden, 1998). Thus, these studies also emphasize the need for improving dental education in periodontics.

Need for the calibration between Instructors and Students

Studies by John et al. (2013) and Lane et al. (2015) also emphasized the importance of calibration between the instructors and the students for diagnosis and treatment planning of periodontal diseases. The former found that participants (Periodontics faculty members, third- and fourth-year dental students) have a high level of agreement on the treatment planning. However, for the diagnosis of aggressive periodontitis, the third-years differed from the fourth-year students. Lane et al. (2015) measured the variations in periodontal diagnosis and treatment planning among the instructors and third- and fourth-year dental students among three schools in the US. They found that there was a low level of agreement at both the school as well as the class level (John et al., 2013; Lane et al., 2015).

Impact of confidence on students' performance and clinical skills

Confidence in oneself symbolizes the belief that one can do things well or deal with situations successfully. Confidence plays an important role in the success of a health care provider. A greater patient outcome is expected when the providers possess higher levels of confidence (Hecimovich & Volet, 2009).

Being confident is one of the most important personal factors influencing clinical decision making because if a clinician believes that he or she has the skills to assess a patient's concerns and that the outcome of this assessment will lead to improved quality for the patient, it is more likely that the clinician will engage in a successful assessment (Hagbaghery et al., 2004; Mason & Ellershaw, 2004).

Fine et al, studied the influence of confidence on the clinical practice of two cohorts of GDPs, during and following an extended period of postgraduate training, thus, showing the importance of confidence to General Dental Practitioners (GDPs). The primary reason for GDPs to opt for post-graduate training was their lack of confidence. It was found that after the training, their confidence was improved for in communication skills, and their ability to undertake complex restorative procedures. This led to greater treatment acceptance by patients resulting in better "job satisfaction" (Fine et al., 2019).

Literature on Clinical Reasoning in Dentistry

Clinical reasoning is a crucial skill in health care. (Gummesson et al., 2018). Williams et al. (2014) surveyed dental and dental hygiene students, assessing their attitudes towards periodontal disease management, self-assessment of periodontal disease and referral, and comparison and awareness of clinical results that trigger a referral. They found that only 40% of the dental and 36% of the dental hygiene students reported confidence in diagnosing, treating, and appropriately referring patients with periodontal diseases. Those students were able to recognize the critical disease and risk factors influencing referral with relatively good precision; however, the poor implementation of that knowledge indicated a gap between knowledge and applied clinical reasoning (Williams et al., 2014). Despite its importance, it is still considered a poorly understood and mostly unfamiliar term amongst dental students. In a study conducted by Nafea and Dennick (2018), it was found that there was a lack of proper understanding and appreciation of the importance of clinical reasoning in dental students. Therefore, it was suggested that more support may be required and offered to the students in the form of taught courses as students tend to appreciate the importance of didactic teaching to foster the development of this skill. As part of clinical reasoning, they discussed not only the diagnosis but also the management of the conditions (decision analysis). One product of the process of clinical reasoning is reaching a reasonable diagnosis (Nafea & Dennick, 2018). Crespo et al. (2004) evaluated qualitative differences in the diagnostic reasoning process at different developmental stages of expertise and found that expert performance is a combination of a knowledge base, reasoning skills, and an accumulation of experiences with patients that is qualitatively different from that of competent and beginner dentists (Crespo et al., 2004).

Since diagnosis is pivotal to the duties of a health professional, teaching and learning diagnostic reasoning should have a critical position for the medical and dental education systems (Yazdani et al., 2017). Although clinical reasoning is key in formulating a proper periodontal diagnosis and treatment, limited research currently exists on this topic. It is well known that the traits of the undergraduate curriculum and the academic history influence the level of competency of the students. Research has shown that there is a need for improvements in the current education to make the students more competitive in periodontal education (Heym et al., 2016). However, none of the studies have assessed their competency in periodontal diagnosis and treatment planning and improvements needed.

At the School of Dentistry, there is a perceived gap between what is occurring within the classroom with little or no emphasis and lack of clinical experience in periodontal problems in children and subsequent performance in clinical practice. Recently, a mixed-method study was conducted to explore third- and fourth-year dental students' competence and confidence in rendering periodontal care at the University of Alberta. This study comprised of a survey to measure and compare students' performance in periodontal diagnosis and treatment plan. It was followed by the interviews the reasons for student suboptimal performance and challenges they faced. It was found that students had a suboptimal performance in periodontal education. The reasons for this were an insufficient simulation of clinical aspects, the relevant material was not taught adequately, and thus, there was a mismatch between the patient complexity and student readiness. (Mofidi, 2020).

Therefore, it can be concluded that the lack of periodontal education identified by the students and/or general dentists in most studies is the reason for their poor performance in academics and clinics. It is, therefore, prudent to study the level of the current periodontal education in pediatric dentistry in the undergraduate dental curriculum. In addition, the clinical application of knowledge is an important part of periodontal education. Studying the clinical reasoning of the students can give us an insight into the clinical implementation of this knowledge.

Research Objectives and Questions

This research was, hence conducted to examine the effectiveness of third- and fourth-year dental students' training on the periodontal diagnosis and treatment planning in pediatric patients.

We aim to address the following research questions in this study:

1. Is there a difference in knowledge and confidence of third- and fourth-year undergraduate dental students in formulating a periodontal diagnosis, treatment planning, and maintenance phases?

2. What is the clinical reasoning of dental students when developing periodontal diagnosis and treatment plan for pediatric patients among dental students at the School of Dentistry, University of Alberta?

Chapter Three: Methods

The following sections outline the methods used in this study. First, an explanation of the study's experimental design and procedure along with a summary of materials used in the study (survey and interview) is presented. Second, the characteristics of participants in this study are outlined along with the sampling rationale. Finally, methods of the statistical analysis of the survey and verbal analysis of the interview data are presented.

Study Design

An explanatory sequential mixed-method study consisted of two distinct phases: quantitative and qualitative (Creswell, 2003). The quantitative data was collected using an online survey to explore the dental students' knowledge and confidence about periodontal diagnosis in pediatric patients. This was followed by a qualitative phase consisted of semi-structured interviews. The purpose of these interviews was to obtain an intricate understanding of the participating students' search phase while formulating a periodontal diagnosis and treatment plan in pediatric patients. The research proposal was submitted to the Research Ethics Board, the University of Alberta, for approval. The study was started after obtaining ethics approval, Number-Pro 00083394.

Participants

Participants were recruited at the University of Alberta in three phases. First, an expert panel consisting of periodontists and pediatric dentists practicing in Edmonton, Alberta, both in academic and private practice, was utilized to formulate a gold standard answer key to the questionnaire. The participants met the criteria of being a periodontist and pediatric dentist practicing in Edmonton. Second, the third- and fourth-year dental students at the University of Alberta. The third-year students were class of DDS'2021, and the fourth-year students were from the class of DDS'2020. This study required students with some clinical experience at the school. All students start seeing patients in the third-year, so they were recruited in the third- and fourth-year of dentistry. There were no exclusion criteria for these participants. Participation in the study was voluntary and had no impact on the students' education assessment or training. Written and

verbal consent was collected for participation in the study. Finally, a sample of third- and fourth-year students were also recruited to participate in an interview. The number of students we interviewed depended on that which allowed for data saturation and was similar in sample size to previous reports published in the same research (Crespo et al., 2004; Nafea & Dennick, 2018). During the interview, the only descriptive data was the year of training for the students.

The four groups in the study who participated in the survey were assigned a number to maintain confidentiality and not to disclose the participants' identity (1- Third-year dental students; 2- Fourth-year dental students; 3- Periodontists; 4- Pediatric Dentists). Further, written and verbal consent was obtained from all participants. Participation in the study was voluntary and did not affect any of the student's course grades. The interviews were conducted based on the participants' preferences in terms of time.

Sampling

Recruitment of voluntary participants was conducted through email invitation to the specialists and the students. Follow-up emails, telephone calls, and in-person requests were used to maximize participation. Snowball sampling was also done. The survey was sent to the specialists and third- and fourth-year students through the online portal, Research Electronic Data Capture (RedCap). The participants were informed that participation was voluntary, all responses were anonymous, and there was no incentive for participation. At the end of the survey, the students were asked if they were interested in participating in the interviews. Only those who expressed interest by leaving their email address were contacted for the second phase of the study to plan the interviews. To capture the diverse perspectives and experiences regarding periodontal diagnosis and treatment, maximum variation sampling was done among Third-year and Fourth-year dental students. To compensate for their time and appreciation for participation in the study interviews, gift cards of value around $20 to a local business (ex. Coffee) were given to the participants after the interviews were completed.

Materials and Experimental Design

The strategy for data collection was methodologically informed after the review of the literature of similar studies. Data was collected using a survey in the first phase of the study. The survey was distributed through the online portal, Research Electronic Data Capture (REDCap) (Harris et al., 2009). REDCap is a secure, web-based application designed to support data capture for research studies. At the end of the survey, the students were asked if they were interested in participating in the interviews. Those who were interested were only contacted for the interview aspect of the study.

Clinical Scenario Survey

The survey included questions and clinical scenarios based on the theoretical knowledge and confidence for diagnosis, treatment planning, and periodontal disease maintenance in pediatric patients. (Appendix B) A list of questions was created and segregated into subcategories: those about history taking, examination, diagnosis, treatment planning, and maintenance schedule for periodontal diseases in pediatric patients. There was a knowledge-based question followed by a confidence question about each of these above-mentioned subcategories. The confidence here referred to the measure of their self-perception and not their competence. It has been shown that practitioner's confidence in their knowledge directly affects their decision-making skills (Teh et al., 2020). The survey used in this study was adopted from another study with a similar research aim (Mofidi, 2020). In that study, they examined the effect of didactic and clinical experiences on students' approach to the formulation of a diagnosis and treatment plan during their periodontal training from a mixed methods perspective. The survey in that study piloted our study survey, and the necessary modifications were made in stages. Since, in the pilot study, the time taken to fill the survey led to decreased participation in the study, the survey was administered to an experienced periodontist, a pediatric dentist, a fourth-year, and a third-year student to monitor time to fill the survey. It was then modified further by a consensus to remove any time issues with the participation. The specialists were the instructors who were actively involved in undergraduate students' didactic and clinical education at the university. Their answers were used to form a gold standard to score the students. This is based on the premise that the students are likely to resolve clinical cases via their instructors' strategies, as suggested by Lanning et al. (2005). Hence, to gauge the students' performance, the use of their instructors as a gold standard is an appropriate

method. Besides, this method has been used in determining correct responses in periodontal questionnaires (Lane et al., 2015; Williams et al., 2014).

The survey consisted of two parts. The first part was designed to answer the first research question (that is, to measure and compare the knowledge of the third- and fourth-year dental students for periodontal diagnosis in pediatric patients). This section comprised of the open-ended questions that were based on the free recall analysis of the participants, as follows:

1. What medical history questions are essential to ask for a pediatric patient presenting with gingival or periodontal disease?

2. What constitutes a thorough gingival and periodontal exam?

3. What are the challenges when performing periodontal probing in mixed dentition vs. adult population?

3. How do the participants formulate a periodontal diagnosis in a pediatric patient?

4. Why and when would a patient need Scaling vs. root planning?

5. What are the considerations when determining a recall interval in pediatric patients with gingival or periodontal disease?

The nature of these questions was based on unprompted free recall by the students, which closely imitates the actual clinical scenario in which general practitioners will be confronted in their everyday practice. Explicit memory depends on individuals to recall previously acquired knowledge (Haist et al., 1992). It relies on retrieving memories and ensuring that once this memory is retrieved, it is the factual answer to the provided case. Compared to the memory recognition test (cued recall), which relies solely on collecting information presumed to be the most accurate (Haist et al., 1992). Although there is generally a correlation between recall and memory recognition testing, the use of free recall is best suited to our study objectives (Bridgeman & Morgan, 1996). Furthermore, by allowing open-ended questions, the study design allows for the application of multiple treatment modalities, combinatory diagnostics, and the ability to convey the information required for a specific question without the limitations of closed-ended questions (John et al., 2013).

Script Concordance Test (SCT)

The second part of the survey consisted of the cases that were designed to compare the clinical reasoning among the two groups about periodontal diagnosis in pediatric patients. Three clinical cases matching those of Lane et al., (2015) were included in the survey cases. Two experts (one periodontist and one pediatric dentist) were asked in an informal interview to describe some clinical situations representing the periodontal diagnosis in pediatric patients and were problematic (Charlin et al., 2000). These cases were generated by extracting case records/vignettes from the American Academy of Periodontology.

The presentation included information like the chief complaint, case history, clinical picture, periodontal charting, and radiographs. This set of information was provided in stages wherein the first stage, and the participants were expected to formulate a diagnosis based on the chief complaint and case history. This was followed by the second stage, where in addition to the information in Stage one, clinical picture, periodontal charting, and radiographs were given, and the participants were required to form a diagnosis and treatment plan for this case.

This staging of the presented information was done to measure and compare the participants' diagnosis' and treatment plan and be able to understand their clinical reasoning using the Script Concordance Test. It enabled us to compare the participants' diagnoses and treatment plans accurately.

The Script Concordance Test stems from this cognitive theory of clinical expertise development. The professional and qualified clinical medicine practitioners differ from less experienced and skilled practitioners because they have extensive knowledge networks tailored to their daily tasks (Charlin et al., 2000). According to script theory, structured knowledge networks, called "scripts," are mobilized by physicians to manage the information and advance towards solutions to clinical problems. These scripts consist of links between conditions, clinical features, and management options.

SCT is based on the principle that it is possible to test multiple decisions made in these clinical reasoning processes and compare their concordance with those of a reference panel of experts. This offers an instrument for evaluating clinical thinking (Fournier et al., 2008). The first segment gives us the diagnostic hypothesis, and the second part gave the diagnosis with additional information. The latest periodontal diagnostic classification 2018 American Academy of

Periodontology (AAP) classification of Periodontal and Peri-Implant diseases was used. A Likert scale ranging from (1=very confident to 5= not confident) was employed after each free recall question to assess participants' confidence in all these knowledge-based questions.

Clinical reasoning is central to the activities of health care providers. It involves a process of thinking and interacting with the environment to understand clinical situations, make diagnostic and therapeutic decisions, and frame and solve clinical problems (Khatami & Macentee, 2011). Clinical reasoning can be investigated with outcome and process measures. Using more than one kind of measure ensures a complete description of clinical reasoning. So, in this study, SCT was used for quantitative assessment, and interviews using the think-aloud method were done for the qualitative assessment of the clinical reasoning used. Script Concordance is an outcome measure, the partial presentation of data allows a reasonable representation of the reasoning process (Higgs et al., 2008). SCT quantifies the degree of concordance between a learner and an experienced clinician and attempts to capture expert clinicians' breadth of responses, acknowledging the significant yet acceptable variation in practice under situations of uncertainty (Power et al., 2017).

Interview

For researching problem-solving and in-depth understanding of the students' thinking process, verbal reporting is generally used (Chi, 2006). Verbal reporting, as a category of a task, can be done in either of the following ways:

i) Concurrent Think-aloud Protocols: Here the participants verbalize the problem information to which they are attending.

ii) Interviews: These include the task to be performed (concurrent Think-aloud interviews) and carefully crafted questions to focus on a specific topic/ scenario and are often sequenced in a meaningful order.

iii) Explanations: Here the participants provide answers to the questions generated by themselves (Chi, 2006).

In this study, a semi-structured interview was conducted using the concurrent think-aloud (TA) technique. Concurrent TA is a method that, in principle, does not lead to much disturbance

of the thought process. The subject solves a problem while the talking is executed almost automatically. The data so gathered are very direct; there is no delay. The subject does not interpret his or her thoughts, nor is he or she required to bring them into a predefined form as in structured techniques. He or she renders them just as they come to mind. Another advantage of using the think-aloud method is that it makes it easy for the subjects because they are allowed to use their language (Someren, 1994).

A common drawback of this technique may be that a subject may verbalize only part of his thoughts. However, this can be overcome with practice. Therefore, while designing such interviews, it is essential to include a practice task that is somewhat similar to the target task. Such a practice task was included in our interview, where the participants were given a clinical situation to solve and could think aloud. The interviewer (DN) gave them feedback if needed for this task (Someren, 1994).

The interview design and setting followed the guidelines as described by (Someren, 1994). Practical procedures in obtaining Think – aloud. The interviews were conducted in-person as well as online due to pandemic restrictions. For in-person interviews, a quiet room with no distractions was used.

Interview Protocol.

At the start of the interview, clear instructions were given. An interview guide was designed to keep the instructions consistent and standard. The participant focused on the task and the interviewer interfered as little as possible with the thought process to avoid influencing its course. The investigator who conducted the interviews (DN) read the script from the interview guide (Appendix D) to each participant.

Written consent (Appendix E) was taken before the start of each interview. Verbal consent was taken during the interview process. It was made clear and reinforced during the instruction phase that the research's focus was not on getting a correct/ incorrect response rather on how they arrive at a diagnosis. Students were assured that they were not being judged would positively influence the participants to verbalize their thoughts. After the instructions were read, the participants were allowed to practice thinking aloud by performing the practice task. The target

task followed this. The target task consisted of assigning a periodontal diagnosis and treatment plan for the case presented. This case was one of the three cases (a periodontal disease in a pediatric patient) presented in the survey. The case was selected in discussion with the experienced periodontist and pediatric dentist. This case was selected as it had characteristic periodontal findings, thus, avoiding ambiguous diagnosis. The information was presented in 4 cards in sequence, to start with case history followed by clinical picture, periodontal charting, and radiographs in sequence. They were asked to think-aloud while they were reading the information on each card. The sequence helped to tell the participants what details they needed to validate their diagnosis.

Immediately after the think-aloud task, follow-up questions were asked about what the participants generally do when formulating a periodontal diagnosis and treatment plan in pediatric patients. Also, questions about their experiences and recommendations for periodontal diagnosis in pediatric patients were asked.

At the beginning of this phase of the study, two pilot interviews were also conducted for one third-year and one fourth-year student by DN. These were then analyzed with the help of an expert. Pilot interviews served dual purposes; they helped the interviewer become familiar with the process, and necessary modifications in the interview guide were made before starting the interview phase of the study. The data was collected until data saturation was achieved; that is, no new information emerged from the data.

Data Analysis

The stored survey data was imported from RedCap and analyzed statistically using Statistical Product and Service Solutions (SPSS) software V23(IBM Corp, 2016).

To compare the knowledge and confidence for the diagnosis, the Script Concordance test was used as explained by (Charlin et al., 2000). The test scoring process is based on the principle that any expert answer reflects the opinion of an expert, and those answers for which there is no agreement among all the experts should not be discarded. In other words, any answer given by an expert has an intrinsic value, even if other experts do not agree with it. Hence, scores for each item are computed from the frequencies given to each point of the Likert-type scale by the experts. A 3-point Likert Scale was created. Items in an SC test do not have the same maximum value. That value depends on the agreement between experts. Scoring is weighted by the degree of agreement between experts. This weighting is in no way artificial or arbitrary; it reflects the way experts answer the question.

Results of the tests are represented by the sum of the scores obtained for each item. The maximum score for a test is the sum of the higher score obtainable on each item. For the convenience of interpretation, it is suggested to transform all scores to get a maximum score of 100. A score of 100 signifies that the examinee gives on each item the answer that most experts provide, and the lower the score, the farther examinees are from the experts' prototypic script for the situation (Charlin et al., 2000). The statistical tests used for the research objectives are summarised in Table 4.

Table 4.

Summary of the statistical tests used for the research objectives

Research Question	Types of Question	Statistical test used
1.Assess and compare knowledge level of third- and fourth-year dental students	Open-ended questions (11)	Independent sample t-Test
	Single answer (11)	Independent sample t-Test with bootstrapping
2. Assess and compare confidence level of third- and fourth-year dental students Confidence	Likert scale (9)	Kruskal Wallis Test Mann Whitney U test
3. To measure and compare the clinical reasoning for the third- and fourth-year students	Script Concordance test (SCT)	Independent sample t-test

To determine consistency and analyze the inter-and intra-rater reliability of the three groups (experts and students), interclass correlation coefficients (ICCs) were calculated, as the outcome measure was ordinal. It is important to check the reliability of the groups as it is the extent to which the measurements can be replicated (Daly LE, 2000). Inter-Class Correlation Coefficient (ICC) is an index of reliability that reflects both the degree of correlation and agreement between measurements. The inter-rater reliability reflects the variation between 2 or more raters who measure the same group of subjects (Koo & Li, 2016). It gives us an idea of how much homogeneity or consensus there is in the ratings given by the judges (McGraw, 1996). Ten forms of ICC have been described based on the “Model” (1-way random effects, 2-way random effects,

or 2-way fixed effects), the "Type" (single rater/ measurement or the mean of k raters/measurements), and the "Definition" of a relationship considered to be important (consistency or absolute agreement). The parameters used in our study were a single-rater, absolute-agreement, 2-way random-effects model. The single rater type considers the individual level whereas the mean of K raters is representative of a group. We chose to use a single rater type as the basis of measurement in our study. The absolute agreement was preferred over consistency because different raters could assign the same score to the same subjects. In our study, the raters were the periodontists and the pediatric dentists from those practicing in Edmonton who responded to the survey. Hence, these raters had similar characteristics (specialists) and were selected from a larger population of raters. This justifies the use of the 2-way random effect model (Koo & Li, 2016).

As a rule of thumb, researchers should try to obtain at least 30 heterogeneous samples and involve at least three raters whenever possible when conducting a reliability study. Under such conditions, it is suggested that ICC values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability (Koo & Li, 2016).

The audio-recorded interviews were sent to Transcription Heroes (transcriptheroes.ca; Transcript Heroes Transcription Services Inc., Ontario, Canada) for verbatim transcription. The verbal data analysis/ verbal analysis was then carried out as described here. The data was managed by NVivo12 (QSR; International Melbourne, Victoria, Australia) (Higgs et al., 2008). The transcripts were read and re-read, and the relevant information was identified from each transcript. The transcripts were then segmented, and the content was coded. A coding scheme was developed in line with the research question: the step-by-step approach used by the participants to arrive at a diagnosis and treatment plan, information the participants found pertinent from the case (knowledge base), and the confidence they had in diagnosing and treating periodontal disease in children. The patterns that emerged from the data were also identified.

Chapter Four: Results

Consistency of Ratings

A total of 117 participants were solicited to participate in this survey study. Response rate for specialists was 35% (5/14) Pediatric Dentists, 50% (9/18) Periodontists and 57.6% (49/85) for students.

To evaluate interrater consistency, ICC estimates for the experts and students and their 95% confidence intervals were calculated based on a single rater, absolute-agreement, 2-way random-effects model (Koo & Li, 2016).

As shown in Appendix F**,** although the obtained ICC value for all respondents is 0.439 (indicating poor reliability), its 95% confidence interval ranges between 0.312 to 0.618, meaning that there is a 95% chance that the true ICC value lands on any point between 0.312 and 0.618. Therefore, based on statistical inference, it would be more appropriate to conclude the level of reliability to be "poor" to "moderate".

When ICC estimates for the two groups of experts and their 95% confident intervals were calculated based on mean rater, absolute-agreement, 2-way random-effects model. The obtained ICC value was 0.867 (average measures), hence, indicating good reliability, see Appendix G. The average measure was used across all the participants in two groups of specialists, either periodontists or pediatric dentists.

Comparison of Knowledge Level

The first objective of the study was to assess and compare the knowledge level of third- and fourth-year by 11 open-ended questions and 11 single-answer questions. The null hypothesis for this was that there is no difference in knowledge due to student's level of training/ academic year. Assumptions were assessed before the conduction of any comparative analysis. In this study, the study participants completed the survey independently. For checking the normality distribution of open-ended knowledge-based questions, skewness values and Z scores were checked, and it was found that the distribution of the data was approximately symmetric (Table 5).

Table 5.

Normality distribution of data for open-ended knowledge-based questions

Question	Skewness value	SE	Z Score = Skew/Skewness
Q1 Med History	0.009	0.340	0.02
Q2 Perio Exam	0.210	0.340	0.61
Q3 Probing challenges	0.153	0.340	0.45
Q4 Diagnostic Considerations	0.329	0.340	0.96
Q6 Recall considerations	0.424	0.340	1.24
Q7 Treatment Plan1	0.153	0.340	0.45
Q7 Recall Considerations	-2.106	0.340	-2.93 (Skew)
Q8 Treatment Plan2	0.251	0.340	0.73
Q8 Recall Considerations	-1.8	0.340	-5.29 (Skew)
Q9 Treatment Plan	0.32	0.340	0.9
Q9 Recall Considerations	-3.15	0.340	-9.2 (Skew)

A boxplot was also plotted in Appendix H. Equal variance assumption for both groups was also tested by Levene's test (Appendix I). Therefore, to compare the mean difference among the groups, an independent sample T-test was performed. For those questions with non-normal distribution, bootstrapping was used in the independent sample T-tests **(**Appendix J).

For knowledge-based questions with a single answer, the assumption of normality was checked using skewness values, Z scores (Table 6), and histograms (Appendix K)**.** It was found that the data was highly skewed for the treatment planning cases1, 2, and 3 and moderately skewed and for the questions about Clinical attachment detection and Scaling vs Root Planing.

Table 6.

Normality distribution of data for knowledge-based questions with single answer

QUESTION	SKEWNESS VALUE	SE	Z Score = SKEW/Skewness
Q3 Detecting Clinical attachment level	-0.56	0.340	-1.86
Q5 Scaling Vs Root Planing	-0.7	0.340	-2.05
Q7 Treatment Plan 1	2.71	0.340	9.03
Q8 Treatment Plan 2	-2.71	0.340	-9.03
Q9 Treatment Plan 3	1.6	0.340	4.7

The Levene's test was used to check if equal variance assumption was met and it was found it was not met for the question on Scaling vs Root Planing and treatment planing for case1 (p<0.05), however, for questions on detection of true clinical attachment level, treatment planning case2 and 3 (p>0.05), equal variance assumption was met for these items (Appendix L). Therefore, to compare the mean difference in knowledge among the groups based on single response questions, an independent sample t-test with bootstrapping was performed (Appendix M).

Overall, there was no difference in knowledge of third- and fourth-year students t(df) = 0.333, p>0.05. For all individual item responses, the results were also non-significant.

Knowledge (open-ended questions)

The results of the independent sample t-test are provided in Appendix I.

It was found that for all the questions, p>0.05 suggesting no difference compared to the null hypothesis. Hence, there was no significant difference between the knowledge for periodontal diagnosis in pediatric patients among third- and fourth-year.

Knowledge (closed-ended questions)

The results of the independent sample t-test with bootstrapping are provided in Appendix M. It was found that for only Q5 (Scaling Vs Root Planing) $p>0.05$ suggesting no strong evidence against the null hypothesis. For all the other questions, the results were not significant ($p<0.05$). Hence, there was no significant difference between the knowledge for periodontal diagnosis in pediatric patients among third- and fourth-year.

Comparison of Confidence

The second objective was to assess and compare the confidence among the study respondents based on their academic year. The null hypothesis was that there is no difference in confidence due to student's academic year. We used a 5-point Likert scale for measuring confidence. Likert Scale data were treated as ordinal data. The data was skewed (non-normally distributed), as shown by, the box plots are shown in Appendix N. To check the equality of variance assumption, Levene's test was used (Appendix O) and the equality of variance assumption was met. Hence, 9 independent Kruskal-Wallis tests were used, and Bonferroni corrected value, $\alpha=0.005$ (Appendix P).

Confidence (Overall Comparison)

Results of the Kruskal Wallis test are provided in Appendix P. Of the nine confidence-based questions except for two questions about treatment planning cases 1 and 3, a statistically significant difference in the confidence of the three groups was found in seven questions.

Confidence (Groupwise Comparison)

To find out, this difference was between which groups, third-year students vs Experts, or fourth-year students vs Experts, or third-year vs fourth-year students, Mann Whitney U test was used (Table 7, 8, 9). Critical alpha value was adjusted the number of groups to prevent Type1 error.

Table 7.

Experts vs Third-year (Confidence)

Test Statistics [a]

	Med Hx	Perio Exam	Probing Challenge	Dx	S vs RP	Recall	Tx plan 1	Tx plan 2	Tx plan 3
Mann-Whitney U	26.00	25.50	78.00	23.50	57.00	40.00	167.50	72.00	144.00
Wilcoxon W	131.00	130.50	183.00	128.50	162.00	145.00	272.50	177.00	249.00
Z	-4.95	-5.03	-3.66	-4.97	-4.41	-4.61	-1.60	-3.83	-2.13
Asymp. Sig (2 tailed)	.000*	.000*	.000*	.000*	.000*	.000*	.110	.000*	.032

* $p < 0.015$

a. Grouping Variables: STUDY RESPONDENTS

There was a statistically significant difference in the confidence of experts and third-year students as the significance was found ($p < 0.015$) for all items except 2 questions (Treatment planning Case1 and Case 3).

Table 8.

Experts vs Fourth-year (Confidence)

Test Statistics [a]

	Med Hx	Perio Exam	Probing Challenge	Dx	S vs RP	Recall	Tx plan 1	Tx plan 2	Tx plan 3
Mann-Whitney U	55.00	37.50	55.50	27.50	55.50	51.00	86.50	51.00	72.50
Wilcoxon W	160.00	142.50	160.50	132.50	160.50	156.00	191.50	156.00	177.50
Z	-2.57	-3.36	-2.45	-3.74	-2.58	-2.69	-1.11	-2.74	-1.72
Asymp. Sig (2 tailed)	.010	.001	.014	.000	.010	.007	.263	.006	.084
Exact Sig (2*(1-tailed)	0.017[b]	0.001[b*]	0.017[b]	.000[b*]	0.017[b]	0.010[b]	0.294[b]	0.010[b*]	0.101[b]

[*] $p < 0.015$

a. Grouping Variables: STUDY RESPONDENTS

b. Not corrected for ties

A statistically significant difference ($p < 0.015$) in confidence between the experts and fourth-year was found for the questions on the periodontal exam, diagnosis, recall, treatment planning case 2. However, for all the other questions (medical history, probing challenges, indications of root planing) no statistically significant difference in the confidence of the two groups was found ($p > 0.015$).

Table 9.

Third- vs Fourth-year (Confidence)

Test Statistics [a]

	Med Hx	Perio Exam	Probing Challenge	Dx	S vs RP	Recall	Tx plan 1	Tx plan 2	Tx plan 3
Mann-Whitney U	180.00	193.00	220.00	205.00	227.50	180.50	262.50	228.00	258.50
Wilcoxon W	316.00	329.50	356.00	341.00	363.50	316.50	398.50	364.00	394.50
Z	-1.86	-1.64	-.97	-1.31	-0.87	-1.87	-0.03	-0.80	-.12
Asymp. Sig (2 tailed)	.062	.101	.330	.190	.384	.061	.972	.423	.899

[*] $p < 0.015$

a. Grouping Variables: STUDY RESPONDENTS

There was no statistically significant difference in the confidence of third- and fourth-year students ($p > 0.015$) for all questions.

Clinical Reasoning

To measure and compare the clinical reasoning for the third- and fourth-year students, the Script Concordance test (SCT) was used. 14 experts participated in the study. As stated by Charlin B et al., 5-10 experts are sufficient to express the variability in answers that experts may show for each item (Charlin et al., 2000).

Scoring for SCT considers the range of potential answers and allows for the variability in clinical reasoning that experts show when confronted with complex questions. Every choice selected by an expert received credit. To develop the scoring grid, the examination was administered to all the Periodontists and Pediatric Dentists in Edmonton, all of whom volunteered to participate.

Scores for each question were computed from the frequencies given to each point of the Likert-type scale. A three-point Likert Scale was developed where +1 means the experts chose the same answer with and without the additional information (new information was useful); a score of -1 was given if with the additional information the experts gave a different diagnosis (new information was useless) and Score 0 for those who said do not know (neither valuable nor useless). Credits for each answer were transformed proportionally to get a maximum score of 1 for modal experts' choice(s) on each item; other experts' choices received partial credit. Answers not chosen by experts received zero credit. For example, for the first clinical question, 7 experts out of 14 had chosen +1, the student choosing +1 would get 1 point (7/7). If 5 experts had chosen -1, then a resident choosing -1 would receive 0.7 points (5/7). Those who chose anything other than these would receive 0 points. The total score for the test was the sum of credits on all items (Fournier et al., 2008; Meterissian et al., 2007; Nouh et al., 2012).

Script Concordance Test Results

The final SCT score represented the level of concordance between the students and the experts. For the third-year this score was 80.5%, and for the fourth-year, it was 82% which showed that the fourth-year responses were closer to the experts. The minimum score obtained by a student (third-year and fourth-year) was 50% and the maximum score was 100%.

To determine if there was a difference in clinical reasoning skills of third-year and fourth-year students, the independent sample t-test was used. All p values at an alpha of less than 5% were considered significant ($p<0.05$).

There was no statistically significant effect of the year of training, t (47) =-0.33, p=.74, despite fourth-year (M = 82.5, SD = 20.2) attaining higher score than third-year (M = 80.5, SD = 19.6). The students' responses mostly differed from the experts in answering the question for diagnosing plaque-induced gingivitis followed by the third- question for diagnosis (Gingivitis associated with the systemic disease) and least for the question based on a diagnosis of aggressive periodontitis.

Interview Results

To explain these results and study the clinical reasoning of the students for periodontal diagnosis in pediatric patients, a qualitative aspect of the study was carried out. Twenty-three interviews were conducted with third-year (n=15) and fourth-year (n=8) dental students. Third-year students included 10 females and 5 males, and fourth-year students included 4 females and 4 males.

1. Patterns of Reasoning.

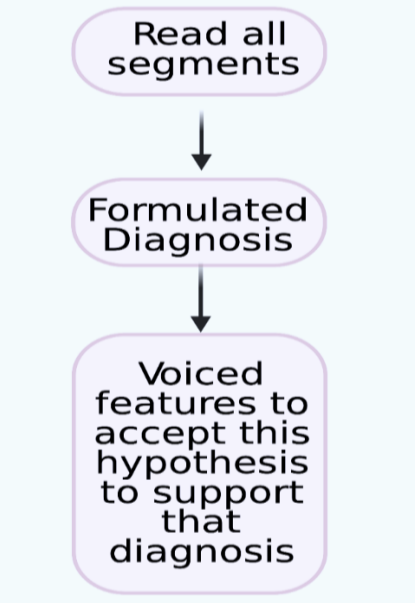
Three patterns of reasoning were identified. The patterns are listed below, starting from the most frequent to the least frequent:

i. ***Forward Search.*** This was used by four fourth-year students and nine third-year students. The students read all the segments and formulated a diagnosis. They then voiced the features to accept this hypothesis to support this diagnosis. This is shown in Figure 2. As a student stated:

> My diagnosis would be if we look at the loss of attachment, the maximum number for the loss of attachment is nine. So according to that, it would fall into the category of Stage 3. I think considering the age and that much amount of bone loss, I would still categorize this child as Grade C, which is a rapid progression. So, this would be my clinical diagnosis, which is Stage 3, and Grade C.

Figure 2.

Forward Search Map



ii. ***Backward Search.*** Three fourth-year and six third-year participants used backward reasoning. Participants who used backward reasoning read the first segment (clinical history and chief complaint) and formulated a preliminary hypothesis. They read the next segments (clinical picture, periodontal charting, and radiographs) then either accepted or rejected their preliminary hypothesis. As one of the participants who accepted their preliminary hypothesis stated:

> So going right off segment one if I were to just diagnose not ideally without probing, but kind of as a working diagnosis let's say based on this chief complaint, I would say periodontitis of some sort of the fact that they're already loose. I would go into periodontal stage three or four and then grade again hard to say, but because he's so young and his teeth are loose, obviously rapidly progressing. I would have a working diagnosis of minimally at least P3C. So, with this charting, it supports the working diagnosis of at least stage 3 or 4 as we have clinical attachment loss greater than 5 millimeters, and we also have bleeding sites. So, I would say this all goes to – and going off the picture and the radiograph, it doesn't look as though there is traumatic occlusion, teeth missing yet. So, I think P3, stage 3 is the most accurate category. Not quite stage 4 yet, but I would still say that this is rapid bone loss and unchecked so grade C as well.

The other who rejected their preliminary hypothesis stated:

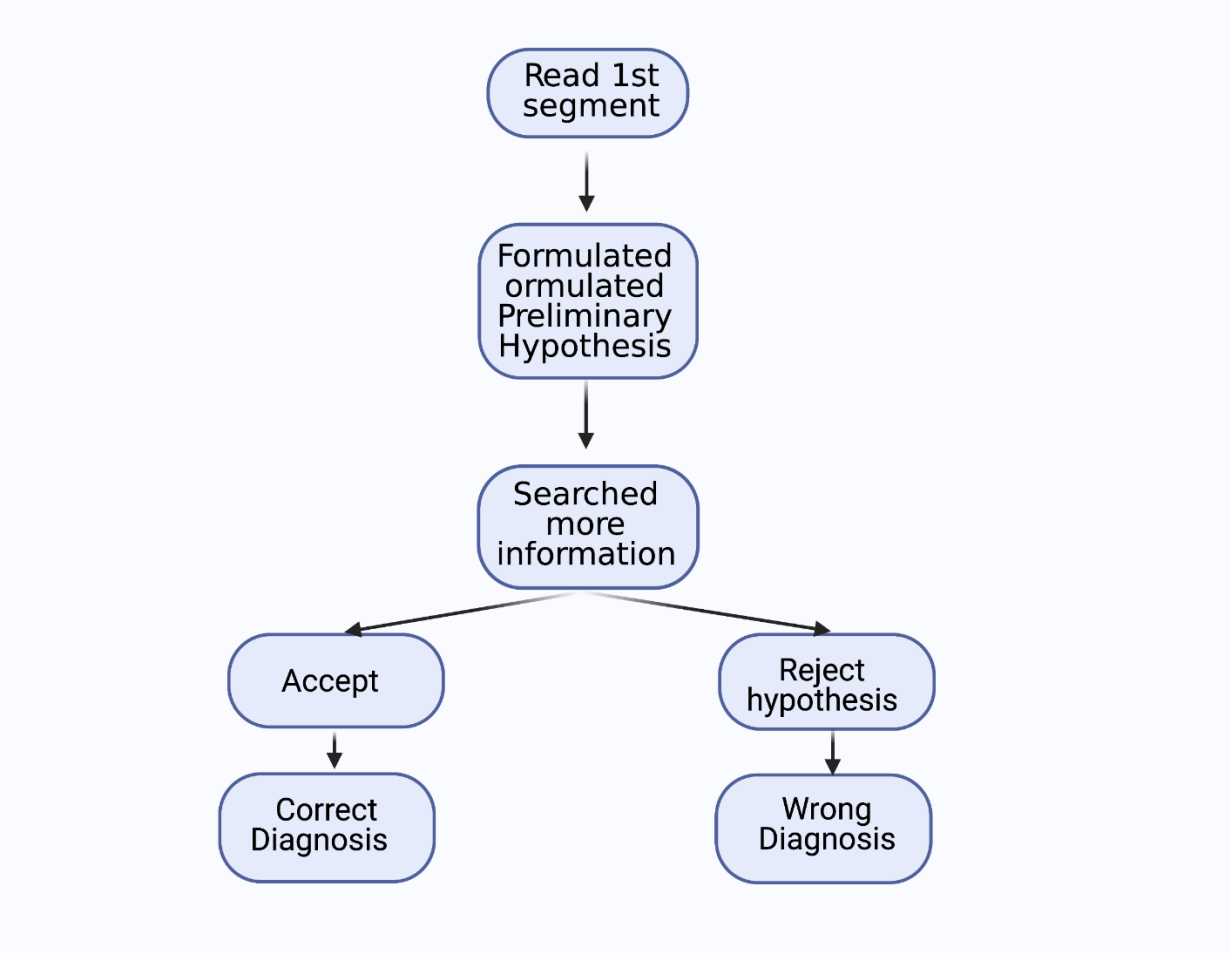
> So, I'll want to question the history of the patient more. First and foremost, I want to find out are the teeth are generally all the teeth loose, or is it just a few teeth? Because I'm thinking I really think it's a case of aggressive periodontitis, here. After considering the information from the clinical picture and the periodontal charting, the participant changed the diagnosis: I'm looking at the charting representative of the whole mouth. Obviously, I'm a bit worried because he does have quite some deep pocket on the molars, particularly. And there's also some recession going on there. So, I see for some of them they're really quite high. So, in my head I'm thinking, hmm, this may just be a case of chronic periodontitis. So, I'm thinking this may just be chronic periodontitis, at this point. Further, after the radiographs were presented and considering all the above segments, the participant gave the wrong final diagnosis. Based on what I have, I want

to just formulate my diagnosis based on this. And this child definitely has some form of chronic periodontitis going on.

The ones who accepted the preliminary hypothesis formulated a correct diagnosis whereas the ones who rejected their preliminary hypothesis formulated the wrong diagnosis. This is explained below, as in Figure 3.

Figure 3.

Backward Search Map

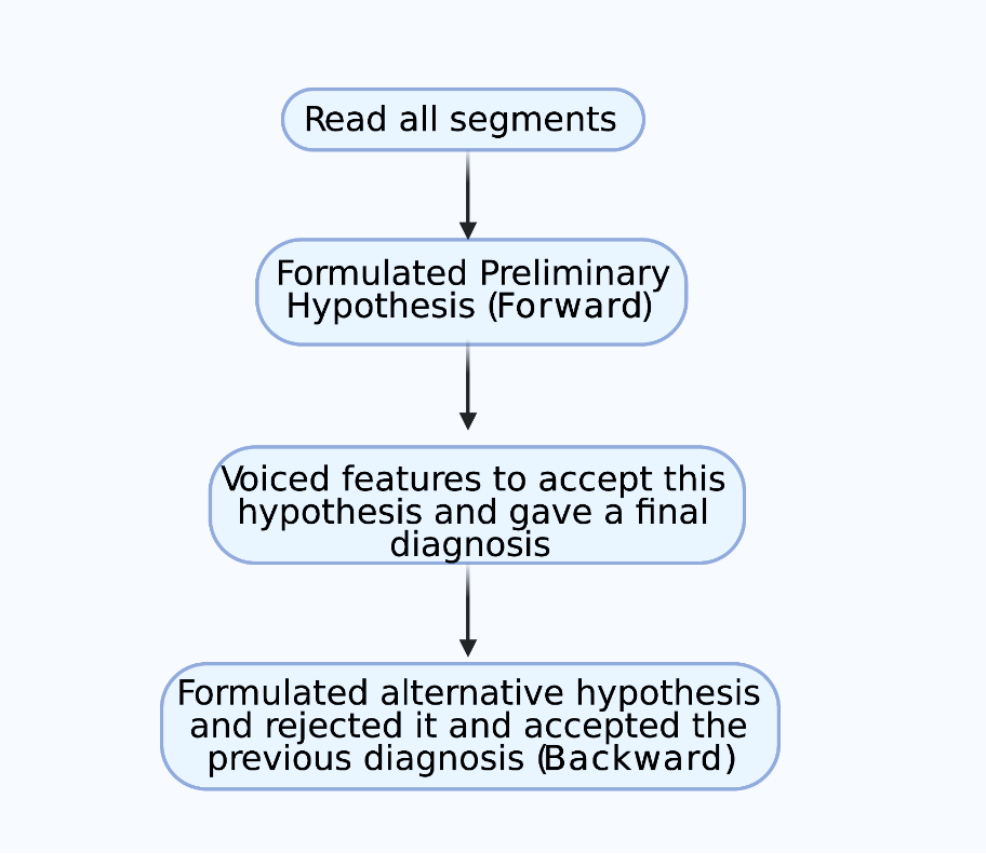


iii. Combination. This pattern was used by one fourth-year student. The student read all the segments and formulated a preliminary hypothesis. They then voiced all the features they used to arrive at this diagnosis (forward reasoning). At the same time, they formulated an alternative hypothesis and rejected it, and finally accepting their previous diagnosis (backward reasoning), as shown in figure 4. As illustrated by one of the participants:

> So, if I considered this is a representation of the whole mouth then probably, I would take the generalised aggressive periodontitis. And I'm going for that because I can see the angular bone loss. However, the deposits and the oral hygiene doesn't look bad by just seeing the clinical picture. But going by the depths and the CAL is suggesting to me that it could be an aggressive periodontitis. If I go for the differential, then it could be plaque-induced which is not there. And in this case, I don't think so. It's 0 plaque in this case. For me it looks to me like in a patient with aggressive periodontitis.

Figure 4.

Combination Search Map



2. The reasoning for Periodontal Treatment Planning in Pediatric Patients.

There was consensus among the students that the treatment planning depends on the diagnosis of periodontal disease. The participants followed the guidelines by the World Workshop of Periodontics 2018 for diagnosing periodontal diseases to determine the plan of action for treatment. As stated by a participant, "First from the staging and grading, I will treatment plan whether she will go for the scaling, root planing or antibiotics or follow-up or any surgery, and things needed".

3. Relevant Information Identified from the Presented Case.

To arrive at a diagnosis and treatment plan, a clinician needs to identify the important signs and symptoms and relate them to their findings from the clinical and radiographic exam. The case presented in the interview had the information about the aspects of a clinical exam, radiographic exam, all that is routinely done in the clinics. Therefore, it was considered important to analyze the information the participants considered relevant for formulating diagnosis and treatment plans. The parts of the case identified by most of the third- and fourth-year students from the segments of the case presented were integrated with their diagnosis. This reflects closer features identified by the experts.

i. Relevant Information from the Chief Complaint and History.

From the first segment about the patient's chief complaint and history of chief complaint, most of the students considered the age (15 years), ethnicity (African American), and the closeness of teeth. As one participant pointed out:

> And knowing the background of African American, they are high risk for certain I guess early-onset aggressive periodontitis. Number one, seeing that he's only 15 years old a lot of times we do associate any kind of periodontal problems with more age-related and if you start seeing them in younger populations that is something that would raise a red flag for me.

ii. Relevant Information from the Clinical Picture.

The second segment consisted of the clinic picture, most of the participants considered recession, loss of attachment on the first molar, especially on the lower first molar. This information was then correlated to their diagnosis. As one participant said, "I mean around the

sixes, I think, there's definitely some attachment loss. So perio again, this is kind of going towards the aggressive periodontitis. bit of a black triangle. It doesn't fill the embrasure spaces". The next most common aspect pointed out was no obvious signs of inflammation. As one student pointed out, "Otherwise, there's no obvious signs of strong inflammation, not seeing like really puffy or swollen gums". The participants also considered the absence of a lot of plaque and/or calculus buildup around teeth in the picture to formulate their diagnosis. As one student commented, "but really not obviously and not too much plaque or calculus deposits either".

iii. Relevant Information from the Periodontal Charting.

From the next segment on the periodontal charting, recession/ clinical attachment loss and pocket depth were considered and their relevance to the diagnosis of aggressive periodontitis was established. As one student pointed:

> So probing depths. OK, so looking at his probing depths, they do not look very good, typically for someone who's 15, like 3mm or less would be healthy and acceptable and that much bleeding on probing is not acceptable. Also, recession in someone that young is also not typical. So, I think the area that – they all look concerning. The 5mm, 7mm, 6mm in addition to the recession.

iv. Relevant Information from the Radiograph.

When presented with the radiographs, vertical bone loss/angular bone loss was noted most, as illustrated, "so vertical bone loss around the 6. Yeah, the lower and upper molars, so – yeah, that's the first thing that jumps out at me. This is peculiar to a kind of periodontitis".

4. Low confidence in diagnosis and treatment planning periodontal diseases in pediatric patients and the reasons.

The participants graded their confidence in diagnosing periodontal issues in pediatric patients on the Likert Scale as 3 (neutral or unsure). The reasons attributed to low confidence/ unsure were limited experience in diagnosing periodontal diseases in pediatric patients. As stated by one student:

> And so many kids that I see, they have very little plaque built up and so I don't really even think about the period aspect of it. And then the kids who come in with lots of plaque, again, I know that kids in general have heavier plaque deposits with less. So again, we don't really, it's not encouraged, I guess it's not focused on in the pediatric clinic as much.

They also suggested that they would like more experience, as illustrated: “I've had zero experiences in the periodontal diagnosis of pediatric patients. I have not diagnosed a single pediatric patient with any periodontal disease. So that's my zero. That's zero experience”.

Another reason was the way the students are trained in periodontal diagnosis in pediatric patients. The participants said that they do not regularly probe pediatric patients in undergraduate clinics at School. Therefore, would need a guideline to teach them when periodontal probing is needed. In this regards, one of the participants, stated: "And I find that you know, like you – if – it's – how early can you catch aggressive periodontitis if you don't probe children?”

The participants were of the view that they are not trained enough for diagnosing and treating periodontal conditions in children and would need additional help from a specialist. As one student pointed out:

> Yes, I would like to get additional help from specialists in that condition because I don't feel that I'm trained enough to definitely make a diagnosis and treat the patient confidently. And I feel like it would be a disservice to the patient to treat them without me being confident in my diagnosis.

In addition, various patient factors like behavioural and anatomic aspect of children were also identified as challenges to proper diagnosis and treatment in children. As one student pointed:

> It is kind of hard to have a child sit through probing’s or sit through the entire Perio exam, so that is going to be. Probably invest more time, talking to them, getting them comfortable. Because simple things like radiographs, sometimes they are hard to manage on the chair when we hit the radiograph.

Another student stated: “I find it kind of confusing when you're probing and looking at radiographs on kid, just knowing when it's disease-based and eruption-based. I haven't seen, I guess, enough cases of children with periodontal disease that I can kind of differentiate the two”. The other one told, “So one being when you're doing your probing, kids may have deeper pockets

because they might have pseudo pocketing. So that could be like a little bit trickier when you're doing your diagnosis".

Summary of the Results

1. Results show different levels of consistency with the expected response in knowledge for periodontal diagnosis in pediatric patients. The interrater reliability, calculated by ICC, between the students and experts was "poor" to "moderate" (ICC value 0.439). The interrater reliability between the two groups of experts was high (ICC value 0.867).
2. There was no significant difference in the third- and fourth-year students' knowledge for periodontal diagnosis in pediatric patients.
3. When comparing the confidence among the third- and fourth-year students and the experts, differences were found in experts' confidence and students in some questions. However, no differences were found in questions relating to medical history, probing challenges, indications of root planing, and no difference was found in confidence between third- and fourth-year students (p>0.015) for all questions.
4. The Script Concordance Test showed that the fourth-year students' (M = 82.5, SD = 20.2) scores for clinical reasoning for periodontal diagnosis in pediatric patients were higher than third years (M = 80.5, SD = 19.6). Thus, the student responses were generally congruent (80-82%) with the experts (100%). There was no statistically significant difference, t (47) =-0.33, p=.74, between the third- and fourth-year students. The minimum score obtained by a student (third-year and fourth-year) was 50% and the maximum score was 100%.
5. The verbal analysis of the interview data showed that:
    i. The students searched through the clinical problem either in a forward direction, backward, or combination. Most of the students in this study used the former.
    ii. The students used the classification of periodontal diseases by World Workshop of Periodontology 2018 for the diagnosis and treatment planning.
    iii. The students identified the relevant information from the clinical case to formulate the diagnosis and treatment plan.
    iv. Further, the student's confidence in diagnosing and treating periodontal disease in pediatric patients was also reported, and the reasons for that were explored. Besides, students' ways to improve their confidence in diagnosing and treating periodontal diseases in children were explored.

Chapter Five: Discussion

The objective of this study was to examine the effectiveness of third- and fourth-year dental students' training on periodontal diagnosis and treatment planning in pediatric patients.

This study is based on the theoretical framework put forth by Newell and Simon (1972) that the experts can be differentiated from the novices in the way they search through "problem spaces". A problem space consists of elements, operators as well as the way these operators work through these elements, that is, all possible or permissible strategies to help search through the problem spaces. Therefore, a problem representation is a model of the search performance of a solver on a specific problem and it has the following parts (Newell, 1972):

1. Understanding Phase: This phase comprises the knowledge about the starting state, the goal state, the permissible operators, and the constraints.
2. Search Phase: This phase consists of a step-by-step search path that could have different patterns like depth-first vs breadth-first or backward search vs forward search.

Based on this framework and to meet the objectives this explanatory sequential mixed-method study was designed. The study started with the quantitative aspect which was comprised of the assessment and comparison of the knowledge and confidence of the third- and fourth-year dental students regarding periodontal diagnosis in pediatric patients utilizing a survey. The reasoning for the specific diagnosis and treatment plan was measured and compared between the third- and fourth-year students and the experts using the Script Concordance Test in three clinical case scenarios. To allow for a further explanation of the results, including the reasoning process and knowledge representation of the students in both groups, verbal reporting, and Think-Aloud interviews were then employed. These verbal components constituted the qualitative phase of the research.

The results of this study will be discussed here within each research question and compared with the existing literature. Then the rigor and limitations of this study, as well as the educational implications of these findings will be explored. Finally, the future directions for further studies will be discussed.

1. Is there a difference in knowledge and confidence of third- and fourth-year undergraduate dental students in formulating a periodontal diagnosis, treatment planning, and maintenance phases?

The survey was conducted to answer this first research question. There was a dissimilarity in the participation rate of the third-year and fourth-year. Almost twice the number of students in their third-year completed the survey as compared to their senior counterparts. This may be another reason for them to be performing well with their senior counterparts for both knowledge and confidence. The answers to the survey questions by the specialists were taken as the gold standard in this study. As such, the students were scored against the experts' responses. The inter-rater reliability results showed that there was good reliability between experts. This would rationalize that they were taken as the gold standard. However, a low degree of reliability was found between the students and the experts. A low ICC is indicative of a low degree of rater or measurement agreement. Some of the reasons for this finding may be due to the lack of variability among the sampled subjects, the small number of subjects, and the small number of raters being tested (Koo & Li, 2016). In addition, the parameters used in this study to calculate ICC like 'single rater, absolute agreement, and 2-way random effects generally give lower inter-rater agreement as compared to other parameters like mean raters, consistency, and one-way random effects, respectively (Koo & Li, 2016).

No statistically significant difference in the knowledge for periodontal diagnosis in pediatric patients was observed between the third- and fourth-year students. This was in contrast to the belief that as one advances through a program/learning process, their knowledge increases. This can be explained by the fact that, as per the University of Alberta undergraduate dentistry curriculum, much emphasis is given to the students' didactic training in periodontology and pediatric dentistry at the beginning of third-year. As the students advance through the training, they are introduced to the clinical perspective focussing on the discussion about diagnosis, treatment plan, re-evaluation, and recall. The focus of the training gradually changes from didactic to clinical from third- to fourth-year. Therefore, in comparison to the fourth-year, where clinical training is emphasized, third-year students were more recently exposed to the didactic content, making it easier for them to recall the parameters of periodontal and pediatric procedures.

Confidence is the self-perception of the knowledge and is not reflective of actual competence. Confidence directly affects the individual's decision-making skills(Teh et al., 2020). In an ideal situation, it is best if the students and the practitioners have a positive self-assessment along with knowledge and skills. For this component of the study, it was found that the third-year and the experts had similar confidence levels in treatment planning for cases 1 (plaque-induced gingivitis) and 3 (aggressive periodontitis). The fourth-year students share similar confidence to the experts in the medical history, probing challenges and specifying the indications of root planing. The third-year had more confidence in the theoretical aspect, as it is taught didactically as well as clinically in the third-year while in the fourth-year students are more focussed on the clinical aspect and are thus, more confident in identifying indications of a procedure and challenges encountered in the practice. However, for all the other questions based on a periodontal examination, diagnosis, recall determination, and treatment planning for clinical case 2, the confidence was different between the fourth-year students and the experts. These findings correlate with a study by Hansson et al., (2017) where they studied the experts 'and novices' assessment of their knowledge and ignorance in four disciplines including history, medicine, physics, and psychology. The authors found students reported a low level of knowledge in their discipline, but no difference was found in other disciplines when compared to the experts (Hansson et al.,2017).

2. Is there a difference in the clinical reasoning of the third- and fourth-year undergraduate dental students when formulating a periodontal diagnosis?

Clinical reasoning was studied quantitatively and as a group measure using Script Concordance Test (SCT). It assesses the reasoning skills of the individuals under the circumstances of uncertainty as in the real clinical situation and has also been used to distinguish between the clinical reasoning skills of the practitioners and the students at different levels of training (Humbert et al., 2011). The higher the congruency, the more favorably the students have been found to interpret the information provided. Script concordance test has been used in medical sciences and nursing, however, in dentistry, the use of SCT is limited to only a few studies (Deshpande et al., 2017). In our study, it was found that the student responses were generally congruent with the experts (80-82%) but there was no statistically significant difference between the third- and fourth-year students. One of the reasons for this could be that both the third-year and the fourth-year have

some clinical experiences and thus, could have previous be exposure to this type of cases. This is in line with the outcome that there was no difference in the knowledge of the students in both years of their training. Knowledge significantly influences the interpretation and reasons for formulating a diagnosis, which in turn affects the treatment plan (John et al., 2013). The students mostly differed from the experts in answering the question for the diagnosis of plaque-induced gingivitis followed by the third- question for diagnosis (gingivitis associated with systemic diseases). However, there was a relatively high concordance between the experts and the students on the question for the diagnosis of aggressive periodontitis. This may be because aggressive periodontitis has more apparent pathognomonic features when compared to gingivitis even though plaque-induced gingivitis is more common in children than aggressive periodontitis (Grade C) (Califano, 2003). To explain these results further, individual clinical reasoning and decision-making were studied via interviews.

Process of Clinical Decision Making

Experts and novices differ not only in the knowledge extent but also in the representation of this knowledge. The differences in the organization of knowledge in the context of a specific domain can be studied by the contrived tasks(Chi, 2006). The four most extensively used contrived tasks for revealing representational differences are a) recalling (creating meaningful chunks from memory as one progresses through training); b)perceiving (how the experts and novices see the more subtle cues and describe the relationship between cues); c) categorizing (can reveal the structure of experts' knowledge, showing how it is arranged and differentiated at both subordinate and superordinate level); d) verbal reporting (task reflection is done as the participants attend to problems). Verbal reporting can be done via three techniques (Chi, 2006):

i) Concurrent think-aloud Protocols: Here the participants verbalize the problem information to which they are attending.

ii) Interviews: These include the task to be performed (concurrent Think-Aloud interviews) and carefully crafted questions to focus on a specific topic/ scenario and are often sequenced in a meaningful order.

iii) Explanations: Here the participants provide answers to the questions generated by themselves.

In this study, we conducted a semi-structured interview with the concurrent think-aloud method of verbal reporting. The same method was used in the study conducted by (Crespo et al., 2004) to compare and study the reasoning process across individuals of varying expertise. The phenomenon of clinical reasoning differs across the health professions like medicine, nursing, physiotherapy, and dentistry. The research on understanding the clinical reasoning in dentistry has mainly focussed on the outcome as compared to the process (Balto & Al-Madi, 2004; Knutsson et al., 2001). It has also been found that the reasoning processes used by dentists and dental students vary by their level of expertise (Crespo et al., 2004; Higgs et al., 2008).

The interview data were analyzed using verbal analysis. According to (Chi, 1997), verbal analysis is a method of quantifying the qualitative coding of the contents of the verbal utterances. In this method, one tabulates, counts/draws relations between the occurrences of different kinds of utterances to reduce the subjectiveness of qualitative coding (Chi, 1997). It is generally used to identify the representation of a student's knowledge about a task (Chi, 1997; Leighton, 2009). Using the verbal analysis, three different patterns of reasoning were identified the forward search, backward search, and combination. These patterns have also been described by Higgs and Jones(2008) to explain clinical reasoning in dentistry (Higgs et al., 2008; Leighton, 2009). In this study, it was found that the majority of the third-year (60%) and the fourth-year (50%) students used forward reasoning. This explains the SCT results where no statistically significant difference in reasoning skills of the third- and fourth-year was used. (Crespo et al., 2004), in a previous observation show that the experts tended to use forward reasoning and recognition of patterns and scripts, while novices tended to use backward reasoning and relied mainly on their didactic knowledge. Groen and Patel (1988) proposed that for any situation, an individual creates a model and continues to use that model in a forward manner precisely until some unfavorable condition is encountered(Groen & Patel, 1988). This could not only explain the use of forward reasoning by the experts but also by the less experienced students. In this study, the third years may have a script for the aggressive periodontitis case / Grade C periodontitis case, and they continued to use that script to reason their diagnosis and treatment plan. The specific features of the disease would have helped the less experienced individuals create this script. Anytime they are encountered with a similar situation/ case, the same script is activated. This is in line with the study by Khatami S. (2011) where they explained that the patterns of the disease, recognised through the scripts are commonly used to identify periodontal disease(Khatami & Macentee, 2011).

Backward reasoning was used by three fourth-year and six third-year participants. They arrived at both the correct as well as incorrect diagnoses using this approach. This is a type of deductive approach used when there is a less extensive knowledge base (Crespo et al., 2004). The participant thinks of a possible diagnosis and then works backward to find out the pieces from the information which support that diagnosis. One fourth-year student used both forward and backward reasoning. This is known to compensate for their lesser experience, as determined by Crespo et al., (2004).

Being able to identify the relevant information for the diagnosis and treatment planning can provide an insight into the organization of knowledge for an individual. As explained by Friedman(1998) and Bordage(1994) the error in clinical reasoning can arise at any of the three steps: 1) deficiency in their knowledge, 2) incorrect data collection, and 3) erroneous analysis of the data (Bordage, 1994; Friedman et al., 1998). Students asking for key additional information and correctly identifying information from the one provided shows that some participants were able to avoid the potential areas of error in clinical reasoning.

When students were asked how they diagnose periodontal disease in children, they reported that they diagnose the periodontal disease in children the same way as they do in adults but with much lesser confidence. Students stated that the reason for their lower confidence was a lack of adequate clinical exposure. Students felt that they did not have enough periodontal disease cases in pediatric patients in the clinics and did not always have a specialist instructor to supervise and teach them. Thus, it can be deduced that although they diagnosed the disease the same way as adults, students were not certain if this was the appropriate way to do it. The low prevalence of periodontal disease in pediatric patients could account for the inadequate student experience in this field. Additionally, many students stated that they did not probe all pediatric patients which could further lead to the underestimation of periodontal disease in the undergraduate pediatric clinic and the students' limited exposure to the disease. Finally, the child's co-operation could also be a limiting factor to probing.

Educational Interventions to Improve the Students' Confidence

To overcome this and provide students with enough exposure for diagnosing and treating pediatric periodontal disease, it is recommended that a quick probing (PSR/ CPITN) be performed in all pediatric cases and the need for further assessment be determined thereafter.

The various confidence-building strategies have been recommended in the literature. Those about dentistry are explained here:

1. Simulations: In a lab setting, where the students are trained in a clinical controlled environment. This allows the students to practice a newly acquired skill and to get immediate feedback. This, in turn, improves their preparation for the clinics and gives them more confidence for the clinics(Hecimovich & Volet, 2009; Lundberg, 2008).

Since its inception, the phantom head simulator has been the classic and predominant simulation technology for dental education. A growing number of computer-assisted and virtual reality simulators have been introduced around the world over time. Simulation software is widely being used to help orthognathic surgery planning and implant treatment, as well as the diagnosis and treatment of periodontal (gum) disease throughout the dental specialties. Periodontal disease is presently being assessed, implant and maxillofacial surgery is being prepared, and 3D simulated teeth are being restored using dental haptic-enhanced VR simulators (Perry et al., 2015).

The advantages of virtual reality are that these are more effective than the traditional simulation teaching techniques. VR offers more efficient learning, objective and reproducible feedback, unlimited training hours, and enhanced cost-effectiveness for teaching establishments. On the contrary, there are high initial setup costs associated, investment in faculty training, and a lack of current educational simulation programs (Perry et al., 2015).

Hence, we should take advantage of the available expansion in the experiential learning tools which imitate "real life" clinical conditions in dentistry. This would be particularly useful to overcome limited cases of periodontal diseases in children.

Suvinen et al. (1998) investigated the early experiences and attitudes of second, third, and fourth-year undergraduate dentistry students at the University of Melbourne and assessed some of the equipment currently available for simulation of clinical operations. They compared preclinical

activities in a typical bench and mannikin laboratory to case-based simulations in a patient simulator. Throughout a three-year testing period, student feedback on teaching and learning in the simulator was uniformly favorable, as measured by a student questionnaire. The learning atmosphere and teaching method were appreciated by students, who preferred it to typical preclinical laboratory instruction(Suvinen et al., 1998).

2. Problem Based Learning(PBL): PBL is a student-centered approach in which students learn about a subject by solving an open-ended problem in trigger material. The PBL approach does not emphasize problem-solving with a predetermined answer, but it does allow for the development of other desirable abilities and characteristics. This includes increased group collaboration and knowledge development (Hecimovich & Volet, 2009). The Centre for Oral Health Sciences at the Sweden Malmö University, in 1990 became the first dental school to adopt PBL. Hong Kong School in China, Dublin School in Ireland, University of South California (USC) in the United States of America, and Manchester School in the United Kingdom are a few more schools that have fully integrated PBL in their undergraduate dental curriculum (Shaju Jacob, 2011).

The implementation of PBL in just Pedodontics at Wuhan University's School of Stomatology (WHUSS) in China in 2000 received a positive response from students and faculty. This included improving students' capacity to convey ideas in a group context, improving a practical approach to solving dental treatment-related difficulties, and developing critical thinking skills, and also increased their enthusiasm for learning (Wang et al., 2008). This eventually led to adopting the PBL curriculum across various disciplines at WHUSS was established for the clinical education of the seven-year program students (Wang et al., 2008).

Bassir SH et al. (2014) conducted a systematic review in which they assessed the efficiency of problem-based learning (PBL) to traditional (non-PBL) approaches in dental education. They discovered that PBL had a beneficial impact on students' confidence in their ability to practice dentistry, which can have a positive impact on their future careers (Bassir et al., 2014).

A study was conducted to assess both knowledge and confidence gained by dental undergraduate students in the Head and Neck Anatomy course by employing didactic lecture-based and problem-based learning methods. It was found that both methods were effective in the improvement of knowledge and confidence. However, no significant reduction in the pre-clinics

knowledge and confidence scores among the PBL lessons proves it to be a potent learning tool for long-term retention of knowledge, and sustainability of confidence (Al-Madi et al., 2018).

PBL students outperformed their classmates in a standard lecture-based curriculum on the United States National Dental Boards Exam (NDBE) (Part I) tests, according to a survey of dental students at the University of South Carolina (USC). USC's "genuine PBL" curriculum includes no planned lectures and follows a PBL pedagogy throughout the four years of the program. PBL was introduced into the first, second, and third (clinical year) dentistry courses at Harvard School of Dental Medicine (HSDM) in 1994. The use of PBL in this setting improved NDBE Part I scores, graduation rates, and the percentage of graduates who went on to postgraduate programs, as well as lowering attrition rates (Shaju Jacob, 2011; Susarla et al., 2003).

3. Peer modeling: It is a purposeful pairing of the students where one observes the other in performing the desired behavior, in a clinical situation in our case (Lundberg, 2008).

In the restorative department at Glasgow Dental School, a pilot project using peer-aided learning (PAL) to teach dental clinical skills was carried out. In a clinical (impression taking) and pre-clinical (handpiece skills) assignment, Bachelor of Dental Surgery (BDS) students from peer-led groups against staff-led groups were compared in a cluster randomized controlled trial. For each activity, BDS5 (peer tutors) offered instruction to BDS1 (tutees) in their last year. Questionnaires were used to collect quantitative data from tutees and peer tutors, as well as open textual comments. Both tutees and peer tutors were enthusiastic about PAL. BDS1 tutees appreciated BDS5 peer tutors for their knowledge delivery and quality of feedback. Peer tutors were seen as more approachable and less intimidating than employees by the tutees. As a result of instruction, peer tutors indicated that their knowledge had risen. No statistically significant difference between the performance of peer-led and staff-led groups was identified in a summative OSCE (objective structured clinical examination) four months after the teaching. It is claimed that PAL can contribute to the development of graduate competencies in addition to being a useful technique of giving subject-specific training(Cameron et al., 2015).

4. Preceptorship/ internship/ outpatient: The more clinical experience that the students gain by having more clinical exposure is directly proportional to the increase in their confidence (Lundberg, 2008). There are various preceptorship programs available in specialties like

periodontology, Pediatric dentistry at various dental schools. These are generally one-year programs to provide advanced training to the undergrads/ beginning general dentists.

Therefore, the literature supports various strategies to be useful to improve students' confidence and learning experience. These methods can be gradually adopted at the School of Dentistry, the University of Alberta depending on their feasibility.

Concept of Self-directed and Autonomous learning associated with confidence

Pajares defined self-efficacy as people's confidence in their ability to accomplish goals, while Sanders and Sanders stated that self-efficacy is the parent idea of academic confidence and may come from the same sources as self-efficacy (Hecimovich & Volet, 2009; Sander & Sanders, 2003).

Recently, self-efficacy and self-beliefs are being seen as key indices of achievement motivation. The perceptions that the students construct, develop, and believe to be true about themselves and their academic talents are crucial forces in their success or failure in school, as per educational research (Pajares & Schunk, 2005).

The significant work by Bandura on self-efficacy theory (Bandura, 1977, 1993), provides important insights into understanding students' confidence in themselves as learners, as it takes into consideration the situation-specific and flexible judgments. These judgments are focused on the future (Bong & Skaalvik, 2003). Self-efficacy theory argues that people's confidence about being able to perform a specific action comes from four sources of information: mastery experience, verbal persuasion, vicarious feedback, and physiological feedback(Sander & Sanders, 2006).

Bandura defined self-efficacy as a person's judgments of their capabilities to organize and execute the courses of action required to attain designated types of performance (Bandura, 1977). Self-efficacy research has aided in elucidating the role of ability and self-confidence in one's ability in academic performance and employment outside of education (Crozier, 1997).

Although self-efficacy is a perception that may or may not correlate with outcome standards of capacity, it plays a vital mediating role in cognitive motivation and, as a result, impacts behavior choice and goal persistence (M. K. Ponton & Rhea, 2006). When a person

chooses an activity, he or she uses self-regulation to act toward a pre-determined goal and self-reflection to assess activities in terms of goal achievement and desired consequences. Self-efficacy has a role in this as well. Individuals who believe they are incapable of accomplishment will avoid the task regardless of the potential for positive outcomes (M. K. Ponton & Rhea, 2006).

Consistent with this aspect of social cognitive theory, Ponton and Carr in 1999 presented a model of self-directed learning. This model encompasses two dichotomous elements: (a) general and contextual applications, and (b) learner self-directedness and self-directed learning(M. K. Ponton, 1999).

According to this model, the examination starts with general beliefs about the situation. General beliefs contribute to the information that leads to one's attitudes about various objects which in turn creates a personal value system. This value system help identify the desired outcomes from life. These desired outcomes help the individual take relevant actions. As specific actions related to specific outcomes are appraised, decisions become increasingly context-specific. Beliefs regarding a variety of actions (such as self-efficacy assessments, goal-outcome correlations, and potential barriers) influence the choice of the most desirable course (i.e., a positive attitude toward given conduct) prompted by expected outcomes (M. K. Ponton, 1999).

Self-directed learning is an activity in which agents (i.e., learners) are inwardly motivated to engage based on socially influenced and personally judged values and assessments of capacity. A subset of actions linked with any self-directed learning endeavor is referred to as autonomous learning (M. K. Ponton & Rhea, 2006).

Ponton et al. (2004) proposed a route analytic model for autonomous learning, proposing that creativity, which is mediated by initiative, has a significant impact on persistence (M. Ponton et al., 2004). As a result, a training facilitator should emphasize first efforts on increasing learner creativity to encourage autonomous learning characteristics. Learners prefer and choose to learn above non-learning actions when the instructor assists them in anticipating the future outcomes of active learning over non-learning activities. Mentors who design courses that allow students to improve their academic activities can improve exams that show improvements in learning abilities give students the tools they need to succeed. In his or her self-directed learning activity, an independent learner demonstrates knowledge, effort, and perseverance.

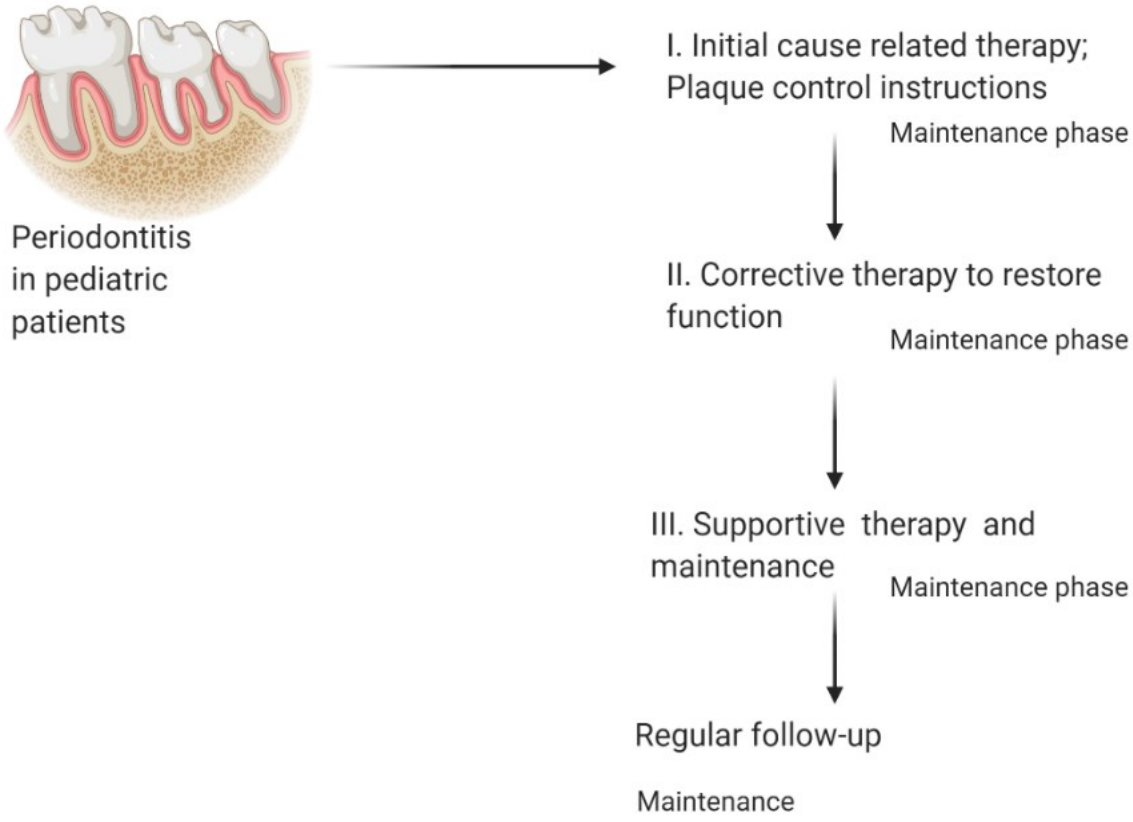
The most common challenge identified by the students in diagnosing periodontal diseases in pediatric patients was the patient factors, such as child cooperation and, anatomical factors in children's teeth because of the different stages of eruption and the presence of pseudo pockets. These findings agree with the challenges identified by (Clerehugh & Tugnait, 2001). The majority of the students identified formulating an accurate diagnosis as the most important factor in determining the treatment plan for periodontal cases in pediatric patients. This is in alignment with the finding of another study that to treat a disease adequately, a correct periodontal diagnosis should be made (John et al., 2013).

When the students' approaches in formulating a treatment plan for the periodontal disease were considered, the most common one was the importance of patient education. In addition, the parental role was also considered important for determining the success of the treatment by the students participating in this study. Periodontal disease is a chronic disease. For the successful treatment of periodontal disease, the patient must do their part in being actively involved in maintaining their oral hygiene. However, low compliance of children to daily flossing, fluoride rinsing, and use of fluoride gel was found in a study done by Ashkenazi et al. (2007) in children attending recall appointments at a pediatric dental specialists' office (Ashkenazi et al., 2007). In another study by Ashkenazi et al. (2012), it was found that pediatric patient's compliance was low with the most common reason cited as 'I forgot'. Thus, it is crucial to remind and emphasize the importance of the participation of the parents in maintaining the oral hygiene of their children (Ashkenazi et al., 2012). Further, in this study, they identified that one of the reasons for non-compliance was negligence and delays on part of the parents in providing appropriate aids for maintaining home care. As found by (Clerehugh & Tugnait, 2001) the parental involvement is a must in children under the age of 7 years as they have limited manual dexterity. As the age advances, the parental involvement may consist of supervision only.

(Clerehugh & Tugnait, 2001), explained that the periodontal disease treatment in pediatric patients is carried out in three phases, as explained in Figure 5.

Figure 5.

Phases of periodontal therapy in children



Note. The figure represents the phases of periodontal treatment in children. Adapted from: "Diagnosis and management of periodontal diseases in children and adolescents.", by V. Clerehugh, A. Tugnait. 2001, Periodontol 2000,26(1): 146–168.

Similar patterns for treatment approaches were found in this study. There was a general approach to start with scaling and root planing, aiming to remove the plaque and calculus on teeth surfaces, as they are the main etiological factors for gingival and periodontal diseases. The recommended corrective therapy for the case comprised of the use of antibiotics along with scaling and root planing, as well as an appropriate referral to the specialist for any surgical treatment. The participants also emphasized scheduling maintenance visits for pediatric patients with periodontal disease. They recommended starting with every three months and extend it based on the patient's response to treatment.

When asked about their confidence in treatment planning for periodontal disease cases in pediatric patients, the participants responded to be either neutral or not confident. The reason for this could be their low confidence in the diagnosis. The students recommended having more clinical cases for periodontal disease in pediatric patients to improve their confidence. They also recommended having both a pediatric dentist and a periodontist present in the clinics. This inter-disciplinary management of cases could be excellent learning as the periodontist can teach the diagnosis and treatment planning for periodontal cases and the pediatric dentist can tailor those for the pediatric patients. Students also suggested increasing the number of lectures and case presentations on periodontal diagnosis in pediatric patients, as this would give them more clinically oriented exposure to the disease.

Hence, this study helped us recognize the effect of a year of training on the knowledge, confidence, and reasoning skills of the students for periodontal diagnosis in pediatric patients. The study shows that the students though have a good knowledge base and decision-making skills, have low confidence in diagnosing and treating periodontal cases in pediatric patients. The reasons for this should be analyzed and efforts should be made to collaborate periodontal and pediatric dental education to make the dental students and thus, general practitioners more confident in diagnosing and treating periodontal disease in pediatric patients.

Chapter Six: Conclusion

To diagnose and treatment plan a clinical case, a clinician should understand the subject. The representation of their subject knowledge significantly affects their clinical decision-making. This study was designed to explore the effectiveness of training of third- and fourth-year students on their knowledge, confidence, and clinical reasoning for periodontal diagnosis in pediatric patients. When comparing the students, it was found that the third-years performed at par with the fourth-years in terms of knowledge, confidence, and clinical reasoning (quantitatively and qualitatively). The search pathway of the students for problem-solving at an individual level was explored through the qualitative aspect. It was identified that most of the students used the forward pattern of search, which resembles that of the experts. Also, most of them identified the relevant information for periodontal diagnosis as per the diagnostic criteria of the 2018 Classification of periodontal and peri-implant diseases (AAP).

When comparing the experts and the students, the student's knowledge and clinical reasoning outcomes were congruent with the experts. However, confidence which is the self-perception of knowledge was varied among the students and experts. During the interviews, most third-and fourth-years reported their confidence to be three on the Likert scale (neutral or unsure). The students' main reasons for this were their limited experience in periodontal disease diagnosis and treatment planning in children. Some other reasons were that clinical training in pediatric patients does not involve probing every tooth and not having a periodontist as an instructor/ supervisor when they see the pediatric patients. Thus, though the students' knowledge and clinical reasoning were not significantly different from the experts, the students had low confidence (self-perception) in diagnosing periodontal disease in pediatric patients.

The students' recommendations for improving their confidence were that they should be able to do more cases, inter-disciplinary management of cases (periodontics- pediatric dentistry) and have more lectures with case presentations for these. These students will become the future general practitioner and will be the first point of contact for the patients, even before the specialist. Therefore, efforts should be made to improve their confidence in diagnosing and treating periodontal disease.

Limitations and Future Directions

This research was done only at one School. In the future, it can be extended to other Canadian and North American Schools. In addition, the level of training at the School of Dentistry, University of Alberta can be compared to other schools in North America. In our study, only three clinical cases were included for the Script Concordance test, and the future multi-center study should have more questions for the script concordance test. The instructor calibration directly affects the students' knowledge, confidence, and clinical judgment, and hence, in future studies, the participating experts can be calibrated to increase inter-rater reliability. Also, observations can be included in the qualitative phase as it would give us an accurate assessment of what the students do in the clinics while diagnosing periodontal disease in pediatric patients. This would also add evidence to the interview.

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Appendix

Appendix A - REB Approval

Notification of Approval (Renewal)

Date:	August 19, 2020	
Principal Investigator:	Ida Kornerup	
Study ID:	Pro00083394	
Study Title:	Students' approach to the formulation of a periodontal diagnosis and treatment plan of pediatric patients: examining the effect of didactic and clinical experiences from a mixed methods perspective	
Sponsor/Funding Agency:	University of Alberta Faculty of Medicine and Dentistry	FOMD
Approved Consent Form:	Approval Date 9/27/2018 9/27/2018 5/8/2020	Approved Document Informed Consent - Interview Information sheet Modified consent form PDF
Approval Expiry Date:	Wednesday, August 18, 2021	

Thank you for submitting this renewal application. Your application has been reviewed and approved.

This re-approval is valid for one year. If your study continues past the expiration date as noted above, you will be required to complete another renewal request. Beginning at 30 days prior to the expiration date, you will receive notices that the study is about to expire. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to recruit and/or interact with human participants at this time. Researchers still require operational approval as applicable (e.g. AHS, Covenant Health, ECSD etc.) and where in-person interactions are proposed, institutional and operational requirements outlined in the Resumption of Human Participant Research - June 24, 2020 must be met.

Sincerely,

Anne Walley
REB Specialist,
on behalf of Ubaka Obgogu, LLB, BL, LLM, SJD
Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B- Survey

Diagnosis and Treatment Planning for Periodontal Pediatric Patients

Resize font:

Diagnosis and Treatment Planning for Periodontal Pediatric Patients

You are invited to participate in a research study as part of an initiative to discover your perspectives on the formulation of periodontal diagnosis and treatment plans in pediatric patients at the University of Alberta, School of Dentistry. You are integral to this study as you will be providing your perspective of how you would diagnose and treat Periodontitis in pediatric patients. This study will help inform our faculty of the challenges dental students are facing when it comes to Pediatric Periodontal training. This study will endeavor to ensure that future courses prepare students effectively for clinical practice.

Submission of this survey indicates consent to participate in this research study.

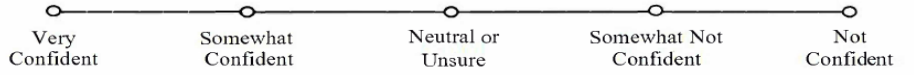
Thank you for your participation!

Please select the option that applies to you:

- ○ Third-year dental student
- ○ Fourth-year dental student
- ○ Periodontist
- ○ Pediatric Dentist

reset

Please refer to this Likert scale for the following questions.



1. a) A pediatric patient presents with gingival or periodontal disease. What medical history questions do you feel are important to ask?

Expand

1. b) Using the provided scale, rate your confidence level in taking a detailed medical history for pediatric patients with gingival or periodontal disease:

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

2. a) In your opinion, what constitutes a thorough gingival and periodontal examination?

Expand

2. b) Using the provided scale, rate your confidence level in completing a thorough gingival periodontal examination in a pediatric patient:

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

Diagnosis and Treatment Planning for Periodontal Pediatric Patients

3. a) What challenges do you face when performing periodontal probing in a mixed dentition versus an adult population?

Expand

3. b) How would you calculate true clinical attachment level?

Expand

3. c) Using the provided scale, rate your confidence level in determining probing depths in mixed dentition:

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

4. a) What do you consider when forming a diagnosis for gingival and periodontal diseases in pediatric patients?

Expand

4. b) Using the provided scale, rate your confidence level in diagnosing gingivitis and/or periodontitis in a pediatric patient:

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

5. a) Some patients require scaling while others require scaling and root planing. Explain why a patient would require scaling only versus scaling and root planing together:

Expand

5. b) Using the provided scale, rate your confidence level in your ability to perform scaling and root planing procedures:

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

6. a) What are the chief considerations when determining the recall interval in your pediatric patients with gingival or periodontal disease?

Expand

Diagnosis and Treatment Planning for Periodontal Pediatric Patients

6. b) Using the provided scale, rate your confidence level in your ability to determine the maintenance schedule for pediatric patients with gingival or periodontal disease:

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

For the following three cases:
- consider the provided information
- determine your diagnosis
- determine your treatment plan for the patient
- determine the time intervals of your planned maintenance schedule

Please refer to the following AAP2018 Classification of Periodontal and Peri-Implant Diseases

Attachment: Classification at a glance.pdf (0.05 MB)

Attachment: Staging and Grading Periodontitis.pdf (0.24 MB)

7 Case History: A 8-year-old Caucasian male with no significant medical history and no history of trauma presented with a parent and reported chief complaint of: "My dentist told me that my child has bleeding teeth." Patient is in mixed dentition phase.

7. a) What is your diagnosis? (only provide one using classification given above)

Expand

7. b) How confident do you feel in your diagnosis for this case?

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

Consider photos of the case, periodontal charting, and radiograph in addition to the above information and answer the following questions.

Charting:

BUCCAL

	53	12	11	21	22	63
PD	2 2 2	2 2 3	3 2 3	3 2 3	3 2 2	2 2 2
GM	0 0 0	0 0 -1	0 0 0	0 0 0	0 0 0	0 0 0
CAL	2 2 2	2 2 2	3 2 3	3 2 3	3 2 2	2 2 2

7. a) What is your diagnosis? (only provide one using classification given above)

Expand

7. b) How confident do you feel in your diagnosis for this case?

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

7. c) What is your ideal treatment plan for this patient? (do not consider financial barriers or patient motivation constraints)

Expand

7. d) How confident do you feel in your treatment plan for this case?

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

7. e) **How frequently would you schedule recall appointments for patient maintenance?**

Expand

7. f) **Would you refer this case to a specialist?**

- Yes
- No

reset

8 **A 15-year-old African- American male presents with the chief complaint of "My teeth are loose." The patient noticed blood in his gingiva whenever he brushed. He also noted his gums bled when flossing. The patient claims to brush his teeth once daily in addition to flossing two to three times weekly.**

8. a) **What is your diagnosis? (only provide one using classification given above)**

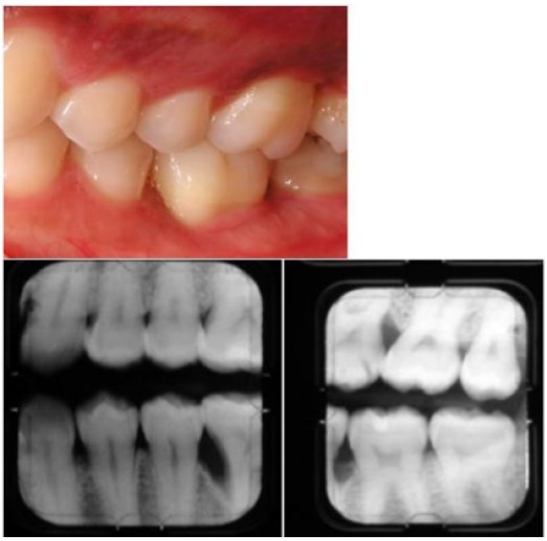
Expand

8. b) **How confident do you feel in your diagnosis for this case?**

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

Consider photos of the case, periodontal charting, and radiograph in addition to the above information and answer the following questions.



Charting:

BUCCAL

	35	36	37
PD	2 1 5	7 3 6	5 2 3
GM	0 0 1	2 1 0	1 0 1
CAL	2 1 6	9 4 6	6 2 4

8. a) What is your diagnosis? (only provide one using classification given above)

Expand

8. b) How confident do you feel in your diagnosis for this case?

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

8. c) What is your ideal treatment plan for this patient? (do not consider financial barriers or patient motivation constraints)

Expand

8. d) How confident do you feel in your treatment plan for this case?

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

8. e) How frequently would you schedule recall appointments for patient maintenance?

Expand

8. f) Would you refer this case to a specialist?

- ○ Yes
- ○ No

reset

9 A 13-year-old Caucasian female presented with a chief complaint of "Bleeding gums on brushing and swollen gingiva in specific areas of the mouth." The patient was referred for a periodontal consultation. Relevant medical history: Patient reports at onset of puberty within past 6 months.

9. a) What is your diagnosis? (only provide one using classification given above)

Expand

9. b) How confident do you feel in your diagnosis for this case?

- ○ Very Confident
- ○ Somewhat Confident
- ○ Neutral or Unsure
- ○ Somewhat Not Confident
- ○ Not Confident

reset

Consider photos of the case, periodontal charting, and radiograph in addition to the above information and answer the following questions.

BUCCAL

	12	11	21	22
PD	3 3 3	3 3 3	3 2 3	3 2 3
GM	0 0 0	0 0 0	0 0 0	0 0 0
CAL	3 3 3	3 3 3	3 2 3	3 2 3

9. a) What is your diagnosis? (only provide one using classification given above)

Expand

9. b) How confident do you feel in your diagnosis for this case?

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

9. c) What is your ideal treatment plan for this patient? (do not consider financial barriers or patient motivation constraints)

Expand

9. d) How confident do you feel in your treatment plan for this case?

- Very Confident
- Somewhat Confident
- Neutral or Unsure
- Somewhat Not Confident
- Not Confident

reset

9. e) How frequently would you schedule recall appointments for patient maintenance?

Expand

9. f) Would you refer this case to a specialist?

- Yes
- No

reset

Submit

Appendix C - Student information Sheet

Study Information Sheet

Project: Students' approach to the formulation of a periodontal diagnosis and treatment plan of pediatric patients: examining the effect of didactic and clinical experiences from a mixed methods perspective

Investigators: Dr. Ida Kornerup, Dr. Monica Gibson, Disha Nagpal

Background:

You are invited to participate in a research study as part of an initiative to discover your perspectives on the formulation of periodontal diagnosis and treatment plans with pediatric patients at the University of Alberta, School of Dentistry. You are integral to this study as you will be providing your perspective of how you would diagnose and treat Gingivitis and Periodontitis in children between the ages of 6-11. This study will help inform our faculty of the challenges dental students are facing when it comes to Periodontal training in pediatric clinics. This study will endeavor to ensure that future courses prepare students effectively for clinical practice. Additionally, the findings of this study may be presented and published as part of our scholarly research in dental education.

Before you decide if you wish to take part, you need to understand why the research is being done and what it will involve for you. Please take the time necessary to read the following information, and ask your facilitator(s) if you have any questions.

Purpose:

Specifically, we hope to accomplish the following: to capture student perspectives their level of comfort and confidence in diagnosing, treating, and maintaining pediatric patients who present with gingivitis or periodontitis as well as clinical scenarios. This study will include two phases. Phase 1 will be an online anonymous survey, followed by phase 2 which includes interviews with students to capture their perspectives on periodontal pediatric patients, and any areas of training where students feel further emphasis and clarification is needed.

Participating in this study will involve:

This study will involve two phases, a survey followed by one-on-one interviews with a facilitator (see below for contact information of the facilitators within this project) who will be your point of contact with this study.

For **Phase 1**, all that is required is for you to participate in a single online survey that should take about 15 – 20 minutes to complete. You may complete the survey on your own time, or attend a lunch-time session with the facilitator. These questions are not invasive, and, if you do not feel comfortable, you may choose not to answer a single question or not submit the survey. This survey will be online and at no time will your identity be captured in the completion and submission of the survey. Submission of the survey implies consent; data cannot be withdrawn once submitted. Once you have completed the survey, you will be taken to a second survey and asked if you wish to participate in an interview. If you say yes, you will be asked for your email. This survey is in no way connected to the first and your answers to the first survey will remain anonymous.

For **Phase 2**, all that is required of you is to attend an interview and engage in dialogue with the interviewer while answering the questions. These questions will not be invasive, and, if you do not feel comfortable, you may decline to answer that

question or end the interview. The interview will be no more than one hour in length. You may be contacted (with your permission) if clarification of a conversation or experience is required.

You may choose to participate in neither, one, or both of the phases of this study.

Possible Benefits:

Although you will not see a direct benefit within your current courses, your involvement in this study will inform our teaching and learning design and may subsequently affect future courses. You will be impacting future students in the School of Dentistry, and be setting the groundwork for the evolution of our learning environment.

Possible Risks:

There are no foreseeable risks involved in this study.

Confidentiality:

Although we will be collecting your name and contact information for the duration of the study (to be used for communication purposes only), your identity will be protected throughout the analysis and subsequent dissemination of this study. A pseudonym will be given to your interview after transcription to protect your data during analysis and dissemination. At no time will those members of the research study who are faculty within the School have access to identifiable information, or know who has participated and who has not participated in any part of this research study.

Data (researchers' notes, audio recordings, transcripts, analysis) will be kept for five years (per University of Alberta guidelines). After this time period, all data collected will be deleted and disposed of according to the University's process for the shredding of confidential materials. All digital data will be stored on encrypted devices and stored in locked cabinets, hard copies will be also be stored in locked cabinets within the Educational Research and Scholarship Centre (ECHA, 11405 87 Avenue, Edmonton, Alberta, Canada T6G 1C9) in a secured office.

Voluntary Participation:

Your participation in this study is voluntary. If you choose not to participate, or withdraw from the study, your grades or academic status in the DDS program will not be affected in any way. **One month** following your interview will be set as the last date that you may withdraw from the study for phase 2. There is no obligation on your part to continue and there is no penalty for withdrawing. Your related data (recordings, notes) can be destroyed and all references removed up to the point of data analysis.

Contact Names and Telephone Numbers:

If you have concerns about your rights as a study participant, you may contact the **Research Ethics Office** at (780) 492-2615. This office has no affiliation with the study investigators.

Please contact any of the individuals identified below if you have any questions or concerns:

Jacqueline Green, MSc
Research Assistant
Educational Research and Scholarship Unit
Phone: (780) 492-1330
Email: jgreen@ualberta.ca

Austin Fairbanks
DDS Student
Email: afairban@ualberta.ca

Thank you for your participation! Your input is extremely valuable and appreciated!

Appendix D: Interview Guide

Interview Guide – Participants (Third- and Fourth-year dental students)

Preamble

This interview is part of a research project that aims to explore your clinical thinking (or reasoning) during periodontal diagnosis and treatment plans in pediatric patients at the School of Dentistry, University of Alberta.This information will help improve periodontal education and care in our school

In this interview, you will be presented with one of the cases included in the survey you filled out for this research. You will be asked to think out load when diagnosing the case and developing a treatment plan for the case. Once this task is completed, I will ask you some follow-up questions to explore how you generally approach periodontal diagnosis and treatment plan in pediatric patients. There is no correct or incorrect answers. The information you share with us will remain confidential. We will audio-record our conversation to facilitate data analysis afterward. Our interview will last ~30 minutes.

Questions

1. What year are you? _____
2. Let us practice thinking aloud. I will guide you during this warmup, if needed. Imagine you have a 8-year-old child with periodontal issues who does not want to be treated. Please Think aloud while addressing this issue

3. You will be given a clinical case now. The case information will be provided in four cards. Read them in the order they are presented and when doing so, think out loud your diagnosis and treatment plan for this case. If you stay silent for longer, I might prompt you by asking," Keep thinking aloud." Again, we are not interested in the solution you come up with as much as we are with how you are thinking about the task. Do you have any questions about the procedure?"

Clinical Case

Segment 1: Chief complaint: A 15-year-old African- American male presents with the chief complaint of "My teeth are loose." The patient noticed blood in his gingiva whenever he brushed. He also noted his gums bled when flossing. The patient claims to brush his teeth once daily in addition to flossing two to three times weekly.

Segment2: Clinical picture

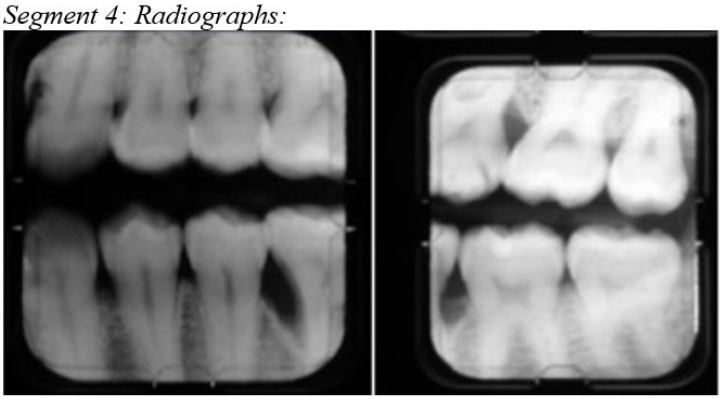
Segment 3: Periodontal charting:

***Charting*:**

BUCCAL

	35	36	37
PD	2 1 5	7 3 6	5 2 3
GM	0 0 1	2 1 0	1 0 1
CAL	2 1 6	9 4 6	6 2 4

Segment 4: Radiographs:



Follow up Questions:

1. Could you please describe what you generally do when diagnosing patients with periodontal conditions?
2. What would you do when diagnosing a pediatric patient with periodontal condition?
3. Overall, how would you assess your level of confidence in diagnosing periodontal issues. On a Likert scale of 1-5, how would you rate yourself? 1 being very confident, 3 being neutral or unsure and 5 being not at all confident. Please elaborate.
4. Could you please describe what you generally do when treatment planning patients with periodontal conditions?
5. What would you do when treatment planning a pediatric patient with periodontal condition?
6. Overall, how would you assess your level of confidence in diagnosing periodontal issues. On a Likert scale of 1-5, how would you rate yourself? 1 being very confident, 3 being neutral or unsure and 5 being not at all confident. Please elaborate.
7. Would you think can be done to improve your confidence in diagnosing and treatment planning periodontal conditions in pediatric patients?
8. Is there anything else you wish to tell us about your experiences in the periodontal diagnosis in pediatric patients?

On behalf of our research team, we would like to thank you for sharing with us your thoughts

Appendix E: Written Consent for the interview

Title of Project: Students' approach to the formulation of a periodontal diagnosis and treatment plan of pediatric patients

Investigator(s): Dr. Ida Kornerup, Dr. Monica Prasad Gibson, Dr. Disha Nagpal.
School of Dentistry, Faculty of Medicine and Dentistry, University of Alberta.

☐ I…… voluntarily agree to participate in this research study.

☐ I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

☐ I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.

☐ I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.

☐ I understand that participation involves carrying out an initial exam on a pediatric patient to arrive at a diagnosis(periodontal), create a treatment plan and maintenance schedule for the patient.

☐ I understand that I will not benefit directly from participating in this research.

☐ I agree to my actions and settings being interviewed.

☐ I understand that all information I provide for this study will be treated confidentially.

☐ I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.

☐ I understand that disguised extracts from the interview may be quoted in dissertation, conference presentation, published papers.

☐I understand that if I inform the researcher that myself or someone else is at risk of harm they may have to report this to the relevant authorities - they will discuss this with me first but may be required to report with or without my permission.

☐ I understand that signed consent forms and original audio recordings will be retained in University of Alberta until the confirmation of the results of the study.

□ I understand that under freedom of information legalization I am entitled to access the information I have provided at any time while it is in storage as specified above.

□ I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

---------- ----------

Signature of participant Date

I believe the participant is giving informed consent to participate in this study

---------- ----------

Signature of researcher Date

Appendix F: ICC between the students and the experts

Reliability

[DataSet1]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	22	22.2
	Excluded[a]	77	77.8
	Total	99	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.981	63

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.439[a]	.312	.618	53.664	21	1302	.000
Average Measures	.980	.966	.990	53.664	21	1302	.000

Two-way random effects model where both people effects and measures effects are random.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

Appendix G: ICC between the two groups of experts

Reliability

[DataSet1]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	22	100.0
	Excluded[a]	0	.0
	Total	22	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.895	14

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.317[a]	.191	.509	9.551	21	273	.000
Average Measures	.867	.768	.935	9.551	21	273	.000

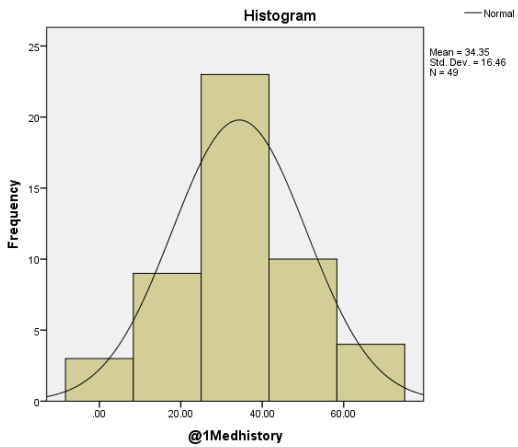
Two-way random effects model where both people effects and measures effects are random.

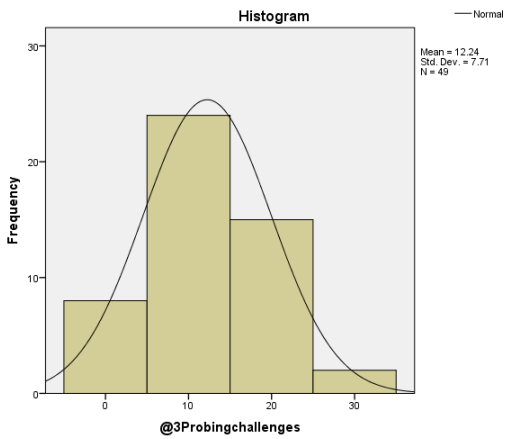
a. The estimator is the same, whether the interaction effect is present or not.

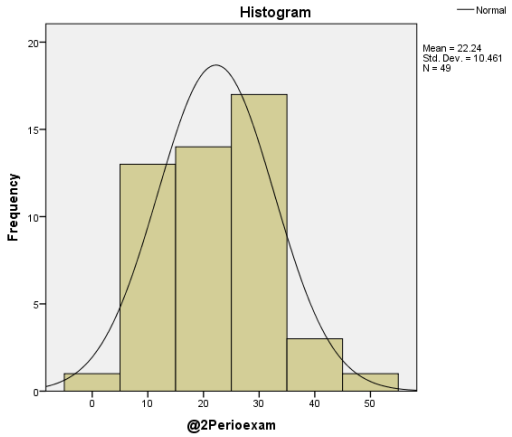
b. Type A intraclass correlation coefficients using an absolute agreement definition.

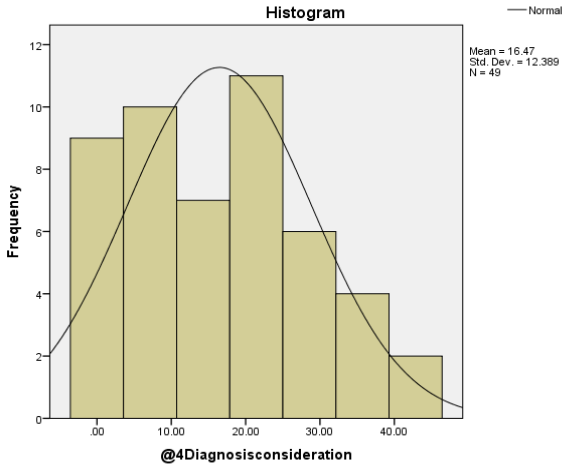
APPENDIX H: KNOWLEDGE BASED OPEN ENDED QUESTIONS- Normality distribution

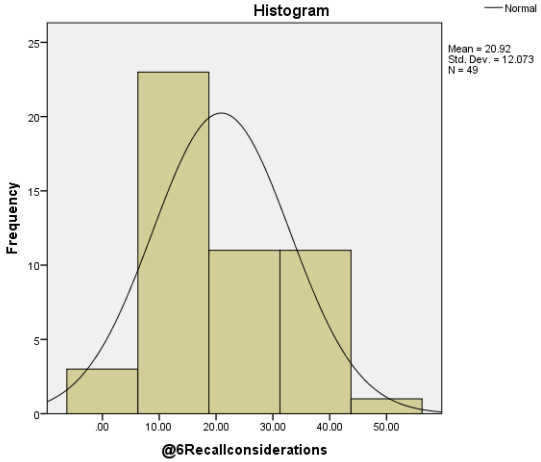
i) Using histograms:

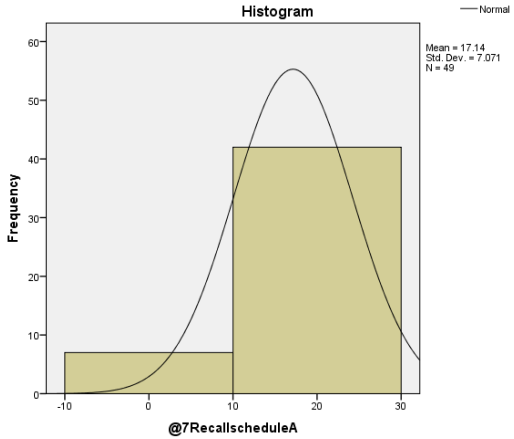


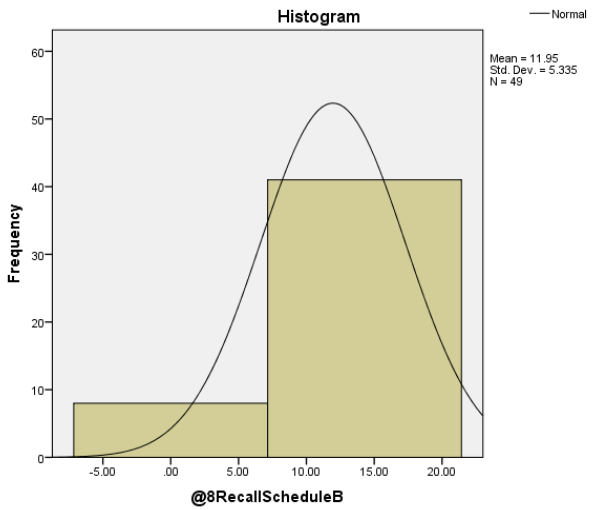








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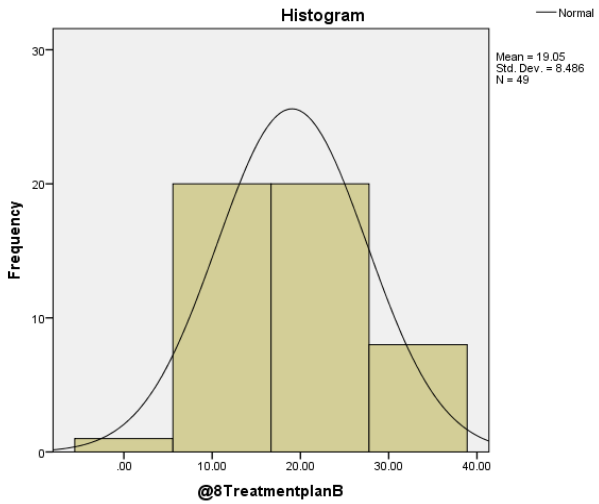
Frequency
@8RecallScheduleB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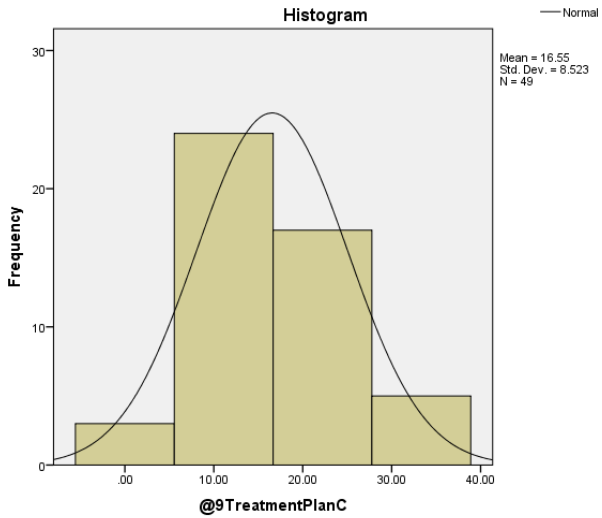
N = 49
Frequency
@8TreatmentplanB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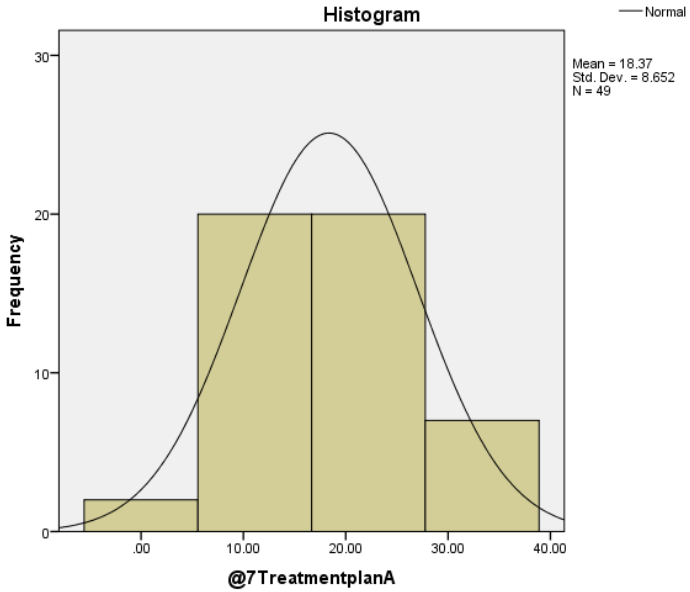
Std. Dev. = 8.523
N = 49
Frequency
@9TreatmentPlanC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Normal
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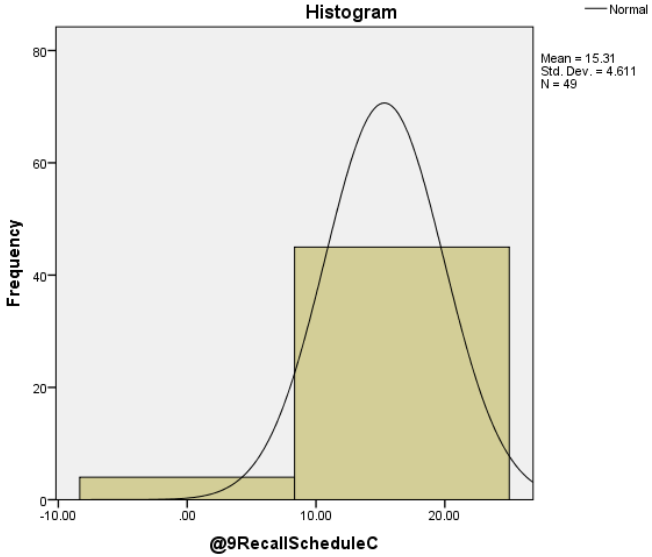
Std. Dev. = 8.652
N = 49
Frequency
@7TreatmentplanA


Histogram
Normal
Mean = 15.31
Std. Dev. = 4.611
N = 49
Frequency
@9RecallScheduleC

Appendix I: KNOWLEDGE BASED OPEN ENDED QUESTIONS- Levene's test (equality of variance assumption)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
@1Medhistory	Equal variances assumed	2.294	.137	1.559	47	.126	7.70202	4.94123	-2.23845	17.64249
	Equal variances not assumed			1.438	24.484	.163	7.70202	5.35746	-3.34368	18.74772
@2Perioexam	Equal variances assumed	1.615	.210	.460	47	.648	1.47727	3.21340	-4.98724	7.94179
	Equal variances not assumed			.416	23.492	.681	1.47727	3.54951	-5.85694	8.81148
@3Probingchallenges	Equal variances assumed	1.143	.291	-.160	47	.874	-.37879	2.37285	-5.15234	4.39477
	Equal variances not assumed			-.144	23.433	.886	-.37879	2.62410	-5.80161	5.04404

@4Diagnosisconsideration	Equal variances assumed	.064	.801	-1.073	47	.289	-4.04491	3.76826	-11.62567	3.53585
	Equal variances not assumed			-1.047	27.957	.304	-4.04491	3.86409	-11.96070	3.87087
@6Recallconsiderations	Equal variances assumed	1.514	.225	.242	47	.810	.89962	3.71442	-6.57284	8.37208
	Equal variances not assumed			.228	25.711	.821	.89962	3.94291	-7.20958	9.00882
@7TreatmentplanA	Equal variances assumed	1.783	.188	-.998	47	.323	-2.63047	2.63571	-7.93284	2.67189
	Equal variances not assumed			-.873	21.873	.392	-2.63047	3.01173	-8.87853	3.61758
@8TreatmentplanB	Equal variances assumed	.871	.355	.169	47	.866	.44192	2.61178	-4.81230	5.69614
	Equal variances not assumed			.158	25.207	.876	.44192	2.79604	-5.31422	6.19806
@9TreatmentPlanC	Equal variances assumed	.330	.568	.329	47	.743	.86279	2.62095	-4.40989	6.13548
	Equal variances not assumed			.340	32.335	.736	.86279	2.53961	-4.30812	6.03371

APPENDIX J: KNOWLEDGE BASED OPEN ENDED QUESTIONS -Independent sample t test using bootstrap (for skewed data Q7, 8, 9 Recall)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
@7Recallschedule A	Equal variances assumed	.245	.623	-.244	47	.808	-.53030	2.17552	-4.90689	3.84628
	Equal variances not assumed			-.249	31.588	.805	-.53030	2.12689	-4.86485	3.80424
@8RecallSchedule B	Equal variances assumed	4.800	.033	1.135	47	.262	1.83983	1.62030	-1.41980	5.09946
	Equal variances not assumed			1.024	23.279	.317	1.83983	1.79732	-1.87575	5.55540

@9RecallSchedule C	Equal variances assumed	2.288	.137	.761	47	.451	1.07323	1.41079	-1.76491	3.91137
	Equal variances not assumed			.676	22.583	.506	1.07323	1.58735	-2.21381	4.36027

Here equal variance assumption is not met for 8 recall Schedule B as $p < 0.05$, strong evidence against null hypothesis.

Bootstrap for Independent Samples Test

		Mean Difference	Bootstrap [a]			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
@7RecallscheduleA	Equal variances assumed	-.53030	-.11392	2.02701	-4.37371	3.45519
	Equal variances not assumed	-.53030	-.11392	2.02701	-4.37371	3.45519
@8RecallScheduleB	Equal variances assumed	1.83983	-.08142	1.73749	-1.58683	5.09768
	Equal variances not assumed	1.83983	-.08142	1.73749	-1.58683	5.09768
@9RecallScheduleC	Equal variances assumed	1.07323	-.05529[b]	1.61761[b]	-1.90476[b]	4.31985[b]
	Equal variances not assumed	1.07323	-.05529[b]	1.61761[b]	-1.90476[b]	4.31985[b]

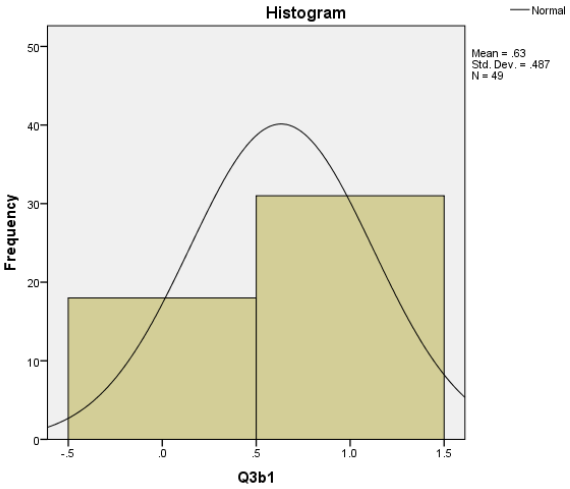
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

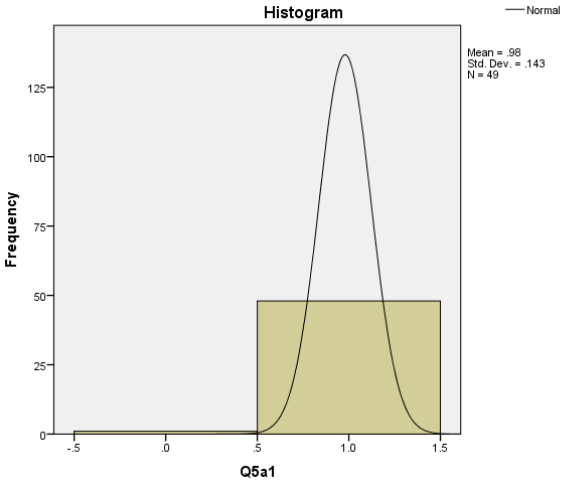
b. Based on 595 samples

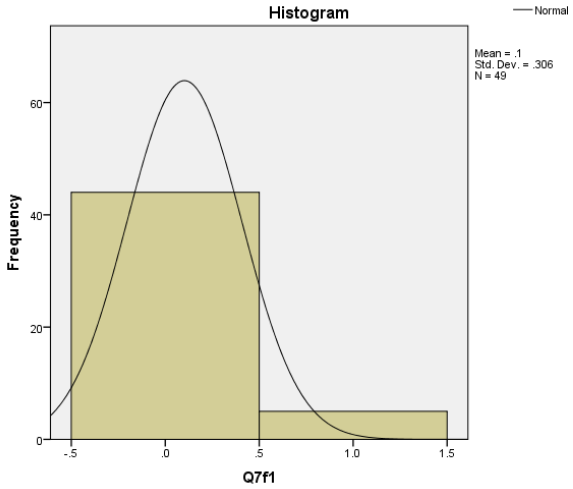
c. Based on 994 samples

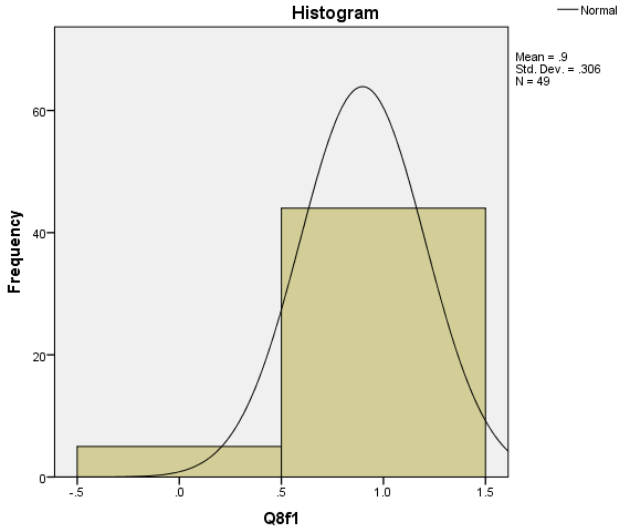
d. Based on 996 samples

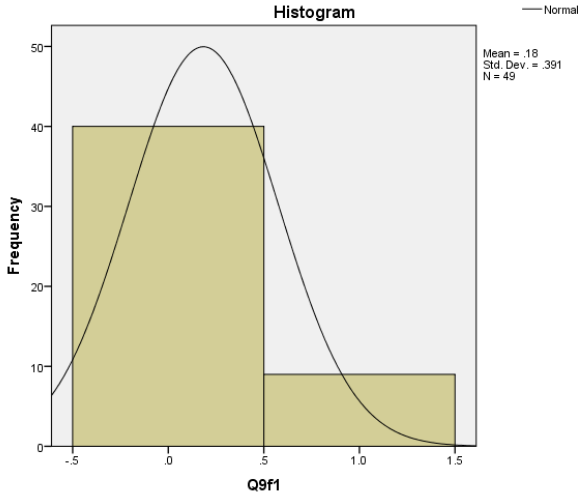
Appendix K: KNOWLEDGE BASED SINGLE ANSWER QUES: Normality distribution











APPENDIX L: KNOWLEDGE BASED SINGLE ANSWER QUES: Levene's test (equality of variance)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Q3b1	Equal variances assumed	1.382	.246	-.545	47	.588	-.081	.149	-.382	.219
	Equal variances not assumed			-.552	30.782	.585	-.081	.148	-.383	.220
Q5a1	Equal variances assumed	9.690	.003	1.453	47	.153	.063	.043	-.024	.149
	Equal variances not assumed			1.000	15.000	.333	.063	.063	-.071	.196
Q7f1	Equal variances assumed	7.674	.008	-1.375	47	.176	-.127	.092	-.313	.059
	Equal variances not assumed			-1.162	20.422	.259	-.127	.109	-.354	.101
Q8f1	Equal variances assumed	1.701	.198	-.626	47	.534	-.059	.094	-.247	.130

	Equal variances not assumed			-.690	38.390	.494	-.059	.085	-.231	.113
Q9f1	Equal variances assumed	2.402	.128	.727	47	.471	.087	.120	-.154	.328
	Equal variances not assumed			.779	35.618	.441	.087	.112	-.140	.314

APPENDIX M: KNOWLEDGE BASED SINGLE ANSWER QUES: Independent sample t test with bootstrapping

Bootstrap for Independent Samples Test

	Mean Difference	Bootstrap[a]				
		Bias	Std. Error	Sig. (2-tailed)	95% Confidence Interval	
					Lower	Upper
Equal variances assumed	-.081	-.004	.143		-.373	.210
Equal variances not assumed	-.081	-.004	.143		-.373	.210
Equal variances assumed	.063	.038[b]	.052[b]	.158[b]	.047[b]	.239[b]
Equal variances not assumed	.063	.038[b]	.052[b]	.146[b]	.047[b]	.239[b]
Equal variances assumed	-.127	-.001[c]	.112[c]		-.372[c]	.067[c]
Equal variances not assumed	-.127	-.001[c]	.112[c]		-.372[c]	.067[c]
Equal variances assumed	-.059	.002[d]	.082[d]		-.206[d]	.115[d]

Equal variances not assumed	-.059	.002[d]	.082[d]		-.206[d]	.115[d]
Equal variances assumed	.087	.004	.109		-.131	.301
Equal variances not assumed	.087	.004	.109		-.131	.301

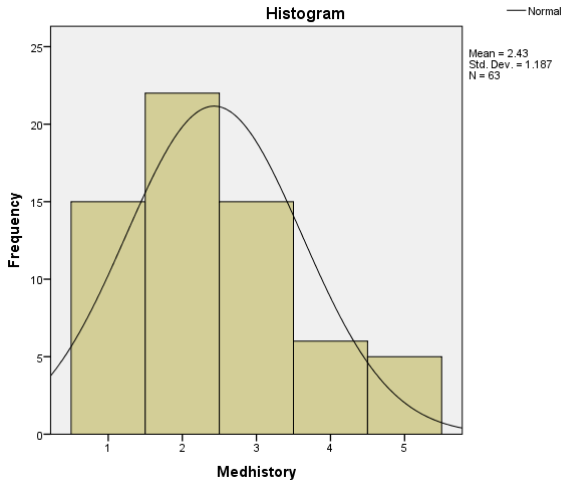
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

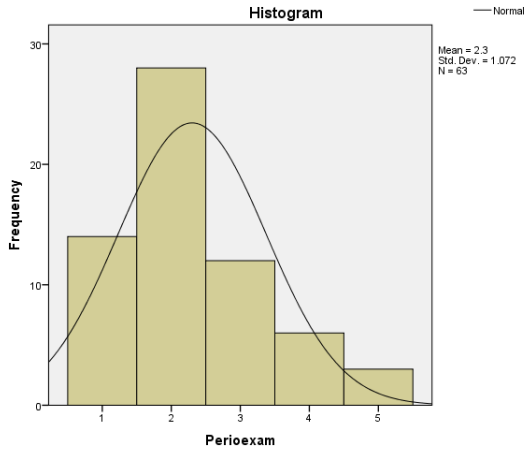
b. Based on 595 samples

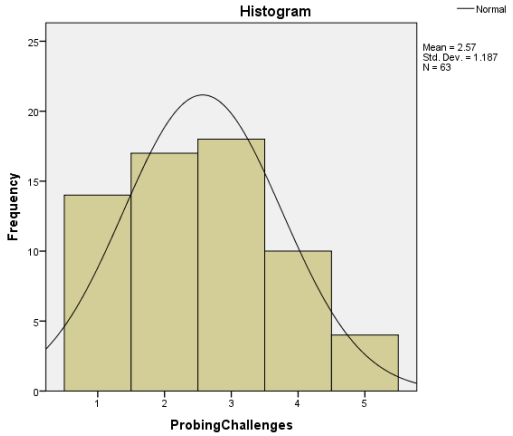
c. Based on 994 samples

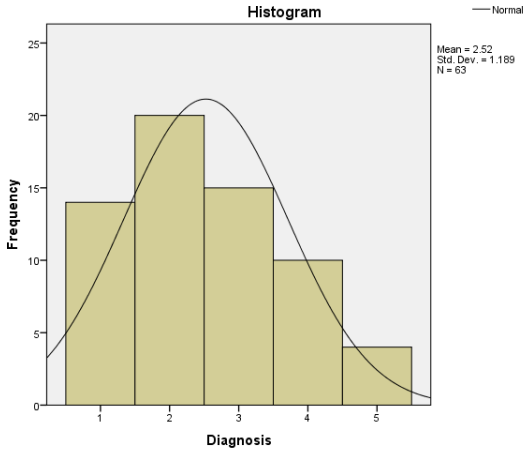
d. Based on 996 samples

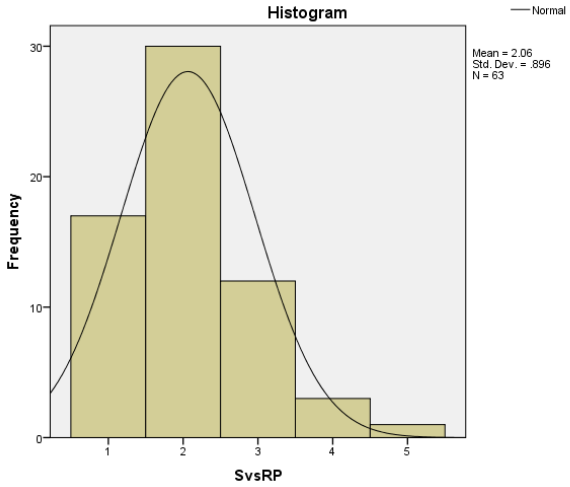
APPENDIX N: Confidence: Normality distribution

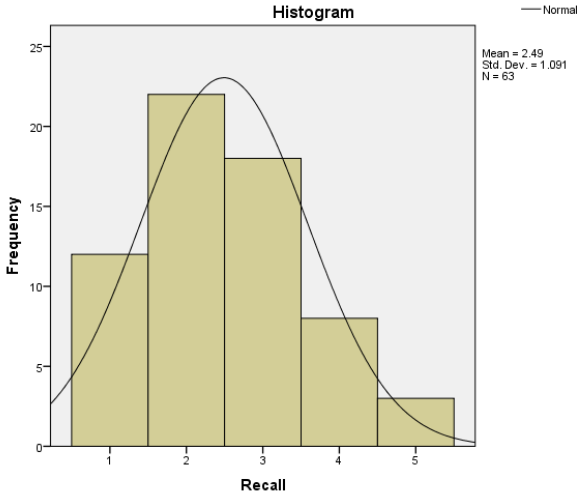


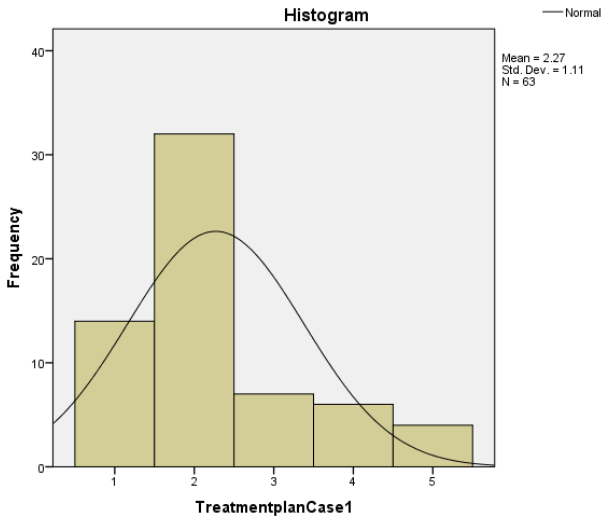








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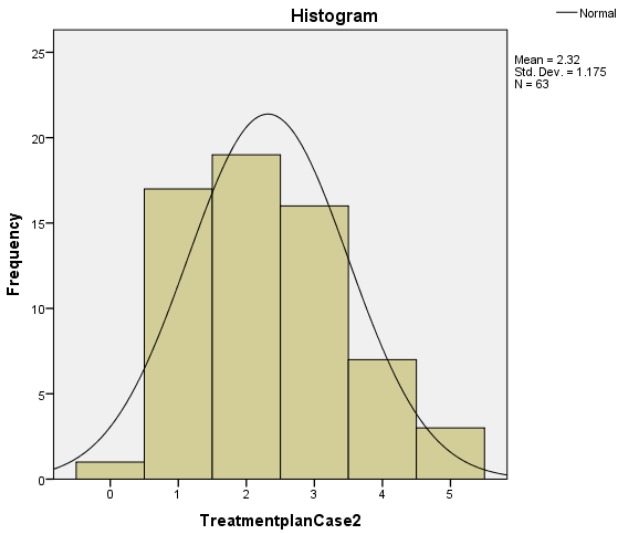
Frequency
TreatmentplanCase1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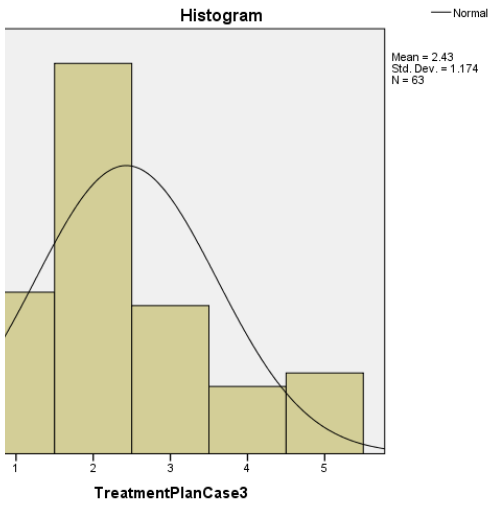
Std. Dev. = 1.175
N = 63
Frequency
TreatmentplanCase2


Histogram
Normal
Mean = 2.43
Std. Dev. = 1.174
N = 63
TreatmentPlanCase3

Appendix O: Confidence: Levine's test (equality of variance)

Independent Samples Test

		Levine's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Med history	Equal variances assumed	3.103	.085	1.673	47	.101	.564	.337	-.114	1.243
	Equal variances not assumed			1.488	22.605	.151	.564	.379	-.221	1.350
Peri exam	Equal variances assumed	.020	.889	1.485	47	.144	.445	.300	-.158	1.048
	Equal variances not assumed			1.413	26.328	.169	.445	.315	-.202	1.092
Probing Challenges	Equal variances assumed	1.683	.201	.966	47	.339	.314	.325	-.340	.969
	Equal variances not assumed			.905	25.340	.374	.314	.348	-.401	1.030
Diagnosis	Equal variances assumed	.916	.343	1.256	47	.215	.405	.323	-.244	1.054

	Equal variances not assumed			1.203	26.737	.240	.405	.337	-.286	1.097
S vs RP	Equal variances assumed	10.617	.002	.205	47	.839	.053	.259	-.468	.574
	Equal variances not assumed			.163	18.327	.873	.053	.326	-.631	.737
Recall	Equal variances assumed	2.193	.145	1.787	47	.080	.532	.298	-.067	1.131
	Equal variances not assumed			1.629	23.849	.116	.532	.327	-.142	1.207
Treatment planCase1	Equal variances assumed	.449	.506	-.033	47	.974	-.009	.289	-.592	.573
	Equal variances not assumed			-.032	27.262	.975	-.009	.300	-.624	.605
Treatment planCase2	Equal variances assumed	4.106	.048	.319	47	.751	.106	.332	-.562	.774
	Equal variances not assumed			.280	22.028	.782	.106	.378	-.678	.890
Treatment PlanCase3	Equal variances assumed	.339	.563	-.051	47	.959	-.017	.333	-.687	.653
	Equal variances not assumed			-.048	25.978	.962	-.017	.352	-.740	.706

Appendix P: Kruskal Wallis Test results

Ranks

	STUDYRESPONDENTS	N	Mean Rank
Med history	1	33	40.76
	2	16	30.31
	3	14	13.29
	Total	63	
Peri exam	1	33	40.38
	2	16	32.22
	3	14	12.00
	Total	63	
Probing Challenges	1	33	37.97
	2	16	32.78
	3	14	17.04
	Total	63	
Diagnosis	1	33	40.08
	2	16	33.59
	3	14	11.14
	Total	63	
S vs RP	1	33	38.38

	2	16	33.25
	3	14	15.54
	Total	63	
Recall	1	33	40.32
	2	16	30.59
	3	14	14.00
	Total	63	
TreatmentplanCase1	1	33	33.97
	2	16	33.50
	3	14	25.64
	Total	63	
TreatmentplanCase2	1	33	37.91
	2	16	33.56
	3	14	16.29
	Total	63	
TreatmentPlanCase3	1	33	34.80
	2	16	34.13
	3	14	22.96
	Total	63	

Test Statistics[a,b]

	Medhistory	Perioexam	ProbingChallenges	Diagnosis	SvsRP	Recall	TreatmentplanCase1	TreatmentplanCase2	TreatmentPlanCase3
Chi-Square	23.955	26.370	13.651	26.239	17.752	22.037	2.538	14.792	4.936
df	2	2	2	2	2	2	2	2	2
Asymp. Sig.	.000	.000	.001	.000	.000	.000	.281	.001	.085

a. Kruskal Wallis Test

b. Grouping Variable: STUDYRESPONDENTS