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**Dental Treatment Planning: Decisions with Interdisciplinary Cases**

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science  
in Dentistry at Virginia Commonwealth University.

By

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## **Abstract**

### **DENTAL TREATMENT PLANNING: DECISIONS WITH INTERDISCIPLINARY CASES**

By: William Porzio, DDS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, Date

Thesis Advisor: Thomas Waldrop, DDS MS

Department of Periodontics

**Purpose:** To explore the variance in treatment planning options with interdisciplinary cases that involve a combination of endodontic, periodontic, and prosthodontic factors.

**Methods:** A REDCap survey was emailed to Virginia based American Academy of Periodontology (AAP) members, American College of Prosthodontists (ACP) members, and periodontal residents to assessing various treatment planning options for six interdisciplinary cases.

**Results:** A total of 56 individuals responded to the survey; 10 periodontal residents, 35 practicing periodontists, 11 practicing prosthodontists. Response rate was not able to be evaluated based on the fact that third-party organizations were used to disseminate the survey in addition to directly contacting individuals. A wide variance in responses was seen for each case



with few aspects obtaining statistical significance. Overall trends suggested that individual treatment planning philosophy outweighs trends seen by profession type.

**Conclusions:** While diagnosis is widely regarded as an objective description of a patient's disease state, treatment planning solutions are widely subjective and may benefit from a more standardized approach.

## **Introduction**

In many clinical situations, the oral healthcare provider may have a high level of certainty with which treatment modality is most appropriate. Certain scenarios denote a “gold standard” whether that be extraction of a non-restorable tooth or scaling and root planing for a chronic periodontitis patient. However, all clinicians are familiar with patient encounters that lack clarity when it comes to choosing between a variety of treatment options, with an ideal choice being less apparent. A combined discussion with the patient is often needed to ascertain treatment priorities whether that be esthetics, function, longevity, or a combination of all three. When esthetics are the driving force, some patients may elect to have certain teeth “sacrificed” therefore influencing the surgical approach. If function is paramount, the esthetic outcome may be impacted in a negative manner, so on and so forth. Sometimes, there may be hope to maximize tooth survival through endodontic or periodontal surgery, but instead extraction and implant placement occur due to prognostic concern. The variety and heterogeneity of treatment planning approaches is illustrated in a 1993 study by Bader and Shugars where the extent of agreement to recommend treatment among dentists was explored for 1187 teeth in 43 patients. Overall agreement was only 22% among participating dentists.<sup>1</sup> This beckons the call for further research on treatment planning decisions and rationale.

When tooth retention is a patient’s priority, pertinent education as to whether or not that is feasible for them must be communicated. The determined prognosis of any tooth is likely to have a heavy impact on treatment planning of extractions as there is often the assumption that retention of periodontally hopeless teeth results in continued attachment loss (AL) on

neighboring teeth. There is a wealth of research that delves into this topic and whether or not to extract is a point of contention in modern day treatment planning. Factors that go into this decision range from the attachment loss on the given tooth, mobility, and whether or not that tooth is present as a fixed abutment among many others. The stability and health of existing tissues weigh heavily on treatment approaches.<sup>2</sup> Every unique clinical scenario will determine whether or not the retention of “hopeless” teeth puts the remainder of a patient’s dentition at risk but evidence exists which tell us that when hopeless teeth undergo continuous maintenance therapy, there is no adverse effect on neighboring teeth. In a study of 17 patients presenting with a “hopeless” tooth adjacent to a non-hopeless tooth which had been treated non surgically for periodontal disease, Wojick discusses the fate of retained periodontally hopeless teeth that underwent consistent treatment. Hopeless teeth were determined by the presence of qualities such as loss of >75% alveolar bone, probing depths >8mm and class III furcation involvement. It was found that there was no statistically significant difference in terms of probing depth, radiographic bone loss thus furthering the assumption that periodontally hopeless teeth can be retained.<sup>3</sup> Conversely, opinions are present in the literature arguing the opposite. A longitudinal study by Machtei explores this topic in a sample of 145 teeth from 129 subjects. The prognosis “Hopeless” was denoted in this study as a tooth having lost >50% supporting alveolar bone or a radiographic class III furcation defect. At four year follow-up it was found that there is statistically significant greater bone loss around retained hopeless teeth than of those that were extracted.<sup>4</sup> Later studies by the same author further support this claim, stating that there is a detrimental effect to neighboring alveolar bone when periodontally hopeless teeth are retained.<sup>5</sup> In clinical situations, a patient can make use of this information in terms of buying time. If

hopeless teeth can be maintained predictably, it will allow a patient adequate time to become educated on treatment options.

Once the decision on whether or not to retain certain teeth has been hurdled, the clinician must then move forward with treatment in terms of restoring teeth that were planned for retention or replacing teeth that were planned for extraction. Endodontic therapy and whether or not to “save” teeth with non-surgical root canal treatment are frequently incorporated into this step of treatment planning. Research exists on the varied success rates of non-surgical root canal therapy (NSRCT) versus single tooth endosseous implants—similar success rates are found which may drive the clinician towards the more conservative approach of avoiding implant therapy when retention of natural teeth is the goal.<sup>6</sup> In a retrospective study of 392 patients (196 patients in the single-tooth implant group and 196 again in the NSRCT group) Doyle offers some context on this topic. Exclusion criteria in this study involved multi-unit restorations and inclusion criteria required at least one adjacent natural tooth. Similarly, inclusion criteria for endodontically treated teeth required one adjacent natural tooth with a coronal restoration having been placed soon after NSRCT. Failure for both categories of treatment was defined as extraction of the tooth and a one-year recall was a minimum requirement. Implant groups were divided into four groups based on the location in the oral cavity (anterior maxilla, anterior mandible, posterior maxilla, posterior mandible) as local anatomical factors and bone quality can have a significant impact on implant success. Success rate for NSRCT was 82.1% whereas 73.5% of implants survived.<sup>7</sup> Similar studies have been performed with varying results. Hannahan performed a more recent study concerning 129 single-tooth implants and 143 endodontically treated teeth with groups broken down similarly to the previously mentioned study. Average recall was 36 months on average for implants and 22 months on average for

NSRCT teeth, resulting in success rates of 98.4% and 99.3 % respectively. <sup>8</sup> While both studies vary in their results, agreement is found on the grounds that successful outcomes are comparable. The decision tree for endodontic therapy vs single-tooth implant is multifactorial and the involved clinician must consider treatment from many standpoints before moving forward.

Understanding why root canal treated teeth fail aids in whether or not endodontic therapy should be initiated. Siqueira explores this topic in a 2001 systematic review noting

“The optimal treatment plan incorporates the best available evidence together with specific case factors and the patient’s desires and needs. Although it is recognized that clinicians vary in their experience, skills, and interests, this should not dictate the treatment plan, because other members of the dental team are available to provide specialized care on a referral basis.”

It is widely accepted with the current body of literature that restored single-tooth implants are a reliable alternative when treating a compromised tooth with a poor prognosis but what defines a “compromised tooth with a poor prognosis” is less transparent and beckons objectivity.<sup>9</sup> As mentioned above, with little difference in long term prognosis of RCT teeth versus extraction and replacement with implant restoration, other factors should be considered such as prosthetic restorability, bone quality, esthetic demands, cost-benefit ratios, systematic factors, and most importantly patient preference.<sup>10</sup> Implant literature has a wealth of evidence discussing the effects of bone quality on long-term success but endodontic literature is sparse on this topic. What information that is available states that location of restorative treatment does not have a

significant impact on the outcome of RCT vs implant restorations.<sup>7</sup> If cost is a deciding factor for a patient, they may opt for RCT as the implant-supported alternative is estimated to be roughly twice that of the endodontic route, when considering mean fees for treatment across the United States.<sup>11</sup> Esthetics are in many ways subjective and should always be deferred to patient opinion. Clinical scenarios exist in which this may be the deciding factor. Many patients desire to sustain as many natural teeth as possible but extensive caries extending below the gingival margin may necessitate a crown-lengthening procedure where completion may develop uneven gingival margins or black triangles. For patients that have a high lip line, hypermobile lip, or wide buccal corridors this could be valuable diagnostic information. In such scenarios an implant supported alternative may be wise. The same can be said of implants in the incisor region where collapse of interproximal tissue is possible upon extraction. In addition to proper technique, the presence of a definitive coronal restoration seems intimately related to endodontic prognosis. In an retrospective analysis of the Washington Dental Service's database, extraction of previous root canal treated teeth had a 4-fold greater occurrence in teeth without a coronal restoration (11.2%) when compared to treated teeth with a coronal restoration (2.5%), noting an overall survival rate of 97.5% during a 2-year follow-up.<sup>12</sup> A later study by Salehrabi looked at the outcome of endodontic therapy in 1,462,936 teeth of 1,126,288 patients across the United States; at 8 years following RCT 97% of teeth survived. When looking at the subset of failures, 85% had no full-coverage restoration in place emphasizing the importance of the coronal seal.<sup>13</sup> When the coronal seal is not present, bacterial reentry into canal space precipitates reinfection. In this same vein it should be noted that there are multiple causes for the failure of endodontic therapy ranging from reinfection to trauma. Only a small share of failures are due to true endodontic infection (9%) while trauma-related or idiopathic fracture may account for a significant

portion.<sup>14</sup> Horizontal root fractures are one such occurrence, compromising 16% of teeth replaced with implants.<sup>15</sup> When crafting a treatment plan for a patient with a horizontally fractured root the biological response to such a fracture should also be considered. Use of three-dimensional imaging can allow the location of fracture to be visualized, garnering relevancy as teeth with horizontal fractures contained within the alveolar housing still have a vital pulp and are not indicated for extraction.<sup>16,17</sup>

A myriad of factors play a role in whether or not a surgically placed implant will be successful and these factors can impact the clinician's decision on whether or not implant placement is the ideal treatment option in a given scenario. Health of surrounding periodontium, anatomic location, and suspected load distribution are but a few.<sup>18</sup> Focus on local soft and hard tissue will be emphasized below. In a 1998 systematic review, Esposito discusses several biologic factors influencing implant outcomes. Surgical trauma was found to be the most important predictor for failure, followed by bone quality and bone volume. Both of the latter are directly related to the anatomic location of the implant in terms of arch selection and location within the arch. Implant success is generally higher in the mandible when compared to the maxilla in all clinical scenarios with one exception, the partially edentulous maxilla where failure rates are comparable to that of the mandible. The dentate status is of importance as well—partially edentulous patients experience roughly half the failures when compared to their completely edentulous counterparts.<sup>19</sup> It should also be noted that fully edentulous mandibles are overrepresented in the literature (due to the prevalence of implant retained mandibular overdentures) lowering the total failure rate for that clinical scenario. Additionally, there exists a trend in the literature for implants placed in the maxilla to have three times the rate of failures than the mandible.<sup>19</sup> These success rates are an extension of bone quality and the impact it has on

primary stability and later implant osseointegration. Highest bone density for edentulous sites is found in the mandibular anterior followed by the mandibular posterior region. The mandible presents with a higher degree of cortication than that of the maxillary arch (particularly posterior maxilla) and aids in primary stability and ultimately osseointegration.<sup>20</sup> A study by Li elaborates on the impact that bone quality has on implant osseointegration stating that a strong positive correlation between bone remodeling rates, mitotic activity, and osteotomy site healing in type III bone and high endogenous Wnt signaling.<sup>21</sup> Wnt-responsive cells are a good measure to use for predicted success as the associated osteoid matrix responsible for osteointegration originates from such cells. Type IV bone presents with thin cortical plates and richly vascularized trabecular space. In one study, failure rates of 35% were reported in presence of type IV bone compared to 3% in types I, II, III bone.<sup>22</sup> The posterior maxilla is a common manifestation of the effect that anatomic location and bone quality has on implant success. It is not uncommon for ridge resorption in this anatomic area to necessitate sinus floor elevation further complicating treatment. In a retrospective study of 273 implants, 14 implants failed resulting in an overall success rate of 94.9%. When only looking at surgeries that involved sinus augmentation, the success rate dropped to 92.2%. However, based on a multivariate analysis in this study it was determined that sinus augmentation was not associated with increased risk of implant failure.<sup>23</sup> When tying these concepts into treatment planning, advances in the technology and availability of CBCT imaging have made the process much more predictable. With the ability to see three-dimensional models, clinicians are able to better predict surgical outcomes whether it be angulation determination or determining if grafting is anticipated at the time of placement.<sup>24</sup> The quality of local soft tissue may also be addressed when determining a patient's ideal treatment plan.



Controversy exists in the body of literature as to what denotes an ideal amount of keratinized tissue (KT) around natural teeth and dental implants. Lang and Loë stated that when less than 2mm of KT is present, inflammation will exist despite effective oral hygiene and this concept is generally accepted although another study by Bowers claims that marginal soft tissue health was achieved with less than 1mm of attached gingiva.<sup>25,26</sup> Similar patterns of thought are also discussed in terms of peri-implant health. The relationship between implant failure and absence of KT has been suggested with a general consensus that success of osseointegrated implants is in part determined by peri-implant soft tissue. However, heterogeneity in the body of literature precludes causation from being declared.<sup>27</sup> In a group of 51 patients with a total of 83 implants, having present and adequate KT ( $\geq 2\text{mm}$ ) was found to be significantly associated with both more esthetic outcomes and greater tissue health.<sup>28</sup> The impact that peri-implant soft tissue quality has on oral hygiene practices has also been described. A 10-year prospective comparative study comprising of 98 patients examined this; absence of KT was associate with higher plaque accumulation, greater gingival recession and exposure of implant-abutment interface, and a higher probability of additional surgical or antibiotic therapy. In this study, 35 patients had their restorative interface emerging through alveolar mucosa and 11 of those required free gingival grafting to facilitate optimal plaque control.<sup>29</sup> Systematic reviews echo this importance of adequate KT and its relationship to effective plaque control.<sup>30,31</sup> This information is invaluable to the everyday clinician when determining an ideal treatment plan and has potential to sway their decision when considering restorative work involving implant restorations.

For patients having rehabilitations in the anterior maxilla and mandible, multiple questions arise in terms of interim therapy and esthetic temporary tooth-replacement options. While interim

prosthetic options are not the focus of this project it should be acknowledged that the “bridging” phase of treatment between surgery and final prostheses can be a deciding factor from the patient’s point of view. It must not be forgotten that oftentimes the overarching goal of dental treatment is to improve quality of life. Certain treatment avenues have a dramatic impact on this and while not easily measured, quality of life should also be considered during treatment planning. Related, the availability of patient funds play a role in this decision tree and is frequently the keystone in designing treatment.<sup>32</sup> Many clinicians synonymize “complex” with full arch treatment, however it is often a single tooth on which a treatment plan hinges.

Through this review in the complex nature of treatment options, it is clear that the decision making tree is multifactorial and necessitates a multidisciplinary approach. Although not targeted in this author’s research, systemic health and smoking status also play a role into whether or not certain treatments should be offered to patients. For example, Linquist reports that smokers have a higher rate of adverse outcomes in terms of horizontal bone loss when compared to healthy controls following implant placement.<sup>33</sup> Finally, the logistics of changing structure in periodontal practices with an increase in group practices and corporate practices may also affect the treatment planning process due to the potential convenience of having multiple specialties present within the same office setting.<sup>34</sup>

The goal of this research is to explore the differences in treatment planning decisions between periodontists, general dentists, periodontal residents, and prosthodontists when faced with cases that may involve the use of implant restorations. Due to feasibility and accessibility, the data provided for clinical cases in this survey were strictly limited to raw clinical data which excluded the patient’s chief complaint and medical history. This was done to gather targeted data

on what treatment planning approaches would be most prevalent in regards to motivation factors of esthetics, functional stability, and retention of natural dentition.

## **Methods**

Inclusion criteria for participants were as follows: board certified periodontists, non-board certified periodontists, board-certified prosthodontists, non-board certified prosthodontists, periodontal residents. Exclusion criteria included any individual within the dental healthcare field as not described above i.e. generalist, endodontist etc. or any individual that completed specialist training outside of the United States without subsequent training within the United States.

Participant recruitment was initiated by contacting the following professional organizations (of which all members met the inclusion criteria): Academy of Osseointegration, American Academy of Periodontology, Southern Academy of Periodontology, Virginia Society of Periodontists, and American College of Prosthodontists. Requests were made to disseminate the study's recruitment letter to their membership base which included a hyperlink to the REDCap survey. All organizations except for Virginia Society of Periodontists either denied the request to participate or failed to respond.

Periodontal participants were identified by three methods: membership to the Virginia Society of Periodontics, employment within the VCU School of Dentistry Department of Periodontics, periodontal residency within VCU. Prosthodontic participants were identified with the help of committee member Dr. Pandora Lee who allowed this author access to the American

College of Prosthodontics 2021 membership directory. Only individuals who were registered in the state of Virginia were contacted. An introductory email was sent with a digital link to the survey in January 2022 to all participants, followed by a six-month data collection window.

The content of the survey used in this study can be classified into four categories: 1) personal demographics related to the participant; 2) clinical records from six cases including intraoral photographs, dental radiographs, and periodontal charting; 3) treatment options related to each of the six clinical cases; 4) Prioritized/motivational factors for the selected treatment option. The demographic information and treatment options in the survey were presented in a multiple-choice format with the prioritized/motivational factors being evaluated using sliders at the conclusion of each individual case on a scale from one to ten (1-10). The three sliders were denoted as “Esthetics”, “Retention of natural dentition”, and “Functional stability” with each having an accompanying slider. Using this medium, it was possible for multiple categories to be described by the same numerical value and was interpreted by this author as both factors having equal priority. Refer to Appendix 1 for a full description of the survey.

A literature review was performed to discover if similar studies have been conducted to aid in content development. Overall, it is this author’s opinion that the survey described above is unique in its nature as no comparable surveys were found in published literature of a dental nature. In terms of the demographic questionnaire, studies completed separately by Zemanovich and White were used to garner examples of how to appropriately gather personal information.<sup>34,35</sup> This was done in an effort to effectively describe data and highlight trends based on the recipients’ training, geographical location, and level of experience in the field.

The clinical cases included in this study were all sourced from the VCU Department of Periodontics and were examined between the years of 2019-2021. All cases are unique and have

not been included in previous studies or publications. Case selection was intended to identify samples that had contentious treatment planning options that may involve dental implant placement or interdisciplinary restorative care. The final selection involved a varied pool of both periodontal and dental diagnoses which was intended to avoid redundancy of the included cases. As mentioned earlier in the introduction of this thesis, treatment planning is not a dichotomous process. To create an approachable survey that would not dissuade participation, selection of treatment planning options was limited to the most realistic options. Input and modifications of all proposed questions and topics were reviewed repeatedly by the thesis research committee. The committee consisted largely of periodontists with experience ranging from less than 5 years to greater than 30 years in addition to a faculty prosthodontist who ensured that the included questions accurately represented prosthodontic treatment approaches. This was done in an effort to create an approachable survey that would garnish a high response rate while still recording target data. The committee also worked to provide cases that could legitimately be treated with varying approaches to avoid leading questions. During data collection, the contact letter prompted recipients notify this author if they had any questions/concerns or if they felt as though their approach was not represented within.

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at Virginia Commonwealth University. REDCap is a secure, web-based application designed to support data capture for research studies.<sup>36</sup> Participants were informed that choosing to participate in the study was voluntary and yielded no compensation. Within the introductory email to members, it was clearly stated that all survey responses would be anonymous and no identifiers collected. By completing the survey, participants indicated their consent to participate in the study. No reminder emails were

disseminated as there were adequate data upon conclusion of the data collection window. This study was approved by Institutional Review Board at Virginia Commonwealth University (HM20022763). The complete survey is given in Appendix 1.

## Results

### Statistical Methods

Responses were summarized using counts and percentages for treatment selections and mean, standard deviation (SD) or median, IQR (inter-quartile range) for the ratings of esthetics, retention of natural dentition, and functional stability. Differences in treatment selections were compared using chi-squared tests or Fisher's exact test as appropriate. Differences in the ratings between providers and based on treatment selections were assessed using ANOVA and Kruskal-Wallis tests. Significance level was set at 0.05. All analyses were performed with SAS EG v.8.2 (SAS Institute, Cary, NC).

### Results

A total of 56 individuals responded to the survey including 35 practicing periodontists (63%), 11 practicing prosthodontists (20%) and 10 periodontal residents (18%). In terms of years in practice, 30% had 26 or more years in practice. Of the practicing periodontists, 74% reported having board certification compared to 36% of practicing prosthodontists (p-value=0.0319). There was an equal split between practice locations in urban setting (50%) compared to suburban (46%) and rural (4%). Two-thirds of respondents were male (n=37, 66%). Complete demographics are provided in Table 1.



	n	%
Provider Type		
Periodontal resident	10	18%
Practicing periodontist	35	63%
Practicing prosthodontist	11	20%
Years in Practice		
Current Resident	10	18%
Up to 5 years	11	20%
5- 10 years	8	14%
11-15 years	2	4%
16-20 years	3	5%
21-25 years	5	9%
26+ years	17	30%
Practice Setting		
Solo practitioner	12	21%
Group practice with general dentists	5	9%
Group practice with other specialists	11	19%
Group practice with general dentists and other specialists	4	7%
Academia	23	40%
Other	2	4%
Board Certification		
Yes, I am a board certified periodontist	26	48%
Yes, I am a board certified prosthodontist	4	7%
No, I am not board certified	24	44%
Practice Location		
Urban	28	50%
Suburban	26	46%
Rural	2	4%
Gender		
Male	37	66%
Female	19	34%

Table 1: Respondent Demographics

*Case 1:*

For the first case, 75% of respondents indicated they would extract tooth #14 with site development and implant placement (n=42). This treatment selection was not significantly associated with the provider type (p-value=0.2269). For the 42 with that answer selection, 62%

would use a conventional implant with stock healing abutment and 29% would use a conventional implant with cover screw. This response was significantly associated with the provider type (p-value=0.0174). Prosthodontists were more likely to select the implant with cover screw (63%) and residents and periodontists would more often select a stock healing abutment (78%, 72%, respectively). Functional stability had the highest average rating for importance with an average of 9.0 (SD=1.15) out of 10 followed by retention of natural dentition (mean=6.4, SD=2.88), and esthetics received the lowest with an average of 3.2 (SD=2.56). The ratings for esthetics (p-value=0.3077), retention of natural dentition (p-value=0.2980), and functional stability (p-value=0.1200) were not significantly associated with the provider type. A summary of the responses to Case 1 are provided in \*P-value for comparison across providers

Table 2.

<b>Case 1</b>	<b>Overall</b>	<b>Practicing Periodontists</b>	<b>Practicing Prosthodontists</b>	<b>Periodontal Residents</b>	<b>P*</b>
<b>Treatment Plan</b>					<b>0.2269</b>
Maintain in current condition	2, 4%	1, 3%	1, 9%	0, 0%	
Endodontic retreatment followed by full-coverage restoration	9, 16%	8, 23%	1, 9%	0, 0%	
Guided tissue regeneration with particulate graft placement and occlusal adjustment	2, 4%	1, 3%	0, 0%	1, 10%	
Extract #14 followed by 3-unit bridge tooth #13-15	1, 2%	0, 0%	1, 9%	0, 0%	
Extract #14 with site development and implant placement	42, 75%	25, 71%	8, 73%	9, 90%	
<b>Post Extraction Plan Case 1 (n=42)</b>					<b>0.0174</b>
Immediate implant with cover screw	1, 2%	0, 0%	1, 13%	0, 0%	
Conventional implant with cover screw	12, 29%	5, 20%	5, 63%	2, 22%	
Conventional implant with stock healing abutment	26, 62%	18, 72%	1, 13%	7, 78%	
Conventional implant with custom healing abutment	3, 7%	2, 8%	1, 13%	0, 0%	
<b>Relative importance of the following categories for Case 1</b>					
Esthetics	3.2, 2.6	3.0, 2.4	4.4, 3.2	2.4, 1.9	0.3077
Retention of Natural Dentition	6.4, 2.9	6.9, 2.8	5.3, 3.4	6.0, 2.2	0.2980
Functional Stability	9.0, 1.2	9.1, 1.1	9.3, 1.1	8.3, 1.3	0.1200

\*P-value for comparison across providers

Table 2: Summary of Responses for Case 1 Based on Provider

*Case 2:*

For Case 2, 68% would extract #7 with site development and single-unit implant placement (n=38), an additional 4% (n=2) would follow up extraction of #7 with a 3-unit bridge for teeth #6-8. Twenty percent (n=11) would extract teeth 7-10 with site development and an implant-supported 4-unit bridge. This treatment plan selection was not significantly associated with the provider type (p-value=0.7031). For those who would extract #7, 71% would treat with an immediate implant and provisional crown. This selection was not significantly associated with

provider type (p-value=0.9142). For those who would extract #7-10, 80% would use a digital workflow with immediate provisional crown. Factors influencing treatment decisions for Case two were predominantly Functional Stability with an average rating of 8.6 (SD=1.43) out of ten and Esthetics with an average of 9.2 (SD=0.95). Retention of natural dentition received an average rating of 5.3 (SD=3.48) and was significantly associated with the provider type (p-value=0.0259). Prosthodontics and periodontal residents rated retention of natural dentition significantly lower (less important) than periodontists. Average importance score for retaining natural dentition was 6.4 among practicing periodontists compared to 3.9 for periodontal residents and 3.3 for practicing prosthodontists. There were marginally significant associations between the importance of esthetics and functional stability and the treatment decision for Case 2. Those who selected the 4-unit bridge rated esthetics slightly higher than those who selected a single-unit implant (9.7 vs 9.2, p-value=0.0846). Those who selected the 4-unit bridge also rated functional stability marginally significantly higher than those who selected a single implant (p-value=0.0622). The median response for those who selected 4-unit bridge was 10 (IQR: 8-10) compared to 9 (IQR: 8-10) for those who would use single implant. A summary of the responses to Case 2 are provided in Table 3.

<b>Case 2</b>	<b>Overall</b>	<b>Practicing Periodontists</b>	<b>Practicing Prosthodontists</b>	<b>Periodontal Residents</b>	<b>P*</b>
<b>Treatment Plan</b>					0.7031
Maintain in current condition	1, 2%	0, 0%	1, 9%	0, 0%	
Endodontic treatment followed by crown lengthening and full-coverage restoration	4, 7%	4, 11%	0, 0%	0, 0%	
Extract #7 and fabrication of 3-unit bridge tooth #6-8	2, 4%	2, 6%	0, 0%	0, 0%	
Extract #7 with site development and single-unit implant placement	38, 68%	22, 63%	8, 73%	8, 80%	
Extract #7-10 with site development and implant supported 4-unit bridge	11, 20%	7, 20%	2, 18%	2, 20%	
<b>Post Extraction of #7 Plan</b>					0.9142
Immediate implant with stock healing abutment	1, 3%	1, 3%	0, 0%	0, 0%	
Immediate implant with provisional crown	25, 71%	14, 40%	5, 45%	6, 60%	
Conventional implant with stock healing abutment	4, 11%	3, 9%	1, 9%	0, 0%	
Conventional implant with custom healing abutment	5, 14%	2, 6%	1, 9%	2, 20%	
<b>Post Extraction of #7-10 Plan</b>					>0.999
Cover screws following implant placement with temporary Essix/Flipper	1, 20%	1, 3%	0, 0%	0, 0%	
Custom healing abutments following implant placement with temporary Essix/Flipper	1, 20%	0, 0%	1, 9%	0, 0%	
Digital workflow immediate provisional	4, 80%	2, 6%	1, 9%	1, 10%	
<b>Relative importance of the following categories for Case 2</b>					
Esthetics	9.2, 0.9	9.1, 1.0	9.4, 0.8	9.6, 0.7	0.2766
Retention of Natural Dentition	5.3, 3.5	6.4, 3.1	3.3, 3.4	3.9, 3.7	0.0259
Functional Stability	8.6, 1.4	8.6, 1.5	9.1, 1.1	8.1, 1.3	0.2280

\*P-value for comparison across providers

Table 3: Summary of Responses for Case 2 Based on Provider

### *Case 3:*

The majority of respondents indicated that they would treat Case #3 by extraction tooth #8 with site development followed by single-unit implant placement (n=49, 88%). The follow-up plan varied more with 62% indicating use of a conventional implant with custom healing abutment, 24% conventional implant with stock healing abutment, and 14% with immediate implant with provisional crown. These responses were significantly associated with the provider type (p-value=0.0076). Practicing periodontists were more likely to select a custom abutment than periodontal residents or practicing prosthodontists (70% 50%, 38%, respectively). Immediate implant with provisional crown was selected by 37.% of practicing prosthodontists, 37.5% of periodontal residents, and no practicing periodontists. Ratings for the factors influencing treatment decisions were highest for esthetics with an average of 9.3 (SD=0.98), followed by functional stability with an average of 8.8 (SD=1.35). Retention of natural dentition received an average rating of 5.7 (SD=3.5). Ratings for esthetics (p-value=0.0847) and retention of natural dentition (p-value=0.0864) were marginally significantly associated with the provider type. Esthetics were rated with a 10 out of 10 by 90% of practicing prosthodontists compared to 51% for periodontists and 60% for periodontal residents. Retaining natural dentition was rated lowest on average by practicing prosthodontists with an average of 3.8 compared to 4.9 for periodontal residents and 6.4 for practicing periodontists. A summary of the responses to Case 3 are provided in Table 4.

<b>Case 3</b>	Overall	Practicing Periodontists	Practicing Prosthodontists	Periodontal Residents	<i>P</i> *
<b>Treatment Plan</b>					0.6101
Extract #8 and fabrication of 3-unit bridge tooth #7-9	7, 13%	5, 14%	2, 18%	0, 0%	
Extract #8 with site development followed by single-unit implant placement	49, 88%	30, 86%	9, 82%	10, 100%	0.0076
Immediate implant with provisional crown	6, 14%	0, 0%	3, 38%	3, 38%	
Conventional implant with stock healing abutment	10, 24%	7, 27%	2, 25%	1, 13%	
Conventional implant with custom healing abutment	26, 62%	19, 73%	3, 38%	4, 50%	>0.999
Custom healing abutments following implant placement with temporary Essix/Flipper	2, 50%	2, 67%	0, 0%	0, 0%	
Digital workflow immediate provisional	2, 50%	1, 33%	0, 0%	1, 100%	
<b>Relative importance of the following categories for Case 3</b>					
Esthetics	9.3, 1	9.2, 1	9.9, 0.3	9.2, 1.3	0.0847
Retention of Natural Dentition	5.7, 3.5	6.4, 3.5	3.8, 2.9	4.9, 3.5	0.0864
Functional Stability	8.8, 1.4	8.7, 1.5	9, 1.1	8.9, 1	0.9533

\*P-value for comparison across providers

Table 4: Summary of Responses for Case 3 Based on Provider

*Case 4:*

The majority of respondents indicated they would treat Case 4 with endodontic treatment followed by crown lengthening and a full-coverage restoration (79%, n=44). Sixteen percent

(n=9) would extract #20 followed by a single-unit implant and 5% (n=3) would do direct restoration with MTA. The treatment choice was not significantly associated with the provider type (p-value=0.1957). For those who would extract #20, eight responded to the follow-up question regarding subsequent treatment. Of those, 5 would treat with a conventional implant and stock healing abutment, 2 with immediate implant and stock healing abutment, and one with conventional implant with custom healing abutment. Retention of natural dentition and functional stability were, on average, scored higher than esthetics. Functional stability was scored on average as 8.7 (SD=1.6), retention of natural dentition with an average of 8.4 (SD=2.2), while esthetics averaged a score of 5.2 (SD=2.6). The ratings for esthetics (p-value=0.4672), retention (p-value=0.1290), and stability (p-value=0.4232) were not significantly associated with the provider type. However, those who selected endodontic treatment followed by crown lengthening rated retention of natural dentition significantly higher than those who indicated they would extract #20 (9.1 vs 3.6,  $p < 0.0001$ ). A summary of the responses to Case 4 are provided in Table 5.



<b>Case 4</b>	Overall	Practicing Periodontists	Practicing Prosthodontists	Periodontal Residents	<i>P</i> *
<b>Treatment Plan</b>					0.1957
Direct restoration with mineral trioxide aggregate (MTA) pulp cap if indicated	3, 5%	2, 6%	1, 9%	0, 0%	
Endodontic treatment followed by crown lengthening and full-coverage restoration	44, 79%	30, 86%	7, 64%	7, 70%	
Extract #20 with site development and single-unit implant placement	9, 16%	3, 9%	3, 27%	3, 30%	
<b>Post Extraction #20 Plan</b>					>0.999
Immediate implant with stock healing abutment	2, 25%	1, 33%	1, 33%	0, 0%	
Conventional implant with stock healing abutment	5, 63%	1, 33%	2, 67%	2, 100%	
Conventional implant with custom healing abutment	1, 13%	1, 33%	0, 0%	0, 0%	
<b>Relative importance of the following categories for Case 4</b>					
Esthetics	5.2, 2.6	5.6, 2.5	4.8, 3.1	4.6, 2.7	0.4672
Retention of Natural Dentition	8.4, 2.2	8.9, 1.4	7.3, 3.0	7.6, 3.1	0.1290
Functional Stability	8.7, 1.6	8.9, 1.2	8.1, 1.9	8.5, 2.2	0.4232

\*P-value for comparison across providers

Table 5: Summary of Responses for Case 4 Based on Provider

*Case 5:*

Almost half of respondents would treat Case 5 by maintaining in current condition (49%, n=27).

A quarter would use orthodontic treatment to close spaces (25%, n=14), and a fifth would extract #7-10 with site development and an implant-supported 4-unit bridge (20%, n=11). The remaining three individuals selected direct restorations to close spaces (5%). The responses were not significantly associated with provider type (p-value=0.1282). For those who would extract #7-10, 55% would use a digital workflow with immediate provisional restorations (n=6). The others five

respondents would use either cover screws (n=3) or custom healing abutments (n=2) following implant placement with a temporary Essix retainer or Flipper. For this case, the relative importance averaged about 8 for each of the three categories: esthetics (mean=7.8, SD=2.5), retention of natural dentition (7.9, 2.8), and functional stability (8.1, 1.6). The rating for retention of natural dentition was significantly associated with the provider type (p-value=0.0093). Practicing periodontists rated retention significantly higher than periodontal residents and prosthodontists with an average of 8.9 compared to 6.1, 6.5, respectively. A summary of the responses to Case 5 are provided in Table 6.

<b>Case 5</b>	<b>Overall</b>	<b>Practicing Periodontists</b>	<b>Practicing Prosthodontists</b>	<b>Periodontal Residents</b>	<b>P*</b>
<b>Treatment Plan</b>					0.1282
Maintain in current condition	27, 49%	17, 50%	4, 36%	6, 60%	
Direct restorations to close spaces	3, 5%	3, 9%	0, 0%	0, 0%	
Orthodontic treatment to close spaces	14, 25%	11, 32%	2, 18%	1, 10%	
Extract #7-10 with site development and implant supported 4-unit bridge	11, 20%	3, 9%	5, 45%	3, 30%	
<b>Post Extract #7-10</b>					0.3961
Cover screws following implant placement with temporary Essix/Flipper	3, 27%	2, 67%	0, 0%	1, 33%	
Custom healing abutments following implant placement with temporary Essix/Flipper	2, 18%	0, 0%	2, 40%	0, 0%	
Digital workflow immediate provisional					
<b>Relative importance of the following categories for Case 5</b>					
Esthetics	7.8, 2.5	7.4, 2.7	8.8, 1.3	7.9, 2.4	0.3349
Retention of Natural Dentition	7.9, 2.8	8.9, 1.6	6.5, 3.0	6.1, 4.2	0.0093
Functional Stability	8.1, 1.6	8.4, 1.4	8.0, 2.0	7.3, 1.8	0.1463

\*P-value for comparison across providers

Table 6: Summary of Responses for Case 5 Based on Provider

*Case 6:*

The majority of respondents would treat Case 6 with an extraction of #4, site development, and a single unit implant (n=39, 70%). The remaining would treat with endodontic treatment followed by crown lengthening and full coverage restoration (n=14, 25%) or extraction of #4 and a 3-unit bridge for teeth #3-5 (n=3, 5%). These selections were not significantly associated with the provider type (p-value=0.2634). For those who would treat with a single unit implant, nearly half would use a conventional implant with stock healing abutment (n=19, 46%), 22% would use conventional implant with custom healing abutment, 20% would do immediate implant and stock healing abutment, and the remaining 12% would do immediate implant with a provisional crown. This selection was not significantly associated with the provider type (p-value=0.6228). For this case, functional stability was rated highest with an average of 8.9 (SD=1.2), followed by esthetics with an average of 6.7 (SD=2.2), and retention of natural dentition rated an average of 5.3 (SD=3.3). These ratings were not significantly associated with the provider type. Complete summary of responses for Case 6 are provided in Table 7. Graphical comparison of motivational factors for each case type is presented in Figure 1.

<b>Case 6</b>	<b>Overall</b>	<b>Practicing Periodontists</b>	<b>Practicing Prosthodontists</b>	<b>Periodontal Residents</b>	<b>P*</b>
<b>Treatment Plan</b>					<b>0.2634</b>
Endodontic treatment followed by crown lengthening and full-coverage restoration	14, 25%	9, 26%	1, 9%	4, 40%	
Extract #4 with fabrication of 3-unit bridge tooth #3-5	3, 5%	1, 3%	1, 9%	1, 10%	
Extract #4 with site development and single-unit implant placement	39, 70%	25, 71%	9, 82%	5, 50%	
<b>Single-unit Implant Placement Plan</b>					<b>0.6228</b>
Immediate implant with stock healing abutment	8, 20%	5, 19%	2, 22%	1, 17%	
Immediate implant with provisional crown	5, 12%	3, 12%	2, 22%	0, 0%	
Conventional implant with stock healing abutment	19, 46%	11, 42%	5, 56%	3, 50%	
Conventional implant with custom healing abutment	9, 22%	7, 27%	0, 0%	2, 33%	
<b>Relative importance of the following categories for Case 6</b>					
Esthetics	6.7, 2.2	7.4, 1.4	6.1, 2.5	5.3, 3	0.1001
Retention of Natural Dentition	5.3, 3.3	5.7, 3.3	4.6, 2.9	5, 3.6	0.4924
Functional Stability	8.9, 1.2	9, 1	8.6, 1.6	8.7, 1.5	0.8432

\*P-value for comparison across providers

Table 7: Summary of Responses for Case 6 Based on Provider

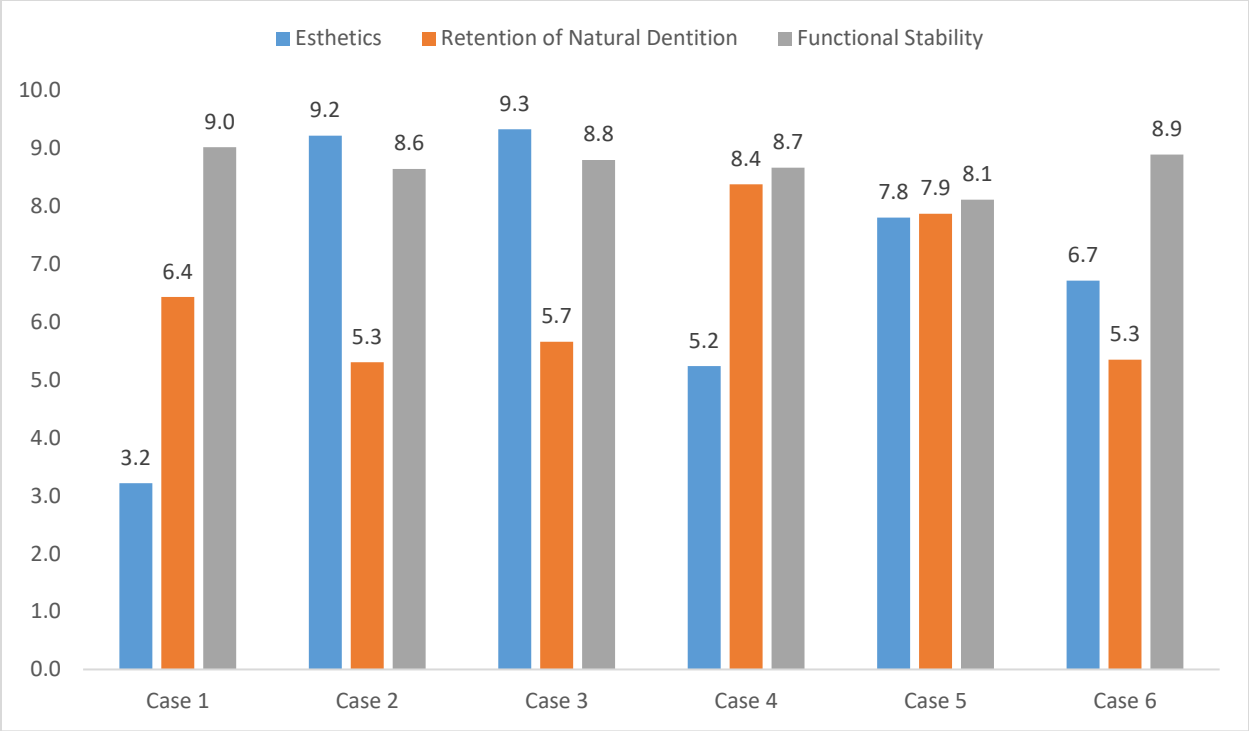


Figure 1: Relative Importance of Esthetics, Retention of Natural Dentition, and Functional Stability by Case

## **Discussion**

### *Limitations*

Prior to analyzing data it is appropriate to acknowledge the limitations that were present in this study. Firstly, surveys must be approachable in their nature to maximize the response rate among participants. In context to this survey, that translated to restricting the number of treatment options for each case. This author acknowledges that each case could be treated in various ways that were not outlined in answer choices. The limited treatment options facilitated completion of the survey and translated to data that was easier to compare between groups. Additionally, there was no open-response portion for participants to comment on treatment approaches that were not listed. This was because any open response category could not be analyzed statistically. Furthermore, there are more players in the treatment planning process than the groups included in this survey. The decision to restrict participants to the periodontic and prosthodontic fields was to focus on individuals that received formal training in implant treatment planning as this was an option for treatment in all cases. Note that all hypotheses mentioned in the discussion below are of my opinion as the author and did not reflect on study design or parameters.

Treatment planning is often the most difficult hurdle to jump when initiating treatment with a new patient. An individual's medical history has a significant impact on treatment options and can often narrow options with one such example being an osteoporotic individual that has

been a long term user of bisphosphonates.<sup>37</sup> Finances are arguably the most restrictive factor and can bar a patient from obtaining their desired outcome. Catering treatment towards a patient's chief complaint is of the utmost priority; often a clinician identifies treatment needs that the patient may not be interested in pursuing due to a lack of perceived value. With all of these variables in play, it can be a daunting task to decide what approach to a patient's unique problem is the "best." All medical information and the patient's chief complaint were omitted from this study in an effort to funnel the participants' focus on the clinical dilemma. In doing so, a streamlined approach was created for evaluating treatment options and motivating factors between the fields of periodontics and prosthodontics. The individual cases will be analyzed in the following section to discuss inclusion rationale and how/if the gathered data reflected the hypothesized response.

*Case 1:*

This is one of four cases included in the survey which brings the participant's focus to an individual tooth as opposed to a generalized concern. As seen in Appendix A it is evident that the tooth in question is #14. As seen in the radiographs, a combination defect of both vertical and horizontal bone loss can be traced mesiodistally across the site. The periodontal chart also notes Glickman class II furcation involvement at the midbuccal entrance. Appendix A clinical photographs do not depict significant findings other than marginal erythema and gingival recession on the palatal aspect. Case 1 is unique in the fact that this is the only case which includes a previously non-surgically root canal treated (NSRCT) tooth. It challenges the participant's knowledge of how endodontic diagnosis can affect the prognosis of proposed treatment. While endodontists did not meet the inclusion criteria for study participants, it is

assumed that the participants' knowledge of endodontic diagnosis is adequate to the point of guiding treatment planning decisions.

It was hypothesized that periodontists' choice of treatment approach would be split between option three "Guided tissue regeneration with particulate graft placement and occlusal adjustment" and option five "Extract #14 with site development and implant placement." The reasoning behind this is discussed by Metzler's paper from 1991 which covers the indications and prognosis of guided tissue regeneration on maxillary molar furcations. While the outcome is less predictable than their mandibular counterparts, sufficient evidence exists in support of guided tissue regeneration for the buccal furcations of maxillary molars.<sup>38</sup> Due to the conservative but unpredictable prognosis of this treatment option, it is likely that the periodontists' training would lead them to choosing option five if unconvinced by option three. It must be noted here that one shortcoming of this survey is that it did not offer any branching logic<sup>36</sup> for options other than implant placement. This is acknowledged here because options two and three for Case 1 are two prongs of an interdisciplinary approach to a case of this presentation. It was hypothesized that prosthodontists would prioritize option five due to the fact that there were no existing restorations on the adjacent tooth which may have justified option four "Extract #14 followed by 3-unit bridge tooth #13-15." For motivational factor sliders, it was hypothesized that both periodontists and prosthodontists would denote the highest values for "Retention of natural dentition" or "Functional stability" due to the fact that this case involved a posterior tooth that was not part of the esthetic zone.

Results for Case 1 show that 75% of respondents elected for the implant related outcome (option five) with the second most prevalent choice being endodontic retreatment (option two). This is logical when factoring in that NSRCT retreatment has a lower success rate than



osseointegration of dental implant placement. However, with a p-value of 0.2269 between provider types these differences were not statistically significant. The Case 1 results for motivational factors reflect that functional stability was by-in-large the deciding factor for survey participants. Patients frequently question providers about the prognosis of chosen treatment options which is reflected in the average score for functional stability being 9.0. It can be interpreted that this treatment option was chosen due to predictability whereas retention of natural dentition would be the less predictable option, garnering a score of 6.4. With no p-values <0.08 for motivational factors there is no statistical significance to this data.

Branching logic for the implant-related outcome is where treatment options between prosthodontists and periodontists is profound. 62 percent of respondents opted for “conventional implant with stock healing abutment” followed by 29% for “conventional implant with cover screw.” With a p-value of 0.0174, the difference is statistically significant for the periodontists choosing the former and prosthodontists the latter, respectively. While these two choices would not alter the overall outcome of the case, it illustrates how the participants could have benefitted from a more thorough case description such as “assuming primary stability is achieved” This omitted information may have impacted the recipient’s choices for this branching logic question.

#### *Case 2:*

This case was included to evaluate how the participant would respond to a clinical scenario in which functionally there is only one tooth in question but is associated with esthetics that would conventionally be considered poor. The attached images (Figure x) depict a fractured tooth #7 with mild to moderate horizontal bone loss across the anterior maxilla. Esthetically, there is uneven interdental spacing along with a discrepancy in crown height ratios. Additionally, the concept of crown:root ratio is of import and should be considered when planning this case.

When finding a middle ground between health and esthetics, it is not uncommon to “sacrifice” adjacent teeth to achieve an outcome that is both functionally stable but also esthetic, thus neglecting retention of natural dentition. For this reason, it was hypothesized that all participants would hold retention of natural dentition in lowest regard. In terms of treatment approach, it was hypothesized that periodontists would opt for options two or four; “Endodontic treatment followed by crown lengthening and full-coverage restoration” and “Extract #7 with site development and single-unit implant placement,” respectively. It is a hallmark of the periodontal specialty to retain natural dentition when possible and there is adequate coronal tooth structure in this case to accommodate a new full-coverage restoration. Similarly, if extraction of tooth #7 was chosen by the periodontist, it was hypothesized that they would limit extractions to that tooth as moderate loss of clinical attachment on tooth #10 could be maintained non-surgically as opposed to extracted. Prosthodontists were hypothesized to prioritize options four or five as it would translate to a more harmonious appearance upon full smile, particularly if option five was pursued.

Results for Case 2 show that 68% of respondents chose to extract only tooth #7 and replace with a single-unit dental implant whereas 20% of respondents chose to extract tooth # 7-10 and replace with a four-unit bridge (Table 2). The p-value for treatment approach between provider type is 0.7031 meaning that there was no statistical significance between professions. Branching logic for implant replacement options grossly favored immediate implant placement with provisional crown fabrication (p-value >0.9) once again showing that there was no statistical significance between professions, implying a greater agreement between provider types.

The hypothesis for motivational factors related to Case 2 was accurate in that respondents (overall) held esthetics in highest regard (9.21/10) followed by functional stability (8.64/10). These categories did not approach statistical significance; retention of natural dentition was valued at 5.31/10 and was statistically significant between provider types at a p-value of 0.0259. Specifically, prosthodontists and periodontal residents valued this factor less than periodontists. When analyzing the relationship between specific answer choices and the associated motivational factors, esthetics was ranked higher for respondents that opted for the implant bridge rather than the single unit (9.7 vs 9.2); this relationship was marginally significant with a p-value of 0.0846. Sub analysis was also performed on which answer choice was associated with stability as the primary motivational factor; the four-unit implant bridge respondents maximized this option 10/10 when compared to the single-unit option (9/10). From the educational perspective, this could mean that the residents' education emphasizes retention of natural dentition to a lesser degree than it has been historically for the field of periodontics. It can be implied here that more aggressive treatment approaches were prioritized to the end that it would lead to a more predictable outcome (health and success of osseointegrated implants and the associated restoration) as opposed to the less predictable longevity of NSRCT. Future research is needed to evaluate patients' perceived value of conservative therapies that retain natural dentition to evaluate whether or not it lines up with treatment options that are recommended by their providers. This case illustrates a present shift in treatment philosophy towards more aggressive treatment options that patients may interpret as being permanent.

### *Case 3:*

Similar to Cases 1, 4, and 6 this clinical scenario brings the participant's attention to an individual tooth (#8). It is unique in the fact that this is the only case to include an isolated

anterior tooth as opposed to Cases 2 and 5 which involve the entire anterior sextant. Clinical photos depict tooth #8 displaced to the buccal aspect with a discolored crown indicative of endodontic disease; radiographic examination reveals roughly 80% bone loss on the distal aspect. The intention of this case was to present the participant with an isolated treatment area which encourages a treatment decision that is based on restorability and periodontic stability. The hypothesis for Case 3 was that there would be a high degree of agreement regardless of profession when it comes to treatment approach. Although the periodontal profession emphasizes retention of natural dentition there are scenarios in which disease is so extensive that the decision to extract must be made. Treatment options three and four for Case 3 involved extraction, “Extract #8 and fabrication of 3-unit bridge tooth #7-9” and “Extract #8 with site development followed by single-unit implant” respectively.

Results showed a high degree of agreement upon participants with only two options being selected; 88% for extraction followed by implant placement and 13% for extraction followed by 3-unit bridge (p-value 0.6101). The high p-value is in line with the hypothesis for this case in that a high level of agreement across specialties was anticipated. An interesting distinction can be found with the branching logic question in regards to treatment approach for the implant-supported option. 62 percent of the participants opted for a custom healing abutment while 10% chose a stock healing abutment. The p-value for this question was 0.0076 denoting statistical significance that periodontists were more likely to proceed with custom healing abutment fabrication as opposed to a stock healing abutment. This speaks to the high level of understanding when it comes to soft-tissue maturation and manipulation that is indicative of periodontal training. The ability of custom healing abutments to accurately position the gingival margins around dental implants has been well documented in the literature. Su discussed the

concept of critical and subcritical contours of custom healing abutments and immediate provisional crowns explaining that the undercontoured subcritical contour allows for a coronal migration of soft tissue which results in more control of where the final gingival margin rests upon final restoration<sup>39</sup>.

Similar to Case 2 which involved the anterior maxilla, Case 3 has an almost identical distribution among the motivational factors with esthetics being the highest at 9.33/10 followed by functional stability at 8.8/10. There was no significant agreement among provider type for this case but instead emphasized how motivation factors are dynamic and not only depend on the clinician's training but the region in the mouth that is being treated in addition to the treatment goal overall. One improvement that could have been made specific to Case 3 is a greater span of options for treatment rationale or potentially an open response section. The lack of bone surrounding tooth #8 could have dissuaded the 7 individuals that opted for the three-unit bridge from choosing the implant retained option. Instead, it can only be assumed what led to that choice being prioritized.

*Case 4:*

As illustrated in Appendix A, Case 4 involves a heavily restored posterior quadrant with carious tooth #20 displaying a lack of coronal tooth structure that encroaches upon the pulp. While no measurements are superimposed on the radiographs, it was left to the participant to determine whether or not adequate coronal structure existed to justify restoration vs extraction. Similar to Cases 2 and 6, the concepts of crown:root ratio and indications for functional crown lengthening are relevant here. Crown to root ratios (CRR) are of importance when considering the restoration of a tooth that is affected by carious lesions or periodontal disease. This is defined as the structural ratio of the suprabony portion of a tooth (crown) versus the intrabony portion of

a tooth (root). There is a wealth of literature on this topic ranging in application from abutment teeth for removable partial dentures, to CRR for implant supported restorations, and in this case CRR for single-unit full-coverage restorations. Tada provides a longitudinal practice-based trial for the survival of abutment teeth for removable partial dentures based on CRR. CRR was scaled from  $<0.75$  to  $>1.5$  and results showed survivability of 89.1% and 46.7% respectively<sup>40</sup>.

While tooth #20 in this case presents with excellent bone levels that could accommodate a dental implant associated with a good prognosis, there is no treatment modality that truly restores a natural tooth in both form and function. Dental implants are successful in restoring occlusion but this treatment process obliterates the periodontal ligament which supplies proprioception and mesenchymal cells to the periodontal unit<sup>41</sup>. Although a crown lengthening procedure may reduce the CRR to a less favorable level the clinician must appreciate that this approach will maintain the natural dentition. For this reason, it was hypothesized that both periodontists and prosthodontists would prioritize a treatment approach that retained the natural tooth #20: choice three “Endodontic treatment followed by crown lengthening and full-coverage restoration.”

Results for Case 4 show that 79% of respondents chose to pursue functional crown-lengthening followed by a full-coverage restoration followed by 16% opting for implant placement. The p-value for this was 0.1957 garnishing no statistical difference in terms of a relationship between professions and treatment approach. Branching logic for the individuals that opted for implant placement had 63% choosing a stock healing abutment. This highlights a trend of practitioners choosing a stock healing abutment for posterior areas that may not be visible upon smile as opposed to Case 3 which had 62% choosing a custom healing abutment. This dictates a need for future research on whether or not the gingival contours that result from a

custom healing abutment translate to a greater level of implant success/health. Results for motivational factors show the highest score for functional stability 8.7/10 followed by retention of natural dentition 8.4/10. When analyzing which treatment options were associated with specific motivational factors, endodontic treatment followed by crown lengthening surgery was associated with higher values for retention (9.1/10) when compared to extraction (3.6/10).

*Case 5:*

The treatment area in question for Case 5 is unique in the fact that the anterior sextant of the maxilla is void of caries and fractures. For prosthodontist participants, this challenges their diagnostic and treatment planning abilities in a situation that does not have an emergent restorative need whereas the periodontal participants must gauge prognosis based on the periodontal condition. It should be noted that in this survey the patients' chief complaints were not included in case descriptions. This choice was made to hone the participants' focus on treatment planning decisions when presented only with clinical data and out of all six cases, this situation is subject to interpretation of perceived need. For example, if the patient's chief complaint was "I don't like the spaces between my teeth, I would like to close these" option three would be most appropriate whereas if the chief complaint was "I know I have bone loss around my teeth but I want to save them at all costs" option one to maintain in the current condition would no doubt be the most prevalent.

The maintenance of periodontal stability is complex in nature but is traditionally based on meticulous home care in addition to professional cleanings. Pihlstrom discusses the variance in stability between molar and single rooted teeth in a study from 1984. Data collected from this study stated that a greater reduction in pocket depth and maintenance of clinical attachment level were found in single-rooted teeth whereas molar teeth displayed a higher level of destruction<sup>42</sup>.

For this reason, it was hypothesized that periodontists would bias towards option one, “Maintain in current condition.” Prosthodontists on the other hand were hypothesized to choose option four “Extract #7-10 with site-development and implant supported 4-unit bridge.” As it was the most restoratively driven plan.

Case 5 had the widest spread of responses likely due to the lack of a chief complaint as mentioned prior. Forty-nine percent chose to maintain in current condition, 25% for orthodontic treatment to close spaces, and 20% for the four-unit implant supported bridge. The associated p-value was 0.1282 offering no correlation between profession and treatment choice.

When considering motivational factors, functional stability ranked the highest at 8.1/10 followed by retention of natural dentition at 7.9/10 and then esthetics at 7.8/10. Interestingly, this is the only case that involved the anterior maxilla that did not have esthetics as the primary motivational factor. No concrete conclusions can be drawn from this but it is this author’s opinion that when there is no evident need for prosthetic rehabilitation, the focus of treatment shifts from esthetics to maintenance of dentition/function. The p-value for retention of natural dentition was 0.0093 which describes a statistically significant relationship where practicing periodontists denoted higher value than periodontal residents and prosthodontists.

*Case 6:*

Case 6 is similar to Cases 2 and 4 in the fact that it involves an isolated tooth whose treatment may violate an acceptable crown:root ratio. It is unique in that this tooth was previously treated with NSRCT in addition to preparation for post space which eventually resulted in a fractured crown at the gingival level. Periodontal charting depicts health of the surrounding periodontium. Upon examination of the figured for case 6 in Appendix A, the lack



of restorative space for crown preparation is evident which would necessitate a functional crown lengthening procedure. The benefits of this elective surgery are that the patient is able to maintain their natural tooth in addition to it being a cost-effective approach when opposed to extraction and implant placement. As described by Zhen, the downsides to this approach involve an increased risk of catastrophic fracture due to the reduction in crown:root ratio and esthetic deformation when performed in an area that is visible upon smile. When occlusal forces remain constant but that ratio is decreased, additional force is applied to the mid-root portion of the tooth (which in this case has already been compromised by NSRCT). As most dental roots taper towards the apex, the lack of diameter in the mid-root portion may be more prone to fracture.<sup>43</sup> For these reasons, the hypothesis was that the majority of respondents would elect for extraction followed by implant placement.

While there was no statistical significance in regards to treatment planning (p-value 0.2634), the majority of respondents (70%) elected for option four “Extract #4 with site development and single-unit implant placement followed by 25% choosing option two “Endodontic treatment followed by crown lengthening and full-coverage restoration.” Branching logic for implant workflow resulted in a wide spread of responses with the most prevalent being a conventional implant workflow with implant placement and stock healing abutment (p-value 0.6228)

Upon analysis of motivational factors, functional stability ranked the highest with 8.9/10 which is consistent with other posterior cases in this research study.

## **Conclusion**

This survey-style research project explored the prevalence of various treatment planning options in regards to multidisciplinary cases involving endodontic, prosthodontic, and restorative treatment options. Overall, there was a wide variance of selections both within treatment disciplines and across the board. The overarching theme from this study is that treatment planning decisions continue to be highly individualized based on the providers training and treatment philosophy. Data from this study suggests a future trend of “aggressive” treatment options that elect for extraction and replacement as opposed to maintenance. While diagnosis is widely regarded as an objective description of a patient’s disease state, this objectivity does not transcend to treatment selection. Furthermore, the results of this study challenge the academic community to answer the questions of whether or not there is always a “best” treatment plan for a patient (when looking solely at clinical findings with no impact of a patient’s desire/chief complaint).

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## **Appendix A**

## Dental treatment planning decisions with interdisciplinary cases

Please complete the survey below.

Thank you!

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Please select the following answer choice that most accurately describes you

- Periodontal resident
- Practicing periodontist
- Practicing prosthodontist

---

Years in Practice

- Current Resident
- Up to 5 years
- 5- 10 years
- 11-15 years
- 16-20 years
- 21-25 years
- 26+ years

---

Which of the following best describes the type of practice you work in?

- Solo practitioner
- Group practice with general dentists
- Group practice with other specialists
- Group practice with general dentists and other specialists
- Military
- Acedemia
- Other

---

Are you board-certified in your respective field?

- Yes, I am a board certified periodontist
- Yes, I am a board certified prosthodontist
- No, I am not board certified

---

Which of the following best describes the location of your practice?

- Urban
- Suburban
- Rural

---

Please indicate your gender:

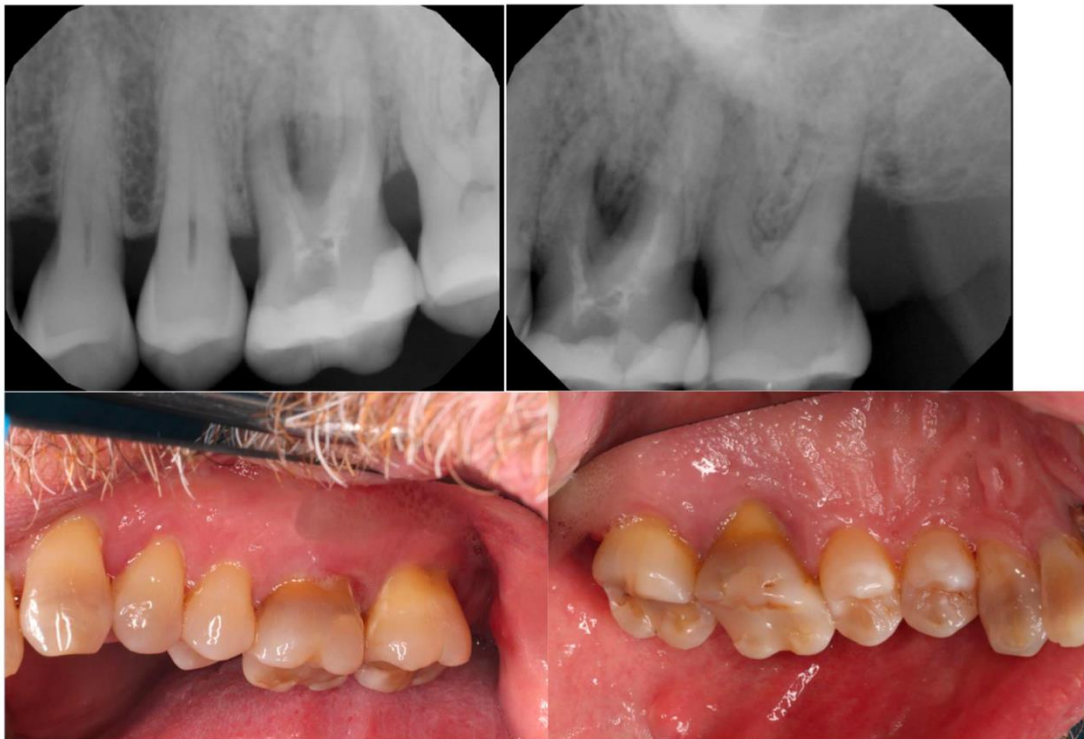
- Male
- Female
- Other



**Case 1: Please use the images below to answer the following questions regarding UL Tooth #14**

Case #1 images

Case #1 UL/#14



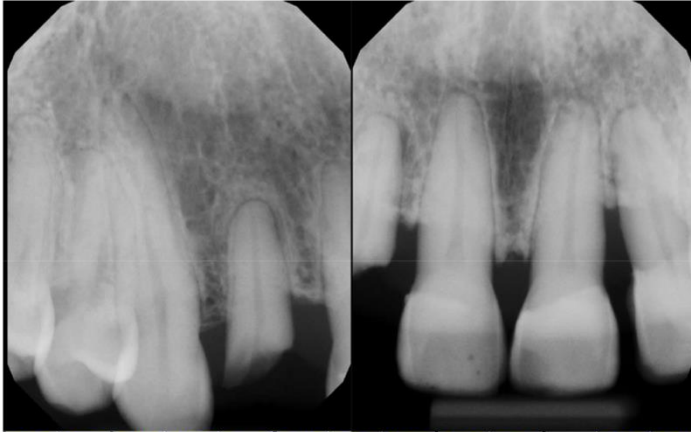
CCC	CCC	CCC	CCC	CCC	CCC	CCC		Calc
F	F	F	F	G	P	P		Prognosis
					2	1		Furcation
2 2 3	6 4 6	2 4 8	6 4 4	4 2 4	111012	107 6		Attach
1 0 0	-2-2-2	1-2-2	1-1-1	2 1 2	-2-2-2	-2-3-1		FG margin
3 2 3	4 2 4	3 2 6	7 3 5	6 3 6	9 8 10	8 4 5		PD
NNN	NNN	NNB	BNN	NNB	B B B	B B B		Bleed
NNN	NNN	NNN	NNN	NNY	YNY	YNY		Plaque
9	10	11	12	13	14N	15	16	
NNN	NNN	NNN	NNN	NNN	YYY	YYY		Plaque
NNN	NNN	NNB	BNN	NNB	B B B	B B B		Bleed
3 3 3	4 3 4	4 3 6	5 3 5	4 4 5	6 109	8 6 12		PD
2-12	-1-11	2-11	2 1 2	2 1 2	2-5-2	-1-1-1		FG margin
1 4 1	5 4 3	2 4 5	3 2 3	2 3 3	4 1511	9 7 13		Attach
CCC	CCC	CCC	CCC	CCC	CCC	CCC		Calc
					1	2	1	2
								Furcation
1	1				1			Mobil



**Case 2: Please use the images below to answer the following questions regarding maxillary anterior tooth #7**

Case #2 Images

Case #2: Maxillary Anteriors/#7



3 2 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	5 2 1	0 0 0	0 0 0	0 3 4		0 0 0	0 0 0	Attach
-1-13	3 2 3	3 2 3	3 2 2	3 3 3	3 2 3	0 0 2	3 2 3	3 2 3	3 -1-2		3 2 3	3 2 2	FG margin
2 1 3	3 2 3	3 2 3	3 2 2	3 3 3	3 2 3	5 2 3	3 2 3	3 2 3	3 2 2		3 2 3	3 2 2	PD
													Bleed
													Plaque
4	5	6	7	8	9	10	11	12	13	14	15	16	
													Plaque
													Bleed
3 2 3	3 2 3	3 2 3	3 2 3	3 2 3	3 3 3	3 3 4	3 2 3	3 2 3	3 2 2		3 2 3	3 2 3	PD
-2-32	3 -13	3 0 3	3 2 3	-10 3	3 -2-2	-3-22	3 2 3	2-23	3 -3-2				FG margin
5 5 1	0 3 0	0 2 0	0 0 0	4 2 0	0 5 5	6 5 2	0 0 0	1 4 0	0 5 4		0 0 0	0 0 0	Attach

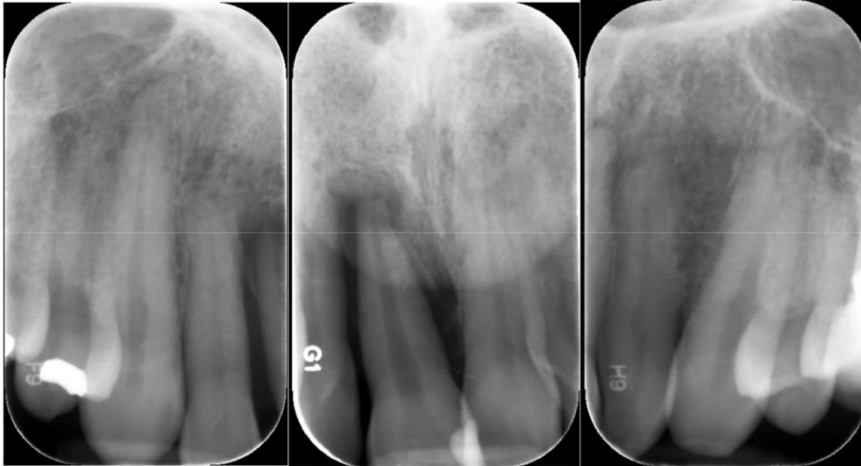




**Case 3: Please use the images below to answer the following questions regarding maxillary anterior tooth #8**

Case 3 images

Case #3: Maxillary Anteriors/#8



3	2	3	3	2	3	3	2	3	9	2	3	3	2	3	3	2	3	2	2	3	2	2	3	3	2	4	3	2	2	3	3	2	3	FG margin	
																																			PD
																																			Bleed
																																			Plaque
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16																				Plaque	
																																			Bleed
3	3	3	3	3	2	2	2	2	2	2	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	PD	
																																			FG margin



---

In your opinion, which of the following treatment options is the most appropriate for tooth #8 given the provided information?

- Maintain in current condition
- Endodontic treatment followed by full-coverage restoration
- Extract #8 and fabrication of 3-unit bridge tooth #7-9
- Extract #8 with site development followed by single-unit implant placement
- Extract #7-10 with site development and implant supported 4-unit bridge

---

You've selected the option "Extract #8 with site development and single-unit implant placement." Please select a treatment approach from the following options which you think would be best suited for this case (assuming primary stability is achieved).

- Immediate implant with stock healing abutment
- Immediate implant with provisional crown
- Conventional implant with stock healing abutment
- Conventional implant with custom healing abutment

---

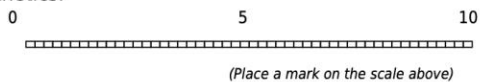
You've selected the option "Extract #7-10 and site development with implant supported 4-unit bridge." Please select a treatment approach from the following options which you think would be best suited for this case (assuming primary stability is achieved).

- Stock healing abutments following implant placement with temporary Essix/Flipper
- Custom healing abutments following implant placement with temporary Essix/Flipper
- Digital workflow immediate provisional

---

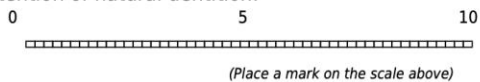
Please indicate on the sliding scale the relative importance of the following categories when making your decision about this individual case.

Esthetics:



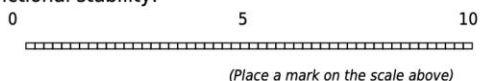
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Retention of natural dentition:



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Functional stability:





**Case 4: Please use the images below to answer the following questions regarding LR Tooth #20**

case 4 images

**Case #4 LR/ #20**



5 5 4	3 5 4	3 2 2	2 3 2	1 2 2	2 2 2	2 4 2	2 3 2	2 3 2	3 2 3	3 2 3	3 2 3	5 6 6	6 5 5		Attach
-1-2-1	-1-2-1	1 0 1	1 0 1	1 0 1	1-1-1	1-2-1	1-1-1	1-1-1	1 0 1	1 0 1	0 0 0	-2-3-2	-3-3-2		FG margin
4 3 3	2 3 3	4 2 3	3 3 3	2 2 3	3 1 3	3 2 3	3 2 3	3 2 3	4 2 4	4 2 4	3 2 3	3 3 4	3 2 3		PD
B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B		Bleed
Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y N	Y Y Y	Y Y Y	Y N Y	Y N Y	Y N Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y		Plaque
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	
Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y N N	Y N Y	Y N Y	Y Y Y	Y Y Y	Y Y Y		Plaque
B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B	B B B		Bleed
5 3 3	4 2 4	4 1 5	3 1 3	3 2 4	4 1 3	4 2 4	4 2 4	4 2 4	4 2 4	3 1 4	4 1 3	3 2 3	4 2 3		PD
-2-1-2	1 1-1	1 0 1	2 1 2	2 1 1	1 1 1	1 1 1	1 1 2	1 1 1	1 1 1	1 1 2	1 1 2	-1-1-2	-2-2-3		FG margin
7 4 5	3 1 5	3 1 4	1 0 1	1 1 3	3 0 2	3 1 3	3 1 2	3 1 3	3 1 3	2 0 2	3 0 1	4 3 5	6 4 6		Attach

In your opinion, which of the following treatment options is the most appropriate for tooth #20 given the provided information?

- Maintain in current condition
- Direct restoration with mineral trioxide aggregate (MTA) pulp cap if indicated
- Endodontic treatment followed by crown lengthening and full-coverage restoration
- Extract #20 with fabrication of 3-unit bridge tooth #18-21
- Extract #20 with site development and single-unit implant placement

---

You've selected the option "Extract #20 with site development and single-unit implant placement." Please select a treatment approach from the following options which you think would be best suited for this case (assuming primary stability is achieved).

- Immediate implant with stock healing abutment
- Immediate implant with provisional crown
- Conventional implant with stock healing abutment
- Conventional implant with custom healing abutment

---

Please indicate on the sliding scale the relative importance of the following categories when making your decision about this individual case.

Esthetics:

0 5 10



*(Place a mark on the scale above)*

---

Retention of natural teeth:

0 5 10

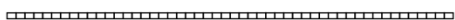


*(Place a mark on the scale above)*

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Functional stability:

0 5 10

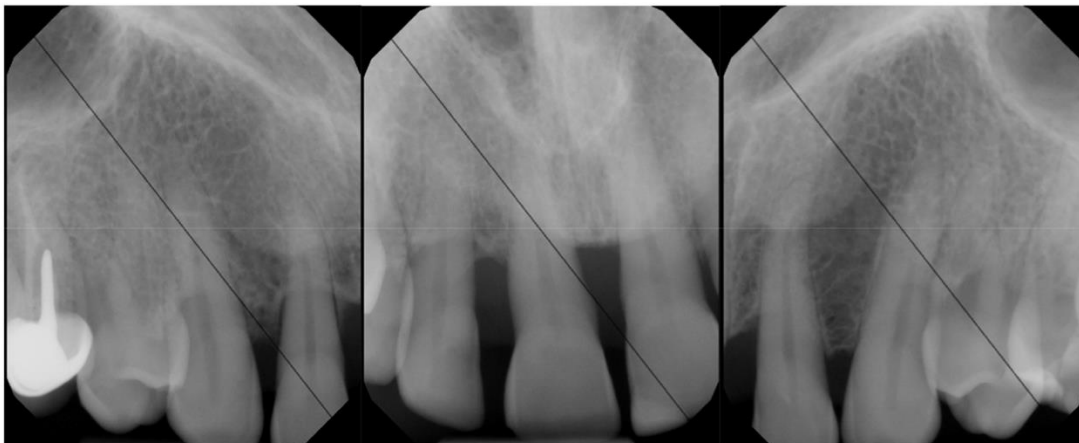


*(Place a mark on the scale above)*

**Case 5: Please use the images below to answer the following questions regarding the maxillary anterior teeth**

Case 5 images

**Case #5: Maxillary Anteriors**



3 4 6	2 3 5	4 4 7	3 2 3	3 2 3	4 3 6	4 7 7	4 3 3	3 2 3	2 4 6	6 7 3	7 2 4	3 3 10	7 7 7	Attach
1 -10	1 -10	-1-2-2	0 0 0	0 0 0	-1-1-2	-1-10	0 0 0	0 0 0	0 -2-2	-1 -4 0	-2 0 -1	0 -1-2	1 -10	FG margin
4 3 6	3 2 5	3 2 5	3 2 3	3 2 3	3 2 4	3 6 7	4 3 3	3 2 3	2 2 4	5 3 3	5 2 3	3 2 8	8 6 7	PD
NNN	NNN	NNN	BNB	NNN	NNN	NBB	BNN	NNN	NBN	BNB	BNN	BBB	BBB	Bleed
														Plaque
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
														Plaque
NNB	BNN	NNN	NNN	NNN	NNN	NNB	BNN	NNB	BNN	NNN	NNN	NNN	NNN	Bleed
4 3 5	4 3 6	5 2 5	4 2 4	5 2 4	4 2 4	7 2 7	7 3 4	3 3 3	3 2 5	6 2 5	4 2 4	5 2 7	8 3 5	PD
1 0 -1	-1-2-1	-1-1-2	0 0 0	0 0 0	0 0 -2	-1 0 0	0 -10	0 0 0	0 0 0	-1 0 0	0 0 0	0 -2 1	1 0 0	FG margin
3 3 6	5 5 7	6 3 7	4 2 4	5 2 4	4 2 6	8 2 7	7 4 4	3 3 3	3 2 5	7 2 5	4 2 4	5 4 6	7 3 5	Attach
														Calc
	2												2	Furcation
0	0	0	0	0	0	0	0	0	0	0	0	0	0	Mobil





**Case 6: Please use the images below to answer the following questions regarding UR Tooth #4**

Case #6 Images

Case #6: UR/#4



4 4 3	4 3 3	2 1 3	2 1 1	1 2 8	3 1 1	1 1 2	2 2 2	2 1 2	3 2 3	2 2 2	3 3 3	3 6 3		Attach
0-10	0 0 0	1 1 1	1 1 2	2 0-2	0 1 2	2 1 1	1 0 1	1 2 1	1 1 1	1 1 1	0-10	0-21		FG margin
4 3 3	4 3 3	3 2 4	3 2 3	3 2 6	3 2 3	3 2 3	3 2 3	3 3 3	4 3 4	3 3 3	3 2 3	3 4 4		PD
NNN	NNN	NNB	NNB	BBB	BNN	NNN	NNB	BNN	BNN	NNN	NNN	NBN		Bleed
														Plaque
3	4	5	6	7	8	9	10	11	12	13	14	15	16	
														Plaque
BBB	BNB	BNB	BNB	BBB	BNB	BNN	NNN	NNN	NNN	BNN	NNB	BNB		Bleed
5 2 4	3 3 4	4 3 6	4 3 5	6 6 7	3 3 4	4 2 3	3 2 4	4 2 3	4 2 3	4 2 3	3 2 4	4 3 4		PD
0 0 1	0 0 2	0 0 0	0 0 1	0-20	0 0 1	1 0 0	0 0 0	0 0 0	0 0 0	1 0 1	1 0 1	1 0 2		FG margin
5 2 3	3 3 2	4 3 6	4 3 4	6 8 7	3 3 3	3 2 3	3 2 4	4 2 3	4 2 3	3 2 2	2 2 3	3 3 2		Attach

In your opinion, which of the following treatment options is the most appropriate for tooth #4 given the provided information?

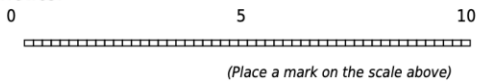
- Maintain in current condition
- Endodontic treatment followed by crown lengthening and full-coverage restoration
- Extract #4 with fabrication of 3-unit bridge tooth #3-5
- Extract #4 with site development and single-unit implant placement

You've selected the option "Extract #4 with site development and single-unit implant placement." Please select a treatment approach from the following options which you think would be best suited for this case.

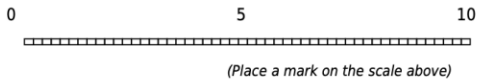
- Immediate implant with stock healing abutment
- Immediate implant with provisional crown
- Conventional implant with stock healing abutment
- Conventional implant with custom healing abutment

Please indicate on the sliding scale the relative importance of the following categories when making your decision about this individual case.

Esthetics:



Retention of natural dentition:



Functional stability:

