ASSESSING THE DIAGNOSTIC VALUE OF LATERAL CEPHALOMETRIC RADIOGRAPHS IN CLASS I DENTAL MALOCCLUSIONS

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ABSTRACT

Introduction: Controversy exists over the value of a lateral cephalogram for treatment planning in different malocclusion types. Discord has been found in the literature, and no studies on the matter have focused solely on Class I dental malocclusions. The aim of this study was to elucidate whether treatment decisions of extraction or non-extraction and the perceived need for a lateral cephalogram would change depending on whether a lateral cephalogram was provided or eliminated in the patient record set.

Methods: A survey was distributed to a random sample of AAO members. The survey consisted of four different patient record sets, each with a Class I dental malocclusion. Each record set had two versions—one with the lateral cephalogram and one without. The survey had randomization of each version of the record sets so that each record set would be viewed an equal number of times with and without its corresponding cephalogram. Subjects were then asked a series of four questions pertaining to each case: was a cephalogram necessary for treatment planning, treatment of extraction versus non-extraction, retention method, and if records were adequate to treatment plan.

Results: In total, 79 orthodontists completed the survey. For all cases combined, record sets viewed with the lateral cephalogram had an increase in the: perceived need for a lateral cephalogram, decision of extraction, and opinion of the records being adequate to treatment plan. All were statistically significant at $P \leq 0.001$. For each record set, the difference in perceived need for a lateral cephalogram was statically significant.

Conclusions: The use of a lateral cephalogram for diagnosing and treatment planning seems to hold value in Class I dental malocclusions, justifying radiation exposure for this diagnostic record. Additionally, the perceived need for a lateral cephalogram is greater when it is presented with the record sets, demonstrating the diagnostic value this radiograph holds.

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CHAPTER 1

INTRODUCTION

Orthodontists have been utilizing cephalometric radiography as an aid for diagnosis and treatment planning since Broadbent and Hofrath published their developments in the 1930s (Jacobson, 2006). Cephalometrics provides the orthodontist with additional information on the etiologies of malocclusion, helps aid in developing treatment goals, and can be utilized to assess craniofacial growth and treatment outcomes. On the other hand, controversy exists over whether a lateral cephalogram is necessary for each patient. Moreover, use of other records could potentially provide adequate information without the need of a lateral cephalogram, in select malocclusion types.

Obtaining diagnostic records is a professional obligation that has both a legal and an ethical basis (AAO, 2017). Currently, the American Association of Orthodontists (AAO) standards for pre-treatment diagnostic records, as written in their *Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics,* include intra- and extra-oral photographs, dental casts, and panoramic/intraoral radiographs. Additionally, these guidelines state that radiographs to allow for assessment of the size, shape, and positions of relevant hard and soft tissues *should* be made (AAO, 2017). Lateral cephalogram radiographs are most commonly utilized by orthodontists to satisfy the latter.

However, it has been argued that obtaining a lateral cephalogram is not necessary for the diagnosis and treatment planning for all patients. Questions have been posed as to whether a lateral cephalogram is truly necessary in all cases, and multiple studies have been conducted to assess the value of lateral cephalometric radiography for orthodontic diagnosis and treatment planning. Not all malocclusions are created equal with regard to complexity in diagnosis and treatment considerations. Class I dental malocclusions are typically considered as less complex. Studies show that over 50% of the population present with a Class I malocclusion, with the lower incisors being the most frequently maloccluded teeth (Graber et al. 2017, Massler et al. 1951, Emrich et al. 1965, Salzmann et al. 1977, Ast et al. 1965). However, no studies have been found that focus on the use of LCR for treatment planning for only this malocclusion type.

This knowledge begs the questions: Is a lateral cephalogram necessary for Class I dental malocclusions? In these cases, would the treatment plan objectives change with the availability of a lateral cephalogram?

Regardless of malocclusion classification, obtaining appropriate diagnostic records play a pivotal role in the treatment decision making process. Radiographs are necessary and hold an important role in accurate diagnosis; however, all dental specialists should abide by the As Low As Reasonably Achievable (ALARA) principle and adhere to the justification that the benefits outweigh the risks (Abbot, 2000).

Because of its quintessential role in orthodontics, many orthodontists take cephalometric radiographs on all patients. However, sometimes, this may occur as a defense mechanism to avoid possible medicolegal repercussions, rather than based on the perceived need for its use in treatment planning.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Diagnostic Records and Lateral Cephalometric Radiography in Orthodontics

The role of the orthodontist is to diagnose and treat skeletal and dental malocclusions. Following clinical examination, obtaining diagnostic records is a fundamental aspect of orthodontics. In more recent years, emphasis has been placed on treating to the soft tissue profile, as opposed to just the dentition. Therefore, the orthodontist must identify the underlying skeletal and dental problems associated with the soft tissue profile. Lateral cephalometric radiography (LCR) is the prototypical method for the study of the hard and soft tissue relationships within the craniofacial complex in terms of height, depth, and time (Downs 1952).

Observation of growth changes in the craniofacial complex was made possible in 1931, when Broadbent released his discoveries of utilizing a head holder to standardize each lateral cephalometric film (Broadbent 1981). Recognizing the potential of LCR to document longitudinal growth in the craniofacial complex, Broadbent and Todd were instrumental in constructing the nation's largest growth studies (Hans et al. 2015). Soon after, the use of the cephalometer segued from a research modality to use in clinical practice. Cephalometric analysis first became popular with the measurements proposed by Downs and Steiner. Then, in 1975, the release of the Bolton Standards helped to popularize the use of the numerous cephalometric analyses that have since been created (Hans et al. 2015).

Lateral cephalometric radiography has proved to be an indispensable tool for researching growth and treatment outcomes, assessing cervical vertebrae maturation, and diagnosing etiology of skeletal discrepancies and dental malocclusions. However, clinical examination along with diagnostic photographs may provide the information needed for treatment planning without the use of LCR in select patients.

Clinical review has been argued as being more important than cephalometric analyses. Many times, cephalometric measurements can be deceiving, showing a more prominent discrepancy than can be detected clinically. If in doubt, however, clinical appearance should always outweigh cephalometric measurements because hard tissue relationships do not reflect how people are actually perceived by others (Sarver and Ackerman 2000). Using only cephalometric radiographs to visualize these relationships are therefore inadequate; pictures taken from frontal and oblique views (in both static and dynamic postures) may provide enough valuable information to the orthodontist without the use of LCR for treatment decisions (Sarver and Ackerman 2000).

Meticulous clinical evaluation of a patient can sometimes reveal etiologies of the patient's chief complaint without the use of a lateral cephalometric radiograph. Assessment of the macroesthetic and miniesthetic characteristics (i.e. looking at facial proportions, incisal display, and tooth morphology) may provide pertinent information not seen on any radiographs (Sarver 2011). For example, oblique photographs are useful in detecting incisor proclination, which can aid in determining if the problem is of dental or skeletal origin.

Taking photographs from the frontal, profile, and oblique views at rest and on smile may provide adequate information to the orthodontist without the use of cephalometric radiography (Sarver 2011). On the other hand, there are instances when only these records in conjunction with LCR will provide the orthodontist with all the etiological information needed to diagnose and create the proper treatment objectives. Patient selection is crucial in determining which diagnostic records are necessary.

Rule of thumb is to take intra-oral and extra-oral photographs and a panoramic radiograph for each patient. Some orthodontists argue that any additional records should be made on a case-by-case decision. Because patients present with ranges of malocclusion types and severity, all records are not necessary nor desirable for each patient; conversely dental casts and lateral cephalograms have been made routine for most patients (Graber et al. 2017). This may be attributed to that fact that the AAO *Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics* includes these in the records for standard of care (AAO, 2017).

Although obtaining diagnostic records is necessary, which records to make should not be based on a one-size-fits-all model. One of the core values of a dentist is beneficence; this entails maximizing the benefits and minimizing the risks for each patient (American College of Dentists 2012). The ultimate goal of obtaining diagnostic records is for the orthodontist to formulate the best possible treatment plan for the patient (Han et al. 1991). The practice of orthodontics is not homogeneous. For example, one case presented to five different orthodontists may render at least five different but viable treatment plans. For this reason, it does not seem reasonable to have one diagnostic standard for the profession (Han et al. 1991).

2.2 Use of LCR in Treatment Planning: Past Studies

Multiple studies have been conducted to assess the value of lateral cephalometric radiography for orthodontic diagnosis and treatment planning. Nevertheless, the topic remains controversial for many reasons. Two possible reasons are that conflicting results have been drawn from such studies, and many of these studies include a broad scope of malocclusion types. However, Class I dental/skeletal malocclusions are the most prevalent malocclusion types, representing over 50% of the population (Graber et al. 2017). Yet to date, no studies have been found that focus on the value of LCR for treatment planning only this malocclusion type.

Questions remain on the usefulness of the diagnostic records routinely obtained by orthodontists. Interestingly, one study found that study models alone yield treatment plans equivalent to those formulated using all of the diagnostic records (study models, facial photographs, panoramic radiograph, and lateral cephalogram) (Han et al. 1991). Although it should be noted that all 57 patients in this study present with a Class II, Division I malocclusion, and only five orthodontists participated.

In another study, the authors assess whether a lateral cephalometric radiograph influences treatment planning decisions. They compare treatment plans that were produced with versus without the use of a lateral cephalogram. Their sample of six patients represent Angle's Class I, Class II div 1, Class II div 2, and Class III malocclusions. The results show that the availability of a lateral cephalogram did not make a significant difference in the treatment planning decisions of the orthodontists, with the exception of one patient (Devereux et al. 2011). For this patient, the extraction decision changed significantly with the use of a lateral cephalogram. Therefore, the authors interpret their results to mean that in some patients, the use of a lateral cephalogram will change the treatment plan in a fundamental way (Devereux et al. 2011). Notably, this patient presents with a Class II Division I dental and Class II skeletal malocclusion.

A similar study concludes that a lateral cephalogram included in the diagnostic records does not add any additional benefit for treatment plan decisions in 20%-30% of cases (Patel et al. 2013). However, for Class II and Class III malocclusions orthodontists did feel a need for a lateral cephalogram for proper decision making. Nonetheless, due to the limited sample size, and some inherent biases, no definitive conclusion on the matter could be deduced (Patel et al. 2013).

More recently, a comparable study also concludes that LCR may not have an influence on orthodontic treatment planning (Durão et al. 2015). Conversely, the authors show that treatment decisions for Class II malocclusions did appear to rely on the use of a lateral cephalogram for diagnostic data. Ultimately, they conclude that because of the great variation in malocclusion types, indications for LCR should be constructed on an individual basis, and that clinical examination is one of the most important factors for the orthodontist to construct an appropriate treatment decision (Durão et al. 2015).

One study was found that does focus on Class I malocclusions, in which the authors evaluate the influence of lateral cephalometric radiography on extraction decisions. Their data show that LCR did not have a significant influence on extraction decisions, and that clinical exam and appearance-related factors remain to be the most important factors when determining to extract (Dinçer et al. 2013). However, the validity of this claim may be considered weak, as only two orthodontists participated in this study.

From these studies, one can conclude that Class II and Class III malocclusions require a lateral cephalogram for diagnostic and treatment decisions more frequently than do Class I malocclusions (Patel et al. 2013, Durão et al. 2015). Results from the preliminary study by Patel et al. serve as the basis for this current study, in which only the Class I malocclusion is evaluated.

2.3 Radiation Considerations

Regardless of malocclusion classification, obtaining appropriate diagnostic records play an essential role in the treatment decision making process. Although radiographs are necessary and hold an important role in accurate diagnosis, exposure to low-dose ionizing radiation poses some real, though not fully understood, risk. It is therefore imperative that all dental specialists abide by the As Low As Reasonably Achievable (ALARA) principle and adhere to the justification that the benefits outweigh the risks (Abbot, 2000).

Effective dose has been determined by the International Commission on Radiological Protection (ICRP) as the preferred unit of measure to compare radiation risk between different radiographic procedures (Ludlow et al. 2008). This model relates the dose quantity to the probability of suffering from the stochastic effects from exposure to low doses of ionizing radiation (Ludlow et al. 2008). The use of current radiographic techniques and updated technology, such as digital sensors and rectangular collimation, has decreased the effective dose in dental radiography over the years, and the equivalent dose to tissues from a lateral cephalometric radiograph may be below that of most dental radiographs (Ludlow et al. 2008). However, we must keep in mind the linear no-threshold (LNT) hypothesis for radiation— for which no matter how small the dose there is no safety threshold (White et al. 2012).

The LNT model used for radiation protection is supported by epidemiological data after exposure to doses over 100 mGy (Dainiak et al. 2018). Although an imperfect model, it has been deemed as the "best" model to date by the National Research Council (NRC), the United Nations Scientific Committee on Atomic Radiation (UNSCEAR), the National Council on Radiation Protection and Measurements (NCRP), and the ICRP (Boice Jr. 2017). Despite the acceptance of this model, studies have shown that there are instances when the LNT hypothesis is not valid, especially with low-dose radiation exposure (below 100 mGy) (Boice Jr. 2017).

Recently, scientists have questioned the appropriateness of the LNT dose-effect relationship model and its relevance to doses below 100 mGy. Many studies support the case that ionizing radiation (IR) below this effective dose, for instance in dental radiographs, may not adhere to the linear-dose effect relationship (Dainiak et al. 2018). With the acknowledgement of this fault, and as our understanding of complex disease processes, cellular responses, and individual variability to IR expands, the Radiation Research Society is encouraging scientists to develop new models to better predict cumulative risks (Dainiak et al. 2018).

Although there is uncertainty in the cause and effect relationship between dental radiographs and malignancy, studies have shown that long term effects of IR exposure include leukemia and other malignancies (Ludlow et al. 2008). Additionally, in the head and neck region, the thyroid and salivary glands are the most vulnerable organs to the harmful effects of radiation, and an elevated risk of thyroid cancer following external radiation has been demonstrated (Signorelli et al. 2016. Hoogeveen et al. 2015). With this in mind, dentists should minimize IR exposure to patients by prudent selection of prescribed radiographs and use a protective lead apron with thyroid collar for each patient, especially in children as they are more susceptible to the stochastic effects of radiation. On the contrary, when taking a panoramic or lateral cephalogram radiograph, lead aprons without the thyroid collar are used in order to visualize necessary anatomy. This introduces yet another consideration for orthodontists to take lateral cephalograms only when needed.

The American Dental Association (ADA) guidelines recognizes that lateral cephalometric radiographs may be necessary for determining the dental and skeletal relationships, but also upholds that clinical judgment be used to assess the necessity of the radiograph on an individual basis (ADA, 2012). In conflict, the AAO guidelines state that diagnostic records should include intraoral radiographs and radiographic imaging to evaluate the hard and soft tissue of the craniofacial structures (i.e. cephalogram or CBCT). These guidelines do state that some variation may be appropriate: “Where limited orthodontic procedures are anticipated, diagnostic records may vary from those associated with comprehensive care… The gathering of appropriate diagnostic records should be considered a standard of care to allow for proper diagnosis, treatment plan and treatment rendered” (AAO, Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics, 2017).

However, this statement may be ambiguous and up for interpretation, thereby resulting in orthodontists taking lateral cephalogram radiographs to avoid any possible medicolegal repercussions.

CHAPTER 3

AIMS OF THE INVESTIGATION

The aim of this study is to investigate the value of lateral cephalometric radiographs for diagnosing and treatment planning patients with Class I dental malocclusions. If this study can demonstrate that there is no difference in perceived need for a lateral cephalogram and no difference in treatment decisions of extraction or non-extraction when the diagnostic records are viewed with, versus without, the lateral cephalogram, then perhaps guidelines can be modified so that orthodontists can freely prescribe LCR on a patient-specific basis without the fear of medicolegal ramifications, thereby decreasing patient exposure to radiation.

By way of survey completion we will compare orthodontists' perceived need for a lateral cephalogram for the diagnosis and treatment planning of patients who meet our inclusion criteria, and compare orthodontists' treatment plan decisions of extraction or non-extraction when a lateral cephalogram is included in the diagnostic records versus when it is omitted.

Our null hypothesis is that there will be no difference in the following: 1) the perceived need for a lateral cephalogram, and 2) the treatment plan of extraction or non-extraction in patients with Class I dental malocclusions when a lateral cephalometric radiograph is presented versus when it is omitted from the diagnostic records.

CHAPTER 4

MATERIALS AND METHODS

Pre-existing pre-treatment records from the Department of Orthodontics at Temple University Kornberg School of Dentistry (TUKSoD) are utilized for this study. All diagnostic records are located from the Dolphin Imaging (Patterson Dental Supply, Inc) software program and are de-identified. Patient eyes are blocked-out and names are replaced with randomly assigned numbers. Each patient had signed an informed consent upon the first patient visit to allow the use of images for research and teaching purposes. The study obtained approval by the university's institutional reviewed board in January 2018.

Patient records were selected based on malocclusion type: Class I molar relationship, permanent dentition from 1st molar to 1st molar, and mild to moderate (<7mm) crowding and/or spacing. Patient age, gender, and race are not criteria in this study. All patient records selected had adequate pretreatment records for all of the following: intra-oral photographs (left lateral, right lateral, center, upper occlusal, and lower occlusal views), extra-oral photographs (frontal, frontal smiling, profile, and oblique smiling), panoramic radiograph, lateral cephalometric radiograph, and photographs/scanned images of the diagnostic models.

Four patient records were selected for the use in a survey that was developed using SurveyMonkey, an online survey development software that allows for custom designed surveys. The survey was constructed using the A/B Test feature; this allows for the random display of different versions of the images (the diagnostic records for each patient). All patient records presented in the survey include intra- and extra- oral photographs, pictures or scans of diagnostic casts, and a panoramic radiograph (Refer to Appendix A for an example of the survey). The lateral cephalogram, however, does not present with each case in each survey.

With the A/B Test feature, each patient record set includes its LCR on an alternating basis—the software randomly assigns different views of the survey each time the link is accessed. Therefore, each subject completes a survey that presents all four cases but each case varies in whether the LCR is provided or not (randomly assigned but such that each case has an equal opportunity to be seen with or without its LCR). Therefore, with enough responses, each case would be seen with and without its LCR an equal number of times. In this way, comparison of responses to each case from when it was viewed with and without the LCR is made possible.

The survey underwent a trial period with three orthodontic faculty to estimate the approximate duration of the survey and for quality assurance. After being reviewed and approved by the AAO General Counsel and the Survey Review Committee, the survey was distributed to orthodontists via The AAO Partners in Research program. The AAO Partners in Research program was established for the distribution of surveys on behalf of faculty/residents of orthodontic residency programs accredited by the Commission on Dental Accreditation. Through this service, the survey is distributed via email to a random sample of up to 2,300 members of the AAO, whose emails are on file in the AAO database. Ultimately, the survey was distributed to 1,999 orthodontists.

The subjects of this study were all members of the AAO. This was the only criteria for these subjects; number of years practicing, active or retired, educational background, gender, etc. were not an inclusion/exclusion criterion.

The email to the orthodontists includes a cover letter of information about the survey and a link to complete the survey. The survey includes the de-identified diagnostic records from the patients selected; no patient names or ages are disclosed. All survey responses are anonymous and questions regarding personal information (such as educational background) are optional.

The first question of the survey is an acknowledgment of the survey terms: “I acknowledge that I choose to be a participant in this survey and that my responses will be recorded and used for research purposes. I understand that all responses will be anonymous and that I may quit the survey at any time.” Three survey questions (refer to Appendix A for the complete survey) asked for background information: 1) What residency program did you attend? 2) How many years have you been practicing orthodontics? 3) Do you routinely use lateral cephalometric radiographs for treatment planning?

Then the patient record sets were shown, followed by four questions pertaining to each case: 1) Is a lateral ceph necessary for treatment planning this case? 2) How would you treat this case—extraction or non-extraction? 3) How would you retain this case (Hawley retainer, fixed lingual, thermoplastic, none of the above)? 4) Were the records adequate to treatment plan this case?

The differences in responses to treatment planning decisions and the perceived need for a lateral cephalogram are analyzed by comparing responses to the four questions for each case when it was presented with, versus without the cephalometric radiograph. Because of the nature of the data, non-parametric data analysis tests are utilized (e.g. McNemar Test). Given previous findings on the topic and standard estimations of alpha and beta (type I and type II error), it is estimated that 52 survey responses (26 per group) are needed for statistical significance.

CHAPTER 5

RESULTS

The survey was distributed to 1,999 orthodontists. Ultimately, 79 individuals completed the survey, resulting in a 3.95% response rate. The survey randomization did not result in an exact 50-50 distribution for all record sets (Figure 1), but the difference was not significant (Case 1: Chi-Square = 2.848, Asymptotic Significance = 0.091; Cases 2,3,4: Chi-Square = 0.013, Asymptotic Significance = 0.910). Subjects who viewed the record set with both the panoramic and cephalometric radiographs are designated as Group A and those who viewed only the panoramic radiograph are designated as Group B. The survey responses were organized into an excel sheet and assigned numerical values in order to be quantified for statistical analysis (refer to Appendix B). McNemar's tests were used to compare dichotomous data and Pearson Chi-Square test to compare non-dichotomous data. The level of statistical significance for all tests was set at $\alpha = 0.05$.

Three dichotomous survey questions pertaining to each patient record set were quantified: 1) Is a lateral cephalogram necessary for treatment planning this case: yes or no?, 2) How would you treat this case: extraction or non-extraction?, and 3) Were the record sets adequate to treatment plan this case: yes or no? Retention method was the fourth parameter, which was quantified but was non-dichotomous data.

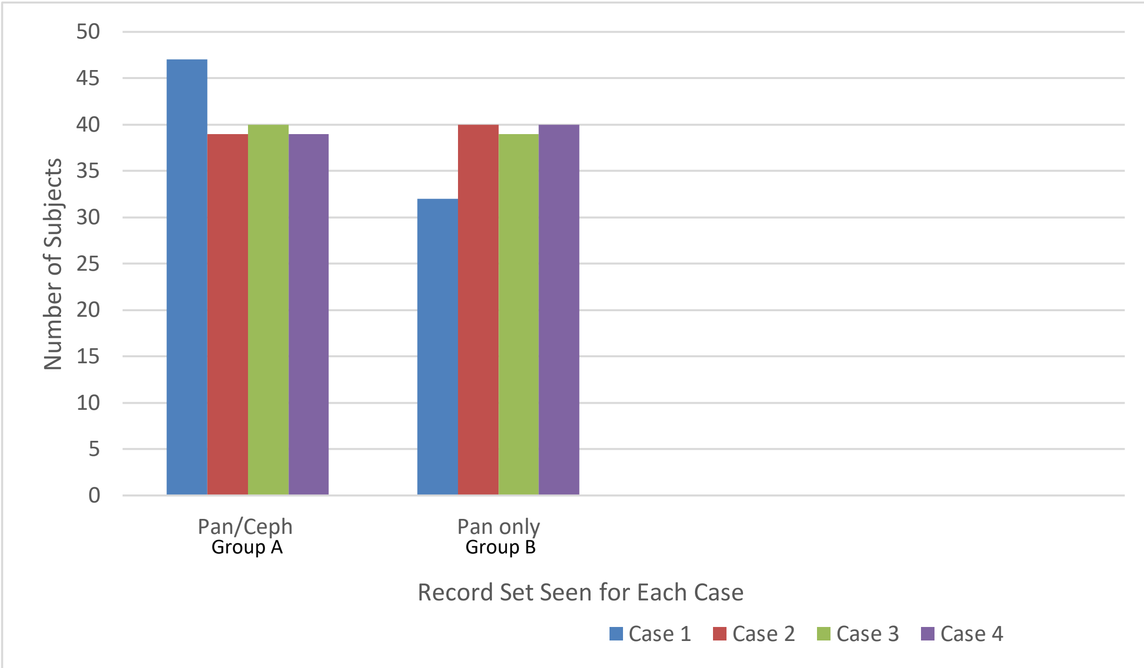


Figure 1. Record Set Distribution

Qualitative responses (free response questions) were not included in the analyses but rather reviewed to see that respondents were from varying orthodontic backgrounds and to gain insight into their survey responses for discussion purposes (refer to Appendix C). Of the 79 subjects, a range of four to 54 years of practice experience is represented, with a mean of 26.2, SD +/- 11.1 years, and median of 29 years (refer to Appendix D for breakdown). Eight of the orthodontists did not disclose his or her orthodontic residency program attended; of the remaining 71 subjects, 38 different residency programs are represented. Additionally, 71 subjects reported they routinely use LCR for treatment planning, four subjects answered ‘No’ to this question, and three subjects responded that their use of LCR depends on the case.

Tables 1-5 show the extracted data and significance levels. Results show that for all cases combined (Table 1), when patient records included the lateral cephalogram, subjects were more likely to perceive the lateral cephalogram as necessary (74.6% versus 65.8%), more likely to choose an extraction treatment plan (33.5% versus 23.3%), and more felt the record sets were adequate (84.1% versus 39.3%) compared to when the cases were viewed without the lateral cephalogram.

Each of these three parameters was statistically significant (refer to Table 1). Retention method was the only parameter measured that did not seem to be influenced by whether a lateral cephalometric radiograph was presented or not—this is true for all cases combined and each individual case. When comparing the results of each individual patient record set these trends held true for all four of these parameters, with a few exceptions.

Table 1

All Cases

Survey Question Answer	**Group A** (Pan/ceph)	**Group B** (Pan only)	**Total** (Both groups)	**Significance** (Chi-sq/ McNemar test)
Ceph is necessary	74.55%	65.77%	70.38%	<0.001 **
Treat with extraction	33.54%	23.29%	28.71%	<0.001 **
Records are adequate	84.14%	39.31%	63.11%	0.001 **
Retention method				0.85
• **Hawley**	19.75%	23.08%	21.33%	
• **Fixed lingual**	42.04%	39.86%	41.00%	
• **Thermoplastic**	31.85%	29.37%	30.67%	
• **None of above**	6.37%	7.69%	7.00%	

** indicates significance level < 0.05

For Record Set 1 (Case 1, refer to Table 2) each of the three questions (was a cephalogram necessary for treatment planning, treatment of extraction versus non-extraction, and were records adequate) had statically significant results. However, when the record set was seen without the lateral cephalogram, extraction plans were more likely.

Table 2

Case 1

Survey Question Answer	**Group A** (Pan/ceph)	**Group B** (Pan only)	**Total** (Both groups)	**Significance** (Chi-sq/ McNemar test)
Ceph is necessary	53.19%	29.03%	43.59%	0.029 **
Treat with extraction	0%	3.13%	1.27%	<0.001 **
Records are adequate	85.11%	67.74%	78.21%	0.013 **
Retention method				0.992
• **Hawley**	15.91%	15.63%	15.79%	
• **Fixed lingual**	52.27%	50.00%	51.32%	
• **Thermoplastic**	25.00%	28.13%	26.32%	
• **None of above**	6.82%	6.25%	6.58%	

** indicates significance level < 0.05

For Record Set 2 (Table 3), all trends held true, but the difference was not statistically significant for whether the record set was considered adequate when viewed with or without the cephalogram. In Record Set 3 (Table 4), a higher percentage of orthodontists from Group B felt that the cephalogram was necessary for treatment planning this patient (84.62%) compared to those in Group A who saw the record set with the cephalogram (77.50%). This difference was statistically significant at <0.001. Record

Set 4 (Table 5) also deviated from the trend in that a higher percentage of orthodontists who viewed the records without the cephalogram opted for extraction compared to those who viewed the records with the cephalogram, but the difference was not statistically significant.

Table 3

Case 2

Survey Question Answer	Group A (Pan/ceph)	Group B (Pan only)	Total (Both groups)	Significance (Chi-sq/ McNemar test)
Ceph is necessary	84.62%	65.00%	74.68%	0.001 **
Treat with extraction	38.46%	17.50%	27.85%	0.003 **
Records are adequate	79.49%	40.00%	59.49%	0.152
Retention method				0.867
• **Hawley**	21.62%	23.68%	22.67%	
• **Fixed lingual**	45.95%	36.84%	41.33%	
• **Thermoplastic**	27.03%	34.21%	30.67%	
• **None of above**	5.41%	5.26%	5.33%	

** indicates significance level < 0.05

In each of the four cases, the difference in perceived need for a lateral cephalogram (when viewed with versus without the cephalogram) was statistically significant. Table 6 depicts a summary of all the data collected from subject groups A and B combined for each case.

Table 4

Case 3

Survey Question Answer	Group A (Pan/ceph)	Group B (Pan only)	Total (Both groups)	Significance (Chi-sq/ McNemar test)
Ceph is necessary	77.50%	84.62%	81.01%	<0.001**
Treat with extraction	64.10%	29.73%	47.37%	0.690
Records are adequate	87.18%	20.51%	53.85%	0.581
Retention method				0.239
• **Hawley**	21.05%	24.32%	22.67%	
• **Fixed lingual**	36.84%	37.84%	37.33%	
• **Thermoplastic**	39.47%	24.32%	32.00%	
• **None of above**	2.63%	13.51%	8.00%	

** indicates significance level < 0.05

Table 5

Case 4

Survey Question Answer	Group A (Pan/ceph)	Group B (Pan only)	Total (Both groups)	Significance (Chi-sq/ McNemar test)
Ceph is necessary	87.18%	76.92%	82.05%	<0.001 **
Treat with extraction	38.46%	40.54%	39.47%	0.200
Records are adequate	84.62%	34.29%	60.81%	0.238
Retention method				0.744
• **Hawley**	21.05%	27.78%	24.32%	
• **Fixed lingual**	31.58%	36.11%	33.78%	
• **Thermoplastic**	36.84%	30.56%	33.78%	
• **None of above**	10.53%	5.56%	8.11%	

** indicates significance level < 0.05

Table 6

Summary of Total Data Per Case

Survey Questions	Answer Choice	Case 1	Case 2	Case 3	Case 4
Ceph included in record set?	No (Group B)	41%	51%	49%	51%
	Yes (Group A)	59%	49%	51%	49%
Is a ceph necessary?	No	56%	25%	19%	18%
	Yes	44%	75%	81%	82%
How would you treat the case?	Non-Extraction	99%	72%	53%	60%
	Extraction	1%	28%	47%	40%
How would you retain the case?	Hawley retainers	16%	23%	23%	24%
	Fixed lingual	52%	41%	37%	34%
	Thermoplastic	26%	31%	32%	34%
	None of the Above	6%	5%	8%	8%
Were the records adequate?	No	22%	41%	46%	39%
	Yes	78%	59%	54%	61%

CHAPTER 6

DISCUSSION

The survey was completed by 79 individuals. Ideally, this would mean that each of the four patient record sets was viewed by at least 38 subjects in each group (with the lateral cephalogram and without the lateral cephalogram). Record Sets 2-4 were all viewed by at least 38 subjects in both groups, however, Record Set 1 was viewed by 47 subjects in Group A and 32 subjects in Group B. These differences are not statistically significant, but with a greater response rate the distribution of record sets seen would be expected to approached a better 50-50 ratio.

The biggest concern with the low response rate is whether or not the results are an accurate representation of most orthodontists' perceptions of the necessity for a lateral cephalogram in patients with a Class I dental malocclusion with mild-moderate crowding and/or spacing. The underrepresentation of orthodontists may have created a non-response bias, thereby affecting the reliability and validity of the survey study findings (Fincham, 2008). However, from our previous analysis, we needed 26 responses per group for each record set for statistical significance, which was exceeded.

Despite the low response rate, the present study was successful in achieving statistically significant findings. For all cases combined and for each record set, more subjects from Group A perceived the record set as adequate compared to those in Group B. Additionally for all cases combined, results show that Group A subjects were more likely to perceive a lateral cephalogram as being necessary and to choose an extraction treatment plan. However, these trends had slight deviations from case to case, which might be attributed to the individual variation in orthodontic backgrounds of the subjects and individual traits of each patient.

For Record Set 1, one subject from Group B opted for an extraction treatment plan compared to no subjects from Group A. Interestingly, this subject stated that a cephalogram is necessary for treatment planning this patient in order to evaluate the IMPA, yet this subject also marked that the records were adequate to treatment plan. This patient presents as a Caucasian/Asian young adult female with a Class I dental/skeletal normodivergent malocclusion with a straight profile overall and straight lower third. She has mild upper arch crowding and moderate lower arch crowding with gingival recession noted on the lower canines and incisors as well as the upper canines and premolars. In the lateral cephalogram the lower incisors appear to be within normal limits (IMPA traced and measured at 99.7 degrees). It is plausible that this orthodontist perceived the lower crowding and thin gingival tissues with recession as a reason for extraction. Also, it is important to note that the survey only recorded whether the subject would treat with extraction or non-extraction—no explanation for treatment or extraction pattern was recorded.

For Record Set 2, there were no deviations from the overall trends. This patient is an African American teenage male with a Class I dental/ Class II skeletal hypodivergent malocclusion with a convex within normal limits overall profile and convex within normal limits lower third. He has mild upper arch spacing and mild lower arch crowding. In the cephalogram the lower incisors appear proclined (IMPA measured at 115.1 degrees). No gingival recession is noted on the lower incisors. The majority of treatment plans were non-extraction, but extraction was a treatment of choice for a total of 27.85%

of subjects. Nearly 75% of subjects marked that a lateral cephalogram was necessary, with reasons for assessing the skeletal relationship and lower incisor proclination.

Record Set 3 had the greatest disparity between Groups A and B, in which 87.2% in Group A felt the record set was adequate versus only 20.5% in Group B. This goes along with the fact that more subjects from Group B felt a lateral cephalogram was necessary for adequate treatment planning. For this patient, orthodontists seemed more unsure of the diagnosis when the cephalogram was missing from the record set. This patient presents as a Caucasian teenage female with a Class I dental/skeletal normodivergent malocclusion with a convex within normal limits overall profile and straight lower third. She has moderate upper and lower arch crowding. The lower incisors appear proclined in the lateral cephalogram (IMPA traced at 103.8 degrees). She is borderline Class I dental, as some may classify her as Class II subdivision right and both canines are Class II. Again, the majority of subjects stated a lateral cephalogram is necessary because they want to evaluate the skeletal relationship and lower incisor inclination in order to determine their treatment options for this patient.

Record Set 4 exhibited a higher percentage of extraction treatment plans from subjects in Group B than from Group A. Although it was not statistically significant, we must question why this outlier exists. This patient is an African American teenage male with a Class I dental/ skeletal normodivergent malocclusion with a convex within normal limits overall profile and lower third. He has mild upper arch spacing and mild lower arch crowding. Additionally he has an openbite tendency. The lower incisors appear proclined in the lateral cephalogram (IMPA measured at 104.5 degrees) and in the panoramic radiograph we can appreciate large caries lesions of the lower 2nd molars. The same comments were made in regards to needing a lateral cephalogram for this patient: to evaluate the skeletal relationship and incisor inclination. In particular for this patent was the concern of facial pattern and openbite tendency. More subjects stated potential for extraction depending on incisor proclination and to aid in bite closure.

For all cases combined, more orthodontists felt the record set was adequate when the cephalogram was presented compared to those who viewed the record set without the cephalogram. This was the most striking difference— 84% compared to 39%, respectively. Additionally, only 66% of Group B subjects felt the lateral cephalogram was necessary. Therefore, we can infer that 34% of Group B subjects felt they could properly diagnose and treat without the cephalogram. Interestingly, 39% of Group B subjects responded that the records were adequate, indicating that 5% of subjects who thought the cephalogram was necessary also marked that the records were adequate to treatment plan. In Group A, 75% perceived the lateral cephalogram as necessary, and although these subjects were provided with the cephalogram, only 84% felt the records were adequate. The free response answers show that lack of a lateral cephalogram was not the only reason why records were perceived as inadequate. Many subjects wanted to know the patient’s chief compliant, as well as the periodontal and TMJ status of the patient.

Overall, subjects’ reasons for needing the cephalogram pertained to evaluating the skeletal relationships, facial pattern, and incisor inclination and position within the alveolar bone— all of which may influence the decision of an extraction versus non-extraction treatment plan. Additional comments for the necessity of a lateral cephalogram were for evaluating the airway and for legal purposes, but this was only stated by two subjects.

It is difficult to compare this study's findings with those found in other studies since the methodologies in each of the studies differ. Each past study on the topic has somewhat differing yet also similar end conclusions to which we have found some agreement and disagreement.

For example, the study by Devereux et al. in 2011 concluded that for most treatment planning decisions the inclusion of the lateral cephalogram did not make a significant difference. Yet they also concluded that with LCR the treatment plan of some patients will be changed in a fundamental way. Their findings also showed that extraction pattern had the greatest variability, with 42.9% of respondents changing their decision with the availability of the lateral cephalogram. However, this study included Class I, Class II, and Class III malocclusions and had a repeat survey to test the intra-rater reliability. So direct comparison of results is not feasible.

Our study partially agrees with the conclusions drawn by Durão et al. in 2015. On one hand, our study disagrees with their conclusion that LCR does not seem to have an influence on treatment planning. On the other hand, our results do agree that indications for LCR should be constructed on an individual basis due to the heterogeneous nature of the specialty. However, again, the validity of a direct comparison between the two studies is questionable since the questionnaire by Durão et al. included forty-three patient records of all malocclusion types and was only completed by ten orthodontists. Furthermore, their results and conclusions seem to be contradictory and inconclusive overall.

Our study disagrees with the conclusion made by Dinçer et al. in 2013. They concluded that LCR did not influence the extraction decision in treatment planning. Dinçer et al. focused on the skeletal Class I malocclusion. The diagnostic records presented to the orthodontists were done in a similar fashion to our current study. However, contrary to our study, the orthodontists were presented with both versions of the record sets at different time points, which enabled the investigators to compare intra-rater reliability. Our study lacked such intra-rater reliability assessment, but the study by Dinçer et al. had increased risk of bias as only two orthodontists were involved in the study and the time period between each assessment was short.

The study by Patel et al. in 2013 identified Class I malocclusions with minor dental irregularities as the malocclusion least likely to necessitate a cephalogram for diagnosis and treatment planning. This study served as the basis for our current study. However, our results showed that even for Class I dental malocclusions there was a statistically significant increase in the treatment plans of extraction, as well as a statically significant increase in the perceived need for the cephalogram when the lateral cephalogram was included in the record sets.

One strength of our study was that results were collected from a greater number of orthodontists than the previous studies presented (79 participants compared to 39 (Devereux et al. 2011), ten (Durão et al. 2015), two (Dinçer et al. 2013), and five (Patel et al. 2013). Conversely, only four patient record sets were evaluated, which may be considered a weakness of our study. Also, our study did not ascertain whether the lateral cephalogram would change an individual orthodontist's treatment plan, as the survey was not repeated to determine intra-rater reliability. However, intra-rater reliability in past studies has demonstrated variable consistency overall (Han et al. 1991; Devereux et al. 2011). Additionally, this decreased the risk of bias since the record sets might be remembered between time points and decreased the probability of subject dropouts and incomplete response rates. It was our goal that with the greater number of orthodontists surveyed, the greater the validity of the results.

Years of experience might also affect the results, would the availability of a lateral cephalogram have less of an impact on the treatment planning decisions of a clinician with more experience? Saghafi et al. (2017) found that more experienced clinicians preferred to extract in borderline cases than the less experienced clinicians. Whether or not this would be influenced by the availability or omission of the lateral cephalogram has not been studied, but it may be a consideration that experience of the clinician could influence the results of our study as well.

We must also consider the psychology of having the extra information (lateral cephalogram) versus not having the cephalogram for treatment planning. Did the cephalogram confirm what the orthodontists already knew? Did not having it ensue doubt versus if they had it did they feel more confident in what they already knew? Atchinson et al. (1991) investigated the contribution of pretreatment radiographs in orthodontists' decision making and confidence gained from the addition of selected radiographs to the treatment records (models, intra- and extra- oral photographs, and exam charting). They found that on average participants were 70% certain of their treatment plan prior to reviewing any radiographs and lateral cephalogram radiographs produced the greatest number of treatment plan changes (30%). However, the individual orthodontist and the specific case were important factors (Atchinson et al. 1991) .

Another interesting thought is that maybe we cannot generalize a malocclusion type into factoring the necessity for specific diagnostic records. Each patient presents with a unique facial type, gingival architecture, and incisor inclination that may dictate specific treatment goals. Many different treatment philosophies exist in orthodontics, which may dictate how an orthodontist prefers to treat his or her patients. Since in orthodontics there typically is no clear-cut right or wrong treatment for most patients, great variability exists amongst the specialty. Many studies on the consistency of orthodontic treatment planning and extraction decisions have demonstrated low inter-examiner reliability (Lee et al. 1999; Ribarevski et al. 1996). Therefore, because orthodontics has such varying methodologies, a definitive conclusion of the matter might be a moot point.

Dental radiographs are the most frequently used radiologic procedures in the United States for healthy individuals (Chauhan and Wilkins 2018) and no amount of radiation exposure may be deemed as "safe." Although dental professionals should always be conscientious when prescribing radiographs, the small amount of radiation exposure from a lateral cephalogram is warranted if essential diagnostic information is obtained. Overall, our results lend to the conclusion that a lateral cephalogram provides the orthodontist with pertinent diagnostic information, which may influence treatment decisions. Therefore, obtaining a lateral cephalogram abides by the ALARA principles set forth by the International Commission on Radiologic Protection so long as the orthodontist perceives it is necessary.

This study was not devoid of weaknesses, with the major weakness being the low response rate. Another weakness of this study was that only four patient record sets were included in the survey, each of which presented with a very different skeletal pattern. Additionally, subjects could not clinically evaluate the patients. A future study might investigate this topic further with a larger sample of patient record sets.

Despite Class I dental malocclusions as being perceived as a less complex malocclusion to treat, the majority of orthodontists still perceived a need for the lateral cephalograms to obtain pertinent diagnostic information, and treatment decisions seemed to be influenced by the evaluation of the lateral cephalogram. In contrast, this study also shows that there were a percentage of subjects who did not feel the need for a cephalogram for each patient. The differences seen between each patient's record set shows the inherent variability among orthodontists' views and treatment philosophies, as well as the need for patient-centered, individualized examination and treatment considerations. Ultimately, a larger follow-up study would be needed to confirm our results.

CHAPTER 7

CONCLUSIONS

In conclusion, the null hypothesis was rejected. Results show a statistically significant difference in the perceived need for a lateral cephalogram and in the decision of extraction versus non-extraction when the lateral cephalogram was included in the patient record set versus when it was omitted. Therefore, we conclude that use of a lateral cephalogram for diagnosing and treatment planning seems to hold value in Class I dental malocclusions.

- The majority of orthodontists (approximately 70%) stated a lateral cephalogram was necessary to make treatment decisions, mainly to evaluate the skeletal relationships and incisor inclinations.
- The perceived need for a cephalogram was greater when it was presented with the record sets versus when it was omitted.
- Record sets viewed with the lateral cephalogram had a higher percentage of extraction treatment plans compared to those viewed without the lateral cephalogram (33.5% versus 23.3%, respectively).
- Obtaining a lateral cephalogram in Class I dental malocclusions abides by the ALARA principles by providing pertinent diagnostic information.
- A larger follow-up study is needed to obtain an accurate representation of orthodontists' perceptions of the necessity of lateral cephalograms for these malocclusion types.

BIBLIOGRAPHY

Abbott, Paul. Are dental radiographs safe? *Aust Dent J*. 2000; 45(3); pp. 208-213.

American Association of Orthodontists. *Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics*. St. Louis, MO: American Association of Orthodontists. Created: 1996. Amended: 2001, 2009, 2010, 2012, 2014, 2016, 2017.

American College of Dentists. Ethics Handbook for Dentists: An introduction to Ethics, Professionalism, and Ethical Decision Making. ACD, Gaithersburg, MD. 2012. Pg 22.

American Dental Association. Council on Scientific Affairs. U.S. Department of Health and Human Services. Food and Drug Administration. *Dental radiographic examinations: recommendations for patient selection and limiting radiation exposure.* Chicago: American Dental Association; 2012.

Ast, David B; Carlos, James P; Cons, Naham C. The prevalence and characteristics of malocclusion among senior high school students in upstate New York. *Am. J. Orthodontics*. June 1965. Volume 51, Issue 6, 437–445.

Atchinson, Kathryn A; Luke, Larry S; White, Stuart C. Contribution of pretreatment radiographs to orthodontists' decision making. *Oral Surg Oral Med Oral Pathol.* February 1991. Vol 71. No 2. 238-245.

Boice Jr, John D. The Linear nonthreshold (LNT) model as used in radiation protection: an NCRP update. *International Journal of Radiation Biology*. May 2017. 93:10, 1079-1092.

Broadbent, B. Holly (*1981*). A New X-ray Technique and Its Application to Orthodontia. *The Angle Orthodontist*: April 1981, Vol. 51, No. 2, 93-114.

Chauhan, Vinita; Wilkins, Ruth C. A comprehensive review of the literature on the biological effects from dental x-ray exposures. *International Journal of Radiation Biology*. DOI: 10.1080/0955300. 2.2019.1547436Nov 2018.

Dainiak, Nicholas; Feinendegen, Ludwig E; Hyer, Randall N; Locke, Paul E; Waltar, Alan E; Synergies resulting from a systems biology approach: integrating radiation epidemiology and radiobiology to optimize protection of the public after exposure to low doses of ionizing radiation. *International Journal of Radiation Biology*. 2018. Vol 94, No 1, 2-7.

Devereux L, Moles D, Cunningham SJ, McKnight M. How important are lateral cephalometric radiographs in orthodontic treatment planning? *Am J Orthod Dentofacial Orthop*. 2011;139(2): e175-181.

Dinçer, Banu; Yetkiner, Enver; Aras, Isil; Attin, Thomas; Attin, Rengin. Influence of lateral cephalometric radiographs on extraction decision in skeletal class I patients. *Head & face medicine*. December 2013, Vol.9, pg 36.

Downs, William B. The role of cephalometrics in orthodontics case analysis and diagnosis. Intern. *Journal of Orthodontia and Dent. For Women*, March 1952. Vol. 38 Issue 3, 162-182.

Durão, Ana Reis; Alqerban, Ali; Pinhão, Afonoso Ferreira; Jacobs, Reinhilde. Influence of lateral cephalometric radiography in orthodontic diagnosis and treatment planning. *The Angle Orthodontist*: March 2015, Vol. 85, No. 2, 206-210.

Emrich, Richard E; Brodie, Allan G; Blayney, JR. Prevalence of Class I, Class II, and Class III Malocculsions (Angle) in an Urban Population. *J. dent Res*. September-October 1965. Vol 44, No 5. 947-953.

Fincham, Jack E. Response Rates and Responsiveness for Surveys, Standards, and the Journal. *American Journal of Pharmaceutical Edcutaion*. 2008; 72 (2) article 43. 1-3.

Graber LW, Vanarsdall RL, Vig KWL, Huang GJ. Orthodontics: Current Principles and Techniques. 6th ed. St Louis, MO: Elsevier; 2017. 211, 219.

Han, UK; Vig, KW; Weintraub, JA; Vig, PS; Kowalski, CJ. Consistency of orthodontic treatment decisions relative to diagnostic records. *Am J Orthod Dentofacial Orthop*. 100 (1991), 212-219.

Hans, Mark G; Palomo, Martin J; Valiathan, Manish. History of imaging in orthodontics from Broadbent to cone-beam computed tomography. *American Journal of Orthodontics and Dentofacial Orthopedics*, December 2015. Vol. 148, Issue 6, 914–921. https://www.aaoinfo.org/practice-management/clinical-practice-guidelines

Hoogeveen, RC; Rottke, D; Van der Stelt, PF; Berkhout, WER. Dose reduction in orthodontic lateral cephalography: dosimetric evaluation of a noevl cephalographic thyroid protector (DTP) and anatomical cranila collimation (ACC). *Dentomaxillofacial Radiology*. January 2015. 44. 20140260.

Jacobson, Alexander; Jacobson, Richard L; Radiographic Cephalometry from Basics to 3-D Imaging. 2nd ed. Hanover Park, IL: Quintessence Publishing Co, Inc; 2006. Pg 26.

Lee, R; MacFarlane, T; O'Brien, K. Consistency of orthodontic treatment planning decisions. *Clinical Orthodontic Research*. 2 (1999) 79-84.

Ludlow John B; Davies-Ludlow, Laura; White, Stuart C. Patient risk related to common dental radiographic examintaions: The impact of 2007 International Commission on Radiographic Protection recommendations regarding dose calculation. *JADA*. September 2008. Vol 139.

Massler, Maury; Frankel, John M. Prevalence of malocclusion in children aged 14 to 18 years. *Am. J. Orthodontics*. October 1951. Vol 37, Iss 10, 751–768.

Nijkamp, Peter G; Habets, Luc LMH; Aartman, Irene HA; Zentner, Andrej. The influence of cephalometrics on orthodontic treatment planning. *European Journal of Orthodontics*. 30 (2008) 630-635.

Patel, JV; Slutsky; Godel, J; Yang, J; Sciote, JJ. Evaluating the diagnostic value of later cephalogram radiographs. *Orthodontic Practice*. March 2014.

Profitt, WR, et al. Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from N-HANES III survery. *Int J Adult Orthod Orthog Surg*. 1998; 13:97-106.

Ribarevski, R; Vig, P; Vig K; Weyant, R; O'Brien, K. Consistency of orthodontic extraction decisions. *European Journal of Orthodontics*. 18 (1996) 77-80.

Saghafi, Niousha; Heaton, Lisa; Bayirli, Burcu; Turpin, David; Khosravi, Roozbeh; Bollen, Anne-Marie. Influence of clinician's experience and gender on extraction decision in orthodontics. *Angle Orthodontist*. Vol 87, No 5, 2017. 641-650.

Salzmann, JA. Malocclusion and treatment need in United States youths 12 to 17 years of age. *Am. J. Orthod.* Nov 1977. Vol 72, Iss 5, 579–581.

Sarver, David M. Enameloplasty and Esthetic Finishing in Orthodontics—Differential Diagnosis of Incisor Proclination—The Importance of Appropriate Visualization and Records Part 2. *Journal of Esthetic and Restorative Dent*. 2011, Vol. 23 (5), 303-313.

Sarver, David M.; Ackerman, James L. Orthodontics about face: The re-emergence of the esthetic paradigm. *American Journal of Orthodontics & Dentofacial Orthopedics*, 2000, Vol.117(5), 575-576.

Signorelli, Luca; Patcas, Raphael; Peltomåki; Schåtzel, Marc. Radiation dose of a cone-beam computed tomography compared to conventional radiographs in orthodontics. *Journal of Orofacial Orthopedics.* 2016; 77, 9-15.

White, SC; Mallya, SM. Update on the biological effects of ionizing radiation, relative dose factors and radiation hygiene. *Australian Dental Journal.* 2012; 57:(1 Suppl): 2–8.

APPENDIX A

SURVEY

Orthodontic Research Survey

PAGE TITLE

1. I acknowledge that I choose to be a participant in this survey and that my responses will be recorded and used for research purposes. I understand that all responses will be anonymous and that I may quit the survey at any time.
There are 19 questions to come.

☐ I acknowledge these terms

2. What residency program did you attend? (optional)

3. How many years have you been practicing orthodontics?

4. Do you routinely use lateral cephalometric radiographs for treatment planning?

○ Yes

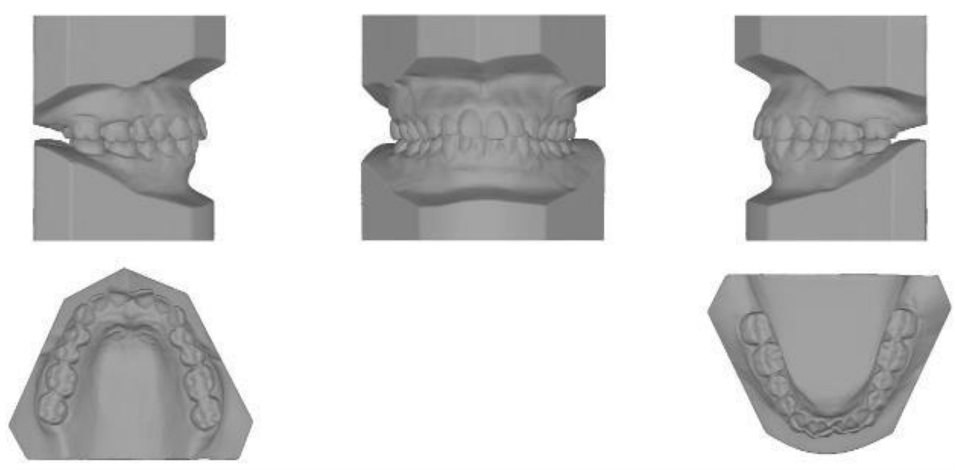
○ No

○ Depends

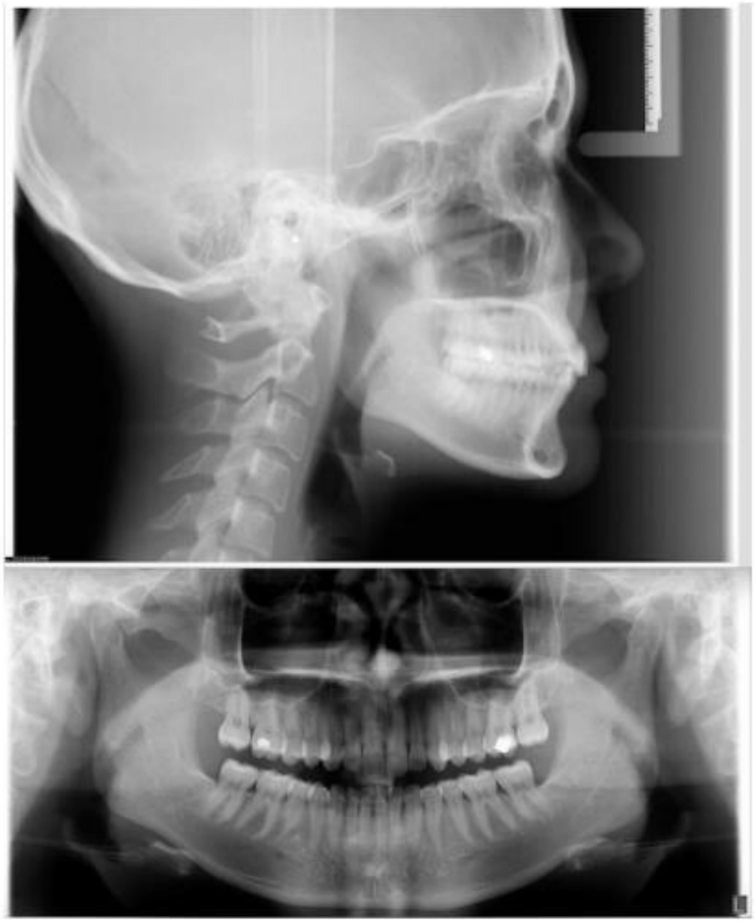
Please specify (optional)

Case 1

Case 1



A 50.0% Case 1



B 50.0% Case 1

5. Is a ceph necessary for treatment planning case 1?

- ◯ Yes
- ◯ No

If yes, please specify (optional)

6. How would you treat case 1?

- ◯ Extraction
- ◯ Non-extraction

7. How would you retain case 1?

- ◯ Hawley retainers
- ◯ Fixed lingual
- ◯ Thermoplastic
- ◯ None of the above

Please specify (optional)

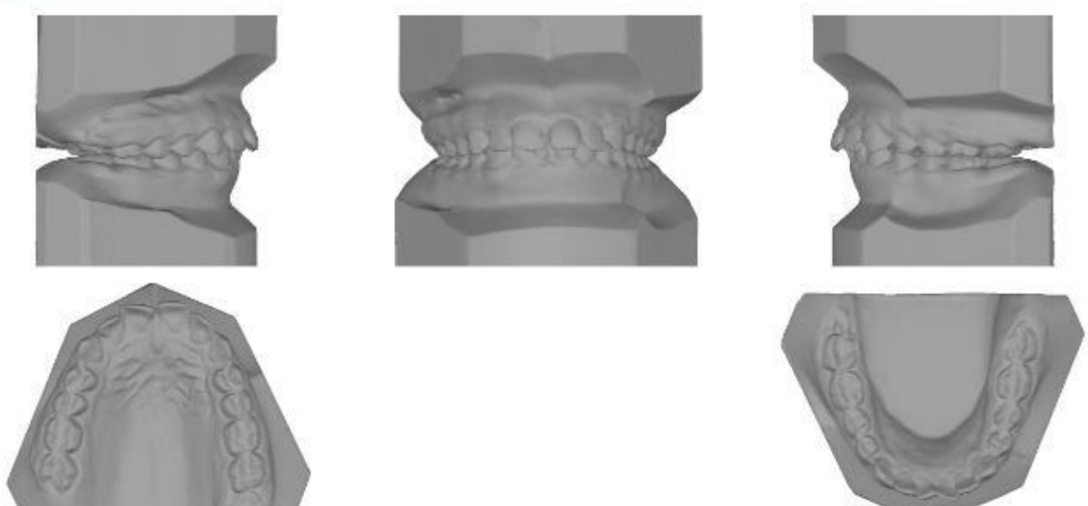
8. Were the records adequate to treatment plan case 1?

- ◯ Yes
- ◯ No

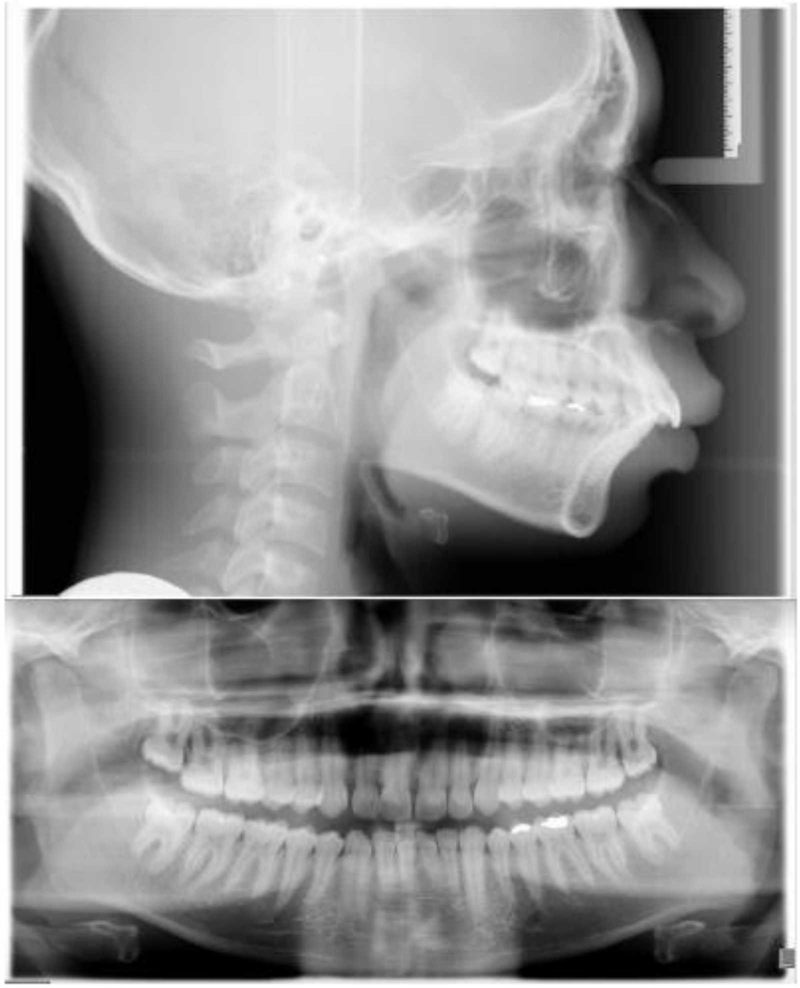
If no, please specify (optional)

Case 2

Case 2



A 50.0% Case 2



B 50.0% Case 2

9. Is a ceph necessary for treatment planning case 2?

- ◯ Yes
- ◯ No

If yes, please specify (optional)

10. How would you treat case 2?

- ◯ Extraction
- ◯ Non-extraction

11. How would you retain case 2?

- ◯ Hawley retainers
- ◯ Fixed lingual
- ◯ Thermoplastic
- ◯ None of the above

Please specify (optional)

12. Were the records adequate to treatment plan case 2?

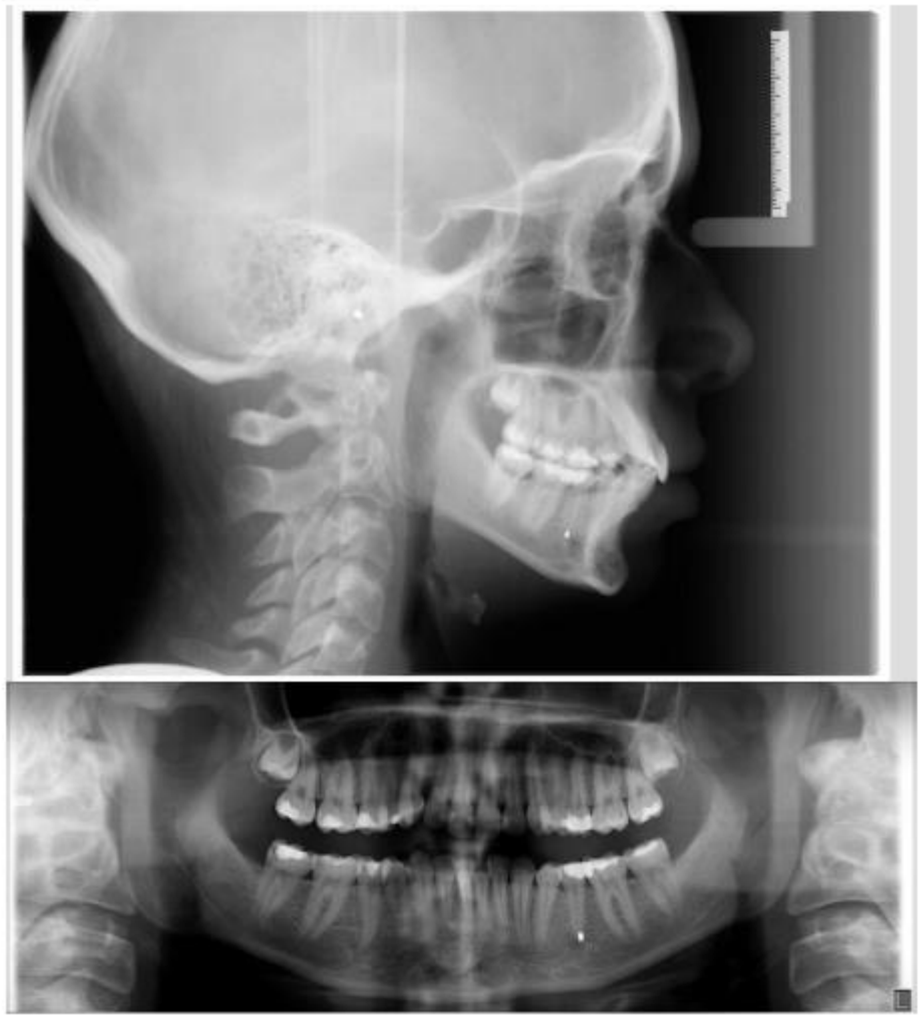
- ◯ Yes
- ◯ No

If no, please specify (optional)

Case 3

Case 3

A 50.0% Case 3



B 50.0% Case 3

13. Is a ceph necessary for treatment planning case 3?

◯ Yes

◯ No

If yes, please specify (optional)

14. How would you treat case 3?

◯ Extraction

◯ Non-extraction

15. How would you retain case 3?

◯ Hawley retainers

◯ Fixed lingual

◯ Thermoplastic

◯ None of the above

Please specify (optional)

16. Were the records adequate to treatment plan case 3?

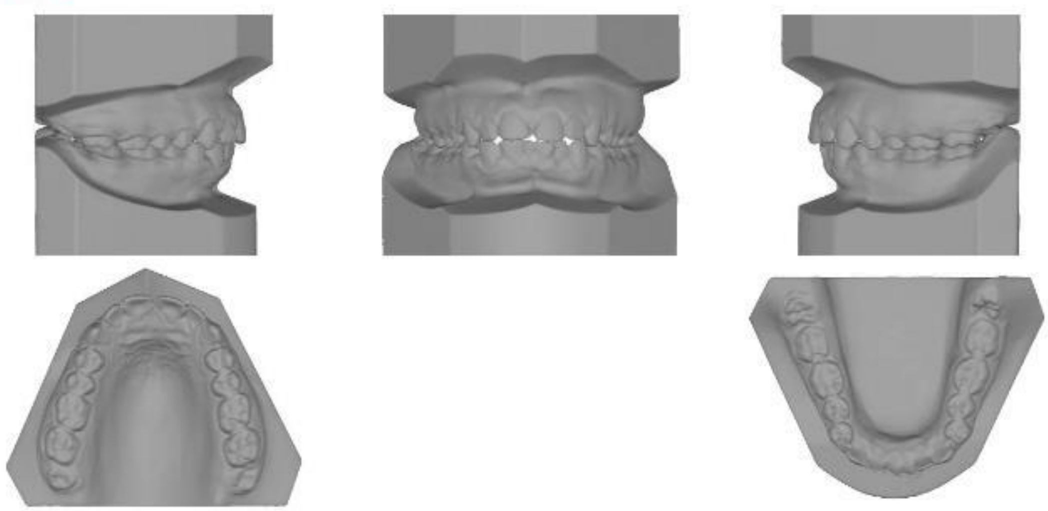
◯ Yes

◯ No

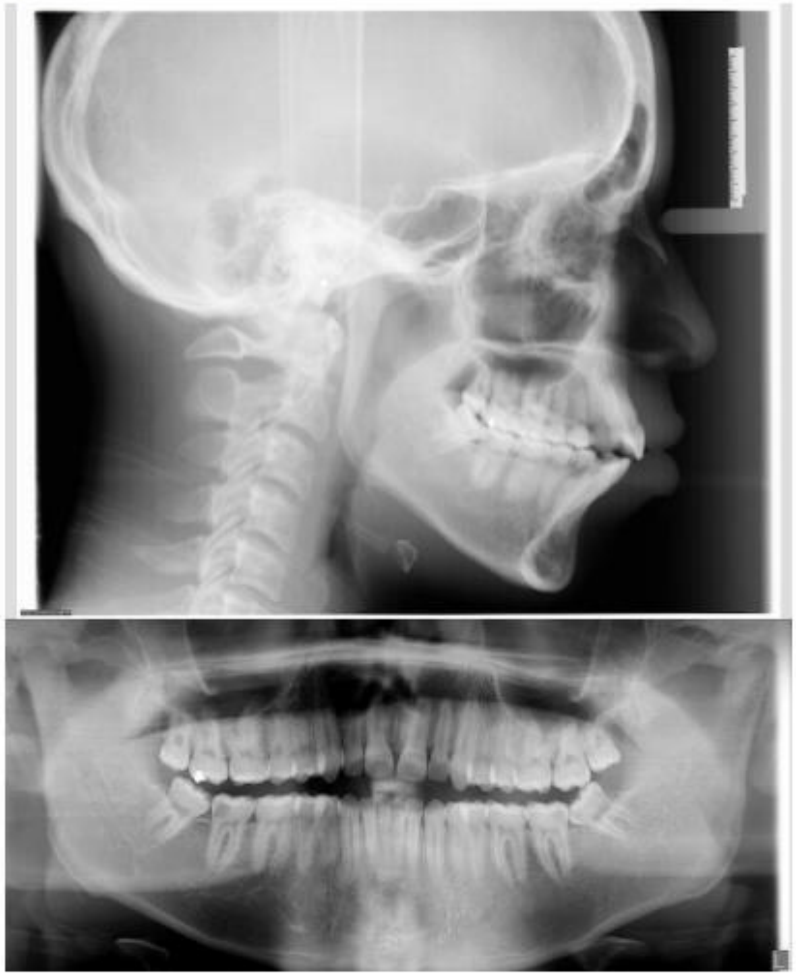
If no, please specify (optional)

Case 4

Case 4



A 50.0% Case 4



B 50.0% Case 4

17. Is a ceph necessary for treatment planning case 4?

- ◯ Yes
- ◯ No

If yes, please specify (optional)

18. How would you treat case 4?

- ◯ Extraction
- ◯ Non-extraction

19. How would you retain case 4?

- ◯ Hawley retainers
- ◯ Fixed lingual
- ◯ Thermoplastic
- ◯ None of the above

Please specify (optional)

20. Were the records adequate to treatment plan case 4?

- ◯ Yes
- ◯ No

If no, please specify (optional)

APPENDIX B

SURVEY RESPONSES:

BACKGROUND QUESTIONS AND QUANTIFIED DATA

What residency program did you attend? (optional)	How many years have you been practicing orthodontics?
Open-Ended Response	Open-Ended Response
UCLA	19
UT Houston	11
	50
University of Pennsylvania	21
	5
Ohio State	30
University of Iowa	29
Jacksonville University	11
	23
Orthodontic Residency at Fort Meade	28
	30
U of Oregon Health Science Center	>40
UMKC	20
Tufts	30
Northwestern University, Chicago	20
U of Washington, Seattle	retired 15 yrs
Northwestern U.	44
UMKC	18

FDU	30
Temple	30
Washington univ st louis,mo	32
Michigan	30
Triservice Ortho Residency Program	10
University of Texas - Houston	>20
Arizona	4
UNC	13
nyu	28
	22
U Penn	30
UIC	28
Emory University School of Dentistry	36
University of Michigan	32
CWRU	24
Marquette University	7
	27
St Louis University	11
University of Washington	44
Iowa	25
USC	11
Washington University	29
Case Western Reserve University	13
LSU	30
UNC	15
Temple University	29
	34

Univ. of the Pacific, San Francisco	23
Penn	33
University of Florida	21
Penn	54
Northwestern University	29
Boston University	13
University. Of Kentucky	40
OHSU	10
Fort Knox/University of Louisville	31
Tennessee	22
Marquette	30
LSU	36
University of North Carolina	12
University of North Carolina	36
UCLA	23
Northwestern	40
Columbia U.	40
University of Iowa	20
Indiana University	34
university of Pittsburgh	25
	15
University of Texas Houston	15
Univ of Penn	30
Fairleigh Dickinson University	36
Univ of Florida	37
UNC	14
UT dept. of Ortho at Houston	43

St. Louis University	26
U of minnesota	30
Louisville	9
Saint Louis University	33
UIC	7
Northwestern University	32
University of Minnesota	29

Do you routinely use lateral cephalometric radiographs for treatment planning?	Case 1 Records Seen	Is a ceph necessary for treatment planning case 1?	How would you treat case 1?	How would you retain case 1?	Were the records adequate to treatment plan case 1?
1 (Yes) 2 (No) 3 (Depends)	1 (Ceph) 2 (No Ceph)	1 (Yes) 2 (No)	1(Extraction) 2 (Non-Extraction)	1(Hawley retainers) 2(Fixed lingual) 3(Thermoplastic) 4(None of the Above)	1(Yes) 2 (No)
1	1	2	2	3	1

3	2	2	2	3	2
1	2	2	2	2	1
1	1	1	2	2	1
1	1	2	2	2	1
1	2	2	2	3	2
1	2	1	2	1	2
1	2	2	2	2	1
1	1	1	2	4	1
1	1	1	2	4	1
1	2	2	2	3	1
	2	1	2	2	2
1	1	1	2	2	2
1	1	1	2	3	1
1	1	2	2	2	1
1	1	2	2	2	1
1	1	2	2	2	1
1	1	1	2	2	2
1	2	1	2	2	1
3	1	2	2	2	1
1	1	1	2	1	1
1	2	2	2	2	1
1	1	1	2	4	1
1	1	1	2		1
1	2	2	2	2	1
1	1	2	2	3	1
1	1	2	2	1	1
1	1	2	2	2	1

1	1	2	2	3	2
2	2	2	2	3	1
1	1	1	2	1	1
1	1	1	2	1	1
1	1	1	2	2	1
1	2	2	2	2	1
1	2	2	2	1	1
2	2	2	2	3	2
1	2	1	2	2	2
1	2	2	2	2	1
1	1	1	2	3	1
1	2	1	2	1	2
1	1	2	2	2	2
1	1	1	2	2	2
1	2	2	2	2	1
1	1	1	2	1	1
1	1	2	2	3	1
1	1	2	2	2	1
1	2	2	2	2	1
1	1	1	2	2	1
1	2		1	2	1
2	2	2	2	3	1
1	2	2	2	2	1
1	1	2	2	1	1
1	2	2	2	1	1
1	1	1	2	3	1
1	2	1	2	2	2

1	1	2	2	2	1
1	2	1	2	1	2
1	1	1	2	2	1
1	1	2	2	3	1
3	2	2	2	2	1
1	2	1	2	2	1
1	2	2	2	4	
1	1	1	2	1	1
1	1	1	2	3	1
2	2	2	2	3	1
1	2	1	2	3	2
1	1	1	2	2	1
1	1	1	2	3	1
1	2	2	2	3	1
1	1	2	2	2	2
1	1	1	2	2	1
1	1	1	2		1
1	1	2	2	2	1
1	1	1	2		1
1	1	2	2	2	1
1	1	2	2	3	2
1	1	2	2	2	1
1	2	2	2	4	1
1	1	2	2	2	1

Case 2 Records Seen	Is a ceph necessary for treatment planning case 2?	How would you treat case 2?	How would you retain case 2?	Were the records adequate to treatment plan case 2?
1(Ceph) 2 (No Ceph)	1 (Yes) 2 (No)	1 (Extraction) 2 (Non-Extraction)	1(Hawley retainers) 2 (Fixed lingual) 3(Thermoplastic) 4 (None of the Above)	1 (Yes) 2 (No)
1	1	2	2	1
2	2	2	3	2
1	1	1	1	1
1	1	2		2
1	1	1	2	1
2	1	2	3	2
2	1	1	1	2
1	2	2	2	1
1	1	2		1
2	1	2	4	2
1	1	2	3	1
2	1	2	2	2
1	1	2	2	1

2	1	2	3	1
2	1	2	3	1
1	1	1	1	1
1	2	2	2	1
2	1	1	2	2
1	1	1	1	1
1	2	2	2	1
2	1	1	1	1
2	1	1	1	2
2	1	2	2	2
2	1	2		2
1	1	1	1	1
1	1	2	3	1
1	1	2	1	1
2	2	2	2	1
2	2	2	3	2
2	2	2	3	1
2	1	2	1	2
1	1	2	2	1
1	1	2	2	1
2	1	2	2	2
2	1	2	1	2
1	1	2	4	2
1	1	2	2	1
1	1	2	2	2
2	1	1	1	2
2	1	2	1	2

2	2	2	2	2
1	1	2	2	1
2	2	2	2	1
1	1	1	1	1
2	2	2	3	1
1	1	2	2	1
1	2	2	2	2
1	1	2	2	1
2	1	1		1
2	2	2	3	1
2	1	2	2	2
1	2	2	1	1
1	1	2	2	1
2	1	2	3	1
1	1	2	3	1
2	2	2	2	1
1	1	1	4	2
1	1	2	3	1
2	2	2	3	1
2	2	2	2	1
1	1	1	2	1
2	2	2	1	1
2	1	2	1	2
1	1	1	3	2
1	2	2	3	1
1	1	1	3	1
1	1	1	2	1

2	1	2	3	2
1	1	1	3	1
1	1	1	1	2
2	1	2	2	2
2	1	2	3	2
2	2	2	2	1
1	1	1	3	1
2	1	2	2	2
2	1	1	3	2
1	1	1	3	2
2	1	2	4	2
2	2	2	2	1

Case 3 Records Seen	Is a ceph necessary for treatment planning case 3?	How would you treat case 3?	How would you retain case 3?	Were the records adequate to treatment plan case 3?
1 (Ceph) 2 (No Ceph)	1 (Yes) 2 (No)	1 (Extraction) 2 (Non - Extraction)	1 (Hawley retainers) 2 (Fixed lingual) 3(Thermoplastic) 4 (None of the Above)	1 (Yes) 2 (No)
2	1	2	3	2

2	2	2	3	2
2	1	1	1	1
1	1	2	2	1
2	1	2	2	2
1	1	1	3	2
2	1	1	1	2
1	2	2	2	1
1	1	1		1
2	1	1	4	2
1	1	2	3	1
2	1	2	2	2
2	1	2	2	2
1	1	1	3	1
1	1	2	2	2
2	1	1	1	1
2	2	2	2	1
1	1	1	2	1
2	1	1	1	1
1	1	2	2	1
1	2	1	1	2
1	1	1	1	1
1	1	1	3	2
2	1	2		2
2	1	2	1	2
1	2	2	3	1
2	1	2	1	2
1	2	2	2	1

1	1	1	3	1
1	1	1	1	1
2	1	1	1	2
2	1	2	2	2
1	1	2	2	1
1	1	1	2	1
2	1	2	1	2
2	1	1	4	2
2	1	1	2	2
1	1	1	2	1
2	1	2	3	2
1	1	1	1	1
2	2	2	2	2
2	1		2	2
2	1	2	4	2
2	1	2	1	2
1	2		3	1
2	1	2	2	2
1	2	1	3	1
1	1	1	1	1
1	1	1		1
1	2	2	3	1
2	2	2	2	1
1	1	1	1	1
1	1	2	2	1
1	1	2	3	1
2	1	1	3	2

2	2	2	3	1
2	1	1	4	2
2	1	2	3	2
1	1	1	3	1
2	1		2	2
1	1	2	2	1
2	2	2		1
1	1	1	1	1
1	1	1	3	1
2	1	2	3	1
2	1	1	3	2
1	1	1	1	1
2	1	2	3	2
1	1	1	3	1
1	1	1	2	2
2	1	2	2	2
1	1	1	4	1
1	2	2	2	1
1	1	1	3	
2	1	2	2	2
1	1	1	3	1
2	1	2	2	2
2	1	2	4	2
1	2	2	2	1

Case 4 Records Seen	Is a ceph necessary for treatment planning case 4?	How would you treat case 4?	How would you retain case 4?	Were the records adequate to treatment plan case 4?
1 (Ceph) 2 (No Ceph)	1 (Yes) 2 (No)	1 (Extraction) 2 (Non-Extraction)	1 (Hawley retainers) 2 (Fixed lingual) 3(Thermoplastic) 4 (None of the Above)	1 (Yes) 2 (No)
1	1	2	3	1
2	1	2	2	2
2	1	2	1	
1	1	2	3	1
2	1	2	2	2
2	1	1	3	2
2	1	1	1	2
1	1	1	2	1
2	1	1		1
2	1	2	4	2
1	1	2	3	1
2	1	1	2	2

2	1	1	2	2
2				
1	2	2	3	1
1	1	2	2	1
2	2	2	2	1
2	1	2	2	1
1	1	2	1	1
1	2	2	2	1
2	1	1	1	1
2	2	2	1	
1	1	1	4	1
1	1	2		1
2	1	2	3	2
2	2	2	3	1
2	2	2	1	2
2	2	1	2	1
1	1	1	3	2
1	2	2	3	1
2	1	2	1	2
1	1	2	1	1
1	1	2	2	1
1	1	2	2	1
1	1	2	1	2
1	1	1	4	2
2	1	2	2	2
2	1		2	2
1	1	1	1	1

2	1	2	1	2
2	2	2	2	2
1	1	2	2	1
1	1	1	4	1
1	1	2	1	1
2	2	1	3	1
1	1	2	2	2
2	1	1		2
2	1	2	2	2
2	1	1		1
2	1	2	3	2
1	1	1	2	1
1	1	1	1	2
1	1	1	1	1
1	1	2	3	1
1	1	1	3	1
2	1	2	1	2
1	1	2	2	2
2	1	1	3	2
1	1	2	3	1
2	2		2	
1	1	1	2	1
2	2	2	1	1
1	1	1	1	1
2	1	1	3	
1	2	2	3	1
1	1	1	3	1

2	1	1	2	1
2	1	1	3	2
2	1	2	3	1
2	1	2	1	2
1	1	2	2	1
1	1	2	4	1
1	1	1	3	1
2	1	2	3	2
1	1	1	3	1
2	1	1	3	1
1	1	2	3	1
2	1	2	4	2
1	2	2	2	1

Appendix C

SURVEY RESPONSES: FREE RESPONSE ANSWERS

Case 1- Ceph necessary?
If yes, please specify (optional)
*left blank= no response

4) I not only look at the inclination of the incisors, mand plane, position of the jaws, but also look at the airways, the cervical spine, the inlcination of the neck, etc.

7) Can we afford to flare the incisors to correct the crowding present and keep them stable within the bone?

9) Want to see how flared are the incisors.

10)For torque and comparison of pre and post treatment root torque

12) It is always critical to discern the facial pattern. A patient with a high angle or poor anterior-posterior facial ratio may look like an easy case only to find the bite opens up when you start moving the teeth. The type of mechanics becomes importan.

13) It is like wearing your seat belt, just in case there is a problem. I want to check the angle of the incisors. What if she were class III, would that change your treatment plan?

14) Need to know position of the lower incisors relative to alveolar bone

18) To determine the angulation of the mandibular incisors and their position within the alvelous.

24) To verify dental position within the skeletal base as well as skeletal and/or Airway issues

28) Normal AP jaw relationship

31) Anterior angulation and jaw position are always important to ascertain for full tx

32) To CONFIRM clinical impression

33) For legal purposes in case there is a lawsuit.

37) To view thickness of lower anterior bone from a lateral point of view

40) Would be good to see proclination of lower incisors. Possible perio complications?

42) To determine incisor AP positions with respect to basal bone

48) To help determine whether extractions are indicated

49) Lower incisor to MP

52) Part of complete records

53) to see if bringing her teeth forward would cause instability/gingival recession

57) There are limits to how flared I will put incisors before doing Air Rotor Stripping.

58) It confirms the diagnosis of incisor inclination and an initial image is necessary for comparison to future images if treatment response is not as expected.

61) To check for potential pathology -- I have discovered several asymptomatic Pituitary Tumors

64) Would still like to know incisor position

66) if you want to flare the incisors to make space you need to know from where they are starting to see if you flare them too far, that said if there were a case where you could safely skip a ceph this patient with a good profile and such minimal crowding would be a reasonable option to skip the ceph

68) Proclination of incisors

70) No, but periodontal augmentation would be required

71) Objectively determine incisor position relative to skeletal bases

78) But I would take one to complete my records and for even, unfortunately, legal reasons.

Case 1- Records adequate?
If no, please specify (optional)

2) Would prefer information on TMJ and perio status

6) Need health history, CC, oral exam

7) Need a ceph.

12) There would need to be a cephlametric tracing and there was no lateral ceph.

13) I would send her to have a periodontal exam due to thin attached gingiva on the facial of U4,5's, LL3, L1's

18) Due to the recession in maxillary posterior and the position of the mandibular incisors within the alveolus, a CBCT should also be taken to determine if there is sufficient buccal bone to support the resultant tooth movement.

29) Periapical's of maxillary anteriors or repeat pan

36) Need TMJ/muscle exam and perio charting.

37) Needs periodontal evaluation

40) Ceph would be helpful to discuss lower incisor positions with patient to do informed consent if in fact they are proclaimed and resorption could be of concern.

41) Dental history with jaw joint exam and questions regarding function would be necessary

42) Would want perio diagnostic information due to apparrent gingival recession

55) would like lateral ceph and the patient's age- is she done growing?

57) I would have mounted the models in CR to see how teeth fit with a seated condylar position.

61) From my perspective -- I would have included a Ceph

66) would like to have had a ceph

70) Needed periodontal evaluation for recession & inflammation

76) panoramic would be helpful

Case 2- Ceph necessary?
If yes, please specify (optional)

6) I would llike to check the incisor positions

7) Lower incisors are flared already, note how short they look on pan. Short image means they are flared.

9) Standard of care

10) For torque and comparison of pre and post treatment root torque

11) To see the extent of bimaxillary protrusion

12) Same reason as before. You need to determine the facial pattern.

13) To evaluate the skeletal relationship and the angle of the lower incisors.

14) need to know what the alveolar bone looks like in the area of the lower incisors

16) He essentially has a Class II skeletal relationship

18) Patient is Class II. Mechanics will require anterior movement of the mandibular dentition therefore knowing Md incisor position is critical

19) Bimax may extract0

24) Same as above

26) Only for discussing options with the patient

31) needed for same reasons as first case

32) To determine severity of proclination of incisors

33) Helps determine the amount of incisor proclination

38) Depends on patient goals.

39) I cannot determine treatment plan without it. What is position of teeth in face? What is CC?

40) Would like to see proclamation of incisors to discuss possible extraction case if patient wants to address protrusion.

42) To determine incisor AP relationships to basal bone

45) Treatment options ex non ex would be explained

47) Pt profile does not look like the ceph. Models of left side show different occlusion from photos. Tx is optional. Ceph shows a bimax but pt does not show lip strain and can close naturally. Tx optional.

49) Love wear incisor to mp

51) Patient is bimax and borderline ext case

54) Evaluate incisor proclination

55) to determine how protrusive his teeth are which would help in diagnosis of extraction vs non ex

57) The degree of protrusion is not obvious in photos but is in the ceph.

59) I would like to see the AP position of the skeletal relationships but probably no absolutely necessary in this case

61) To check for potential pathology

64) I want to see incisor position

66) the incisors are incredibly flared and coming through the front of the bone so I need the ceph to confirm this

68) Proclination of incisors

69) to determine skeletal bimaxillary protrusion

70) VTO for extraction to plan anchorage & understand soft & hard tissue anticipated changes

71) Determine incisor position relative to skeletal base and Jaw relationship

72) Skeletal issue, amount procclination?

75) I would like to see incisor inclination

Case 2- Records adequate?
If no, please specify (optional)

2) Would prefer information on TMJ and perio status

4) Clinical examination is important, the tongue posture and function might be an issue on this case

6) Need CC, health history and oral exam

7) Need a ceph.

10) Need to get a lateral ceph

12) Same as before. I always want to know the facial pattern even if I think I can "eye-ball it"

18) Left buccal photos & Models do not match up.

23) would like to see a ceph for angulation of teeth

24) Ceph is necessary for ALL treatment planning

29) Periapical's of Maxillary anteriors or repeat pan

31) need ceph

34) I would like to see a cephalopods

35) Ceph

36) Need patient's chief concern

38) Need mounted models. photos don't match the models

39) Need ceph, CC

40) Ceph needed to evaluate skeletal and dental positions to discuss protrusion.

41) Dental history with jaw joint exam and questions regarding function would be necessary

47) Need to verify data. I would suggest no tx. Pt needed to be seen and discuss options.

50) One caveat, would be is the patient OK with the protrusion, if not extractions (other than 8's) may be considered.

51) Need CEPH

57) Pre-treatment mounted models would have been better.

64) Would like to know how patient feels about his own facial pattern

68) need ceph

70) Either tomograms or articulated models as study models & photos have a different occlusion. Which is correct? Is your goal to have the condyle seated in the fossa when the teeth fit? If so, it would be helpful if you knew where the condyles were at the beginning of tx.

71) Pt appears skeletal Class II with flared lower incisors -- I would like to know this before starting

72) Need to be sure, one could probably be okay but it those rare instances one could get in trouble, like pathological issues.

75) I would like a ceph

76) Ceph may be helpful

77) Would like cbct to fully evaluate lower anterior bone, airway, amount of bone, etc.

78) Ceph would be nice if one of patient's concerns were the bimaxillary protrusion (normal to that ethnic group)

Case 3- Ceph necessary?
If yes, please specify (optional)

7) Crowding, with incisor flaring and retrusive lower third. Frog will help determine extraction pattern.

9) Same as above, need to see inclination.

10) Confirm excess labial flare of the anteriors and for torque and comparison of pre and post treatment root torque

12) I would want to determine the facial pattern and also the position of the upper and lower anteriors. They look slightly proclined.

13) Skeletal relationship, angle of the mandible (cw or ccw), angle of the incisors etc

14) need to know where the lower incisors are in the bone

18) Md incisor angulation

19) Poss extract need to review inc angulation mpa etc

21) P A x-rays on lower anterior teeth

24) Same as #1

27) need ceph to determine incisor position and mandbiular position

31) Skeletal and dental alignment must be determined

32) To CLARIFY clinical impression

33) For legal purposes in case there is a lawsuit.

35) Incisal inclination

40) noted protrusion of teeth. Good discussion with patient for possible removal of teeth.

42) To determine incisor AP relationships to basal bone

47) While not necessary, I would still have one taken.

49) Lower incisor to MP

52) The class II the right and the amount of crowding requires information on the the skeletal pattern and the inclination of the anterior teeth.

54) Same as above

55) to determine position of LL1 in the ajw

57) The incisors are already showing signs of gingival recession and I would not want to flare them off of the alveolar bone.

59) Want to see AP maxillary/mandibular relationships and also the incisor protrusion

60) lower incisor angulation, dolicho

61) Potential Pathology

64) Want to see skeletal pattern

66) to evaluate incisor position

69) To determine Skeletal open bite tendencies

70) ext & non-ext with periodontal augmentation and appropriate VTO's

71) Pt appears skeletal Class II with flared lower incisors -- I would like to know this before starting

72) Help determining if extractions are plan of choice

75) it would be helpful

78) To see how Class II as well as how flared anteriors (especially lower anteriors)

Case 3- Records adequate?
If no, please specify (optional)

2) Would prefer information on TMJ and perio status

6) Need CC, health history, oral exam and perio consult.

7) Need a ceph

10) Need to get a lateral ceph

12) I would want to evaluate the position of the anterior teeth. I might consider upper and lower second premolar extractions if the anteriors were proclined as it looked like they might be.

13) Perio eval

15) Bolton discrepancy calculation

23) model left does not match photos on left lateral bite

24) Ceph needed

31) need ceph to trace

32) No ceph

35) Ceph

36) Need to know prognoses on teeth with large fillings, possible apical lesion #20 will affect tx plan.

37) Needs ceph, but looks like upper 4 lower 5 extraction case

39) Need ceph and CC

41) Dental history with jaw joint exam and questions regarding function would be necessary

42) Need ceph to confirm non extraction treatment plan

46) No lateral ceph or CBCT image provided

47) Mild asymmetry to the right.

55) lateral ceph

57) I would have liked a lateral and frontal ceph and mounted models.

58) I would prefer to have a ceph and a periapical of LL5

60) lat ceph would be helpful

66) should have had ceph

68) need cep

70) periodontal evaluation

71) Pt is dental Class II - I would like to know what her skeletal relationship is to determine all treatment options

75) i would like a ceph

77) Cbct to see true root positions, canted occlusal plane, etc

78) Ceph as indicated

Case 4- Ceph necessary?
If yes, please specify (optional)

2) Would like to know FMA and/or SnGoGn to determine cause of anterior open bite tendency

7) Openbite with vertical issues. Need a ceph.

8) I wanted to see the maxillary plane in relation to the mandible.

9) Same as above

10) For torque and comparison of pre and post treatment root torque

12) Facial pattern determination. With an anterior open bite, I would want to be very careful with mechanics and would need to evaluate extractions to aid in bite closer.

13) skeletal relationship, angle of the mandible, open bite potential

24) Same as above

29) ? Skeletal open bite

31) For skeletal and dental measurements

32) To help identify source of open bite

33) For legal purposes in case there is a lawsuit.

40) Would like to see skeletal features to determine dental or skeletal open bite?

42) To determine skeletal vertical dimensions and incisor AP relationships

50) The patient has a Class III growth tendency, I would want a ceph as a pre-tx reference.

51) Import to see if patient is hyperdivergent or not

54) Same as above

56) eval nature of anterior open bite

57) The degree of flaring and protrusion will determine how to treat the openbite.

59) Want to evaluate vertical dimensions

61) Potential Pathology

66) you need to have a ceph to evaluate the position of the incisors

68) open bite

69) To determine skeletal open bite tendencies

70) yes, if he is growing & patient or family history of skeletal Class III open bite

71) Dental Class I with Skeletal Class II with proclined lower incisors

72) Mechanics needed to treat case

73) Thin bone over mandibular incisors and open bite more visable on ceph

78) To see how flared anteriors are...Consider removing 5's if patient concerned with that, otherwise Invisalign would help close the openbite.

Case 4- Records adequate?
If no, please specify (optional)

2) Would prefer information on TMJ and perio status

6) Need CC, health history and clinical exam

7) Need a ceph.

10) Need to get a lateral ceph

12) Any time an open bite is present, I am going to be suspicious that the facial pattern may be playing a part in it. Also, he looks a bit bi-maxillary protrusion. I might consider extractions on this case after initial alignment.

13) I need photos with his mentalis and lips in a relaxed state, he needs an airway evaluation to determine why he has an anterior open bite, I need to know what will happen with the third molars and the carious lower second molars.

28) However a ceph would help to assess how much the skeletal vertical pattern contributes to the open bite, would not change the mechanics. Third molar extractions and endo eval may be needed for lower second molars

29) Periapical's of maxillary anteriors or repeat pan

36) Need to know prognoses on teeth with apparently severe decay. Also, the ceph is tilted and I would want a tracing (the orientation is affecting to appearance of upper and lower incisor positions)

37) Need ceph to definitively decide extraction or non extraction

40) Ceph needed

41) Dental history with jaw joint exam and questions regarding function would be necessary

46) a CBCT image file would show the airway more. If airway not an issue an extraction option would be proposed as well.

47) Pt needed to be seen and consulted.

50) What is patients desire? Does the protrusion bother him, ext of 4's may be indicated, hard to treatment plan a case without patients input

52) I would like to know his age.

56) like to have seen a Ceph

57) I would have preferred mounted models. If the openbite were more extreme it could have been a surgery case.

58) Need ceph and posterior bitewings

64) Need to know prognosis of decay evident in pan

70) Tooth size discrepancy, age of patient, how is caries to be resolved md 7's

74) I would like to see a ceph

78) Would like ceph...I would ext 8's and get restorative done ASAP

APPENDIX D

SURVEY RESPONSES: YEARS OF EXPERIENCE BREAKDOWN

Years Practicing Orthodontics	Number of Subjects
0-10	7
11-20	16
21-30	33
>31	23