Original Article

Value-addition of lateral cephalometric radiographs in orthodontic diagnosis and treatment planning

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ABSTRACT

Objective: To investigate the value-addition of obtaining lateral cephalometric radiographs during the treatment planning phase of orthodontic treatment.

Materials and Methods: The records of 100 orthodontic patients were presented to seven scorers during two phases that were 6 weeks apart. In the first phase, scorers completed a seven-question survey with questions regarding treatment planning. They were given various diagnostic records that did not include a lateral cephalometric radiograph. Six weeks later, the same scorers completed the same survey for the same patient cases with the same diagnostic records that additionally included a lateral cephalometric radiograph. Correlation coefficients were used to calculate intrarater agreement and inter-rater agreement within the study.

Results: Cohen's kappa values showed moderate to almost perfect agreement for the majority of survey questions. Intrarater agreement ranged between 0.430 and 1. Cronbach's alpha reliability statistics showed good interrater agreement for all questions in the survey. Agreement ranged from 0.710 to 0.913 across the survey questions. Diagnosing Angle classification of occlusion had the highest level of agreement and differentiating between skeletal and dental malocclusion had the lowest level of agreement.

Conclusions: The lateral cephalometric radiograph is not a necessary diagnostic tool for most cases in orthodontic diagnosis and treatment planning. Weighing the usefulness of a lateral cephalometric on a case-by-case basis should be recommended to align with the principle of ALARA (as low as reasonably achievable), especially in a primarily pediatric population. (*Angle Orthod.* 2020;90:665–671.)

KEY WORDS: Lateral cephalometrics; Treatment planning

INTRODUCTION

In developing a treatment plan for a patient, the majority of orthodontists obtain diagnostic records of diagnostic casts, intraoral photographs, extraoral photographs, and radiography that typically includes a panoramic radiograph and a lateral cephalometric radiograph.[1] For the better half of a century, the lateral cephalometric radiograph has been a routine measure in orthodontic diagnosis and treatment planning. The primary purposes of the lateral cephalometric radiograph are to provide detailed views of the relationships between the patient's skeletal, dental, and soft tissue morphology, and to evaluate a patient's progressive response to treatment.[2] Debate exists regarding whether the lateral cephalometric image is necessary as part of orthodontic diagnosis and treatment planning, as the clinical exam has the potential to provide sufficient information for diagnosis.[2] The degree to which the lateral cephalometric image is useful in treatment planning can often vary by case.[3] Employing

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cephalometric analyses also has been theorized to be a limited methodology that uses normative standardized values, which can be misleading due to the vast variation in craniofacial morphology of orthodontic patients.[4]

Previous studies regarding the topic of whether lateral cephalometric radiographs are necessary for orthodontic treatment have resulted in varying and somewhat uncertain conclusions. In 1979, Silling et al.[3] conducted a study using 24 orthodontists and six cases that found that, for obvious cases, lateral cephalometric radiographs were not necessary but that they might be necessary for more complicated cases, like Class II, division I cases. Stupar et al.[5] also conducted a similar study using two orthodontists and 25 patient cases and found that the lateral cephalometric image had no influence on extraction treatment planning decisions. Devereux et al.[6] conducted a study in 2011 using 199 orthodontists and six patient cases and found that, for all patients but one, the lateral cephalometric image did not have a significant impact on treatment. Most recently, Durao et al.[7] conducted a study in Portugal using 10 orthodontists and 43 patients that found that the majority of the orthodontists felt that using the lateral cephalometric image was key for proper diagnosis but the results seemed to indicate the contrary. The uncertainty surrounding the issue indicated that further research on the utility of the lateral cephalometric radiograph would be beneficial. Regardless, many orthodontists view the lateral cephalometric image as necessary for every patient case to track the progress resulting from treatment by overlaying cephalometric tracings taken prior to the start of treatment and cephalometric tracings taken during treatment.[2,7] An estimated 90.5% of orthodontists in the United States routinely use the lateral cephalometric image as a pretreatment diagnostic record.[1]

As with any form of radiography, there is an associated dose of ionizing radiation delivered to the patient with each radiograph taken. Although the radiation dose delivered by lateral cephalometric radiographs is relatively low, the lateral cephalometric still delivers radiation to multiple radiosensitive organs, such as the brain, bone marrow, thyroid gland, and salivary glands.[8] The effective dose of lateral cephalometrics with photostimulable phosphor is 5.6 microsieverts, which is a 51% increase in effective dose compared to the calculated effective dose in 1990 according to the International Commission on Radiological Protection.[9] This pattern of increasing effective doses is a significant indication for studying how much diagnostic value radiographs have and whether there are acceptable methods to limit patient exposure to radiation.[9] The radiation doses delivered by lateral cephalometrics is a pressing concern particularly in the field of orthodontics due to the majority of orthodontic patients being children and adolescents who are still in the developing stages of growth.[8] The organs that bear the greatest brunt of ionizing radiation from the lateral cephalometric are the salivary glands, thyroid, and bone surfaces.[9] Ionizing radiation has the potential to cause DNA damage to tissues in the form of single- and double-strand breaks, and DNA-protein crosslinks, ultimately increasing overall risk of cancer.[10]

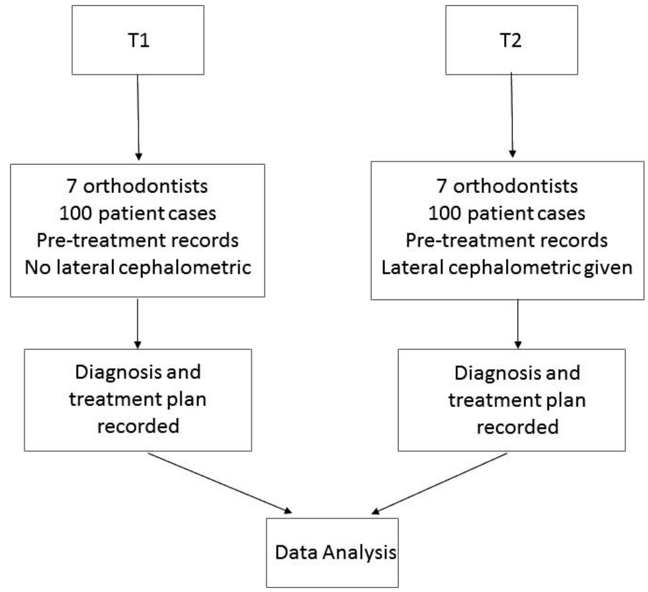

Figure 1. Study design.

The purpose of this study was to help determine and further clarify if the presence of a lateral cephalometric radiograph as a diagnostic record in orthodontic treatment planning has enough value to justify exposing orthodontic patients to the associated radiation. Unlike previous studies, this study included a large sample size of patient cases and included less experienced orthodontists to better represent the range of experience present among various providers of orthodontic care in the United States.

MATERIALS AND METHODS

Informed consent was obtained from all patients prior to initiation of treatment. All of the radiographs and photos were de-identified and had no personal information attached to the images. An institutional review board exemption to use the images was obtained from the University of Connecticut School of Dental Medicine.

Study Design

A total of 100 pretreatment patient records were evaluated during the two separate phases of this study as shown in Figure 1. During phase 1 of the study, a

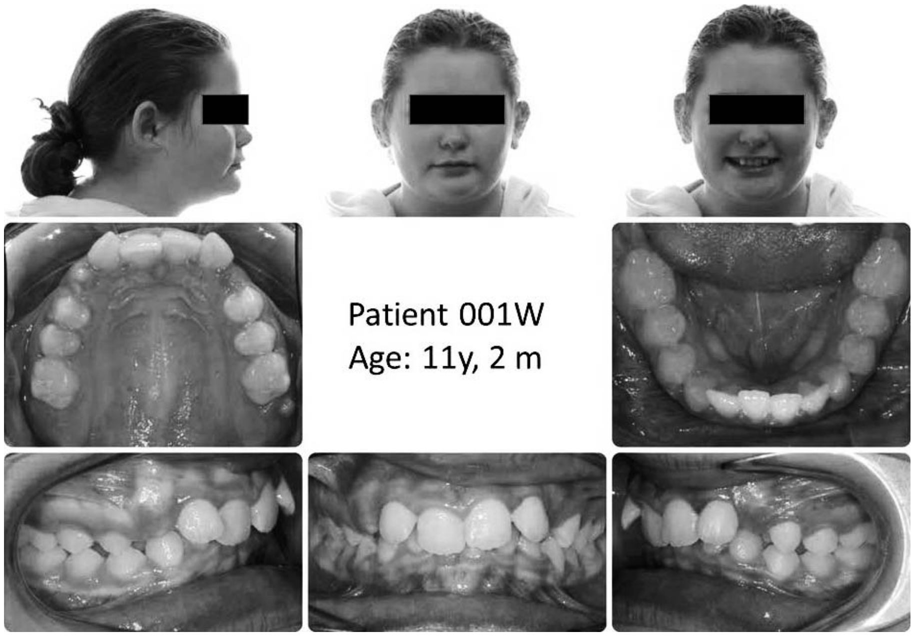

Figure 2. Presentation of extraoral photos, intraoral photos, patient age, and code.

group of seven scorers were presented with a set of 100 different orthodontic patient records and asked to complete a seven-question survey that included questions regarding diagnosis and treatment planning for each patient. These records did not include a lateral cephalometric radiograph. After a gap of 6 weeks to ensure that the scorers would not be able to recall the initial patient records, the scorers were given a second set of patient records, which consisted of the same records for the same patients as the first phase, while also including a lateral cephalometric radiograph for each patient. The scorers included three orthodontists, three third-year orthodontic residents, and one first-year orthodontic resident. Their levels of experience ranged from 1 year to 10 years, and all scorers were familiar with using digital models. The scorers were given 3 weeks to complete and return the surveys in both phases of the study. The patient cases were obtained from a local private practice orthodontist, who was not a scorer for the study. The cases involved in this study were treated within the last 10 years and consisted of patients ranging in age from 8 to 21 years old. The cases presented were comprised of a patient pool that was 56% female, 44% male, and 95% Caucasian. Cases chosen for the study included Class I, Class II, and Class III malocclusion patients. In both phases of the study, scorers were also provided with patient age to help ascertain the stage of development in which each patient was.

Phase 1 records consisted of extraoral photographs, intraoral photographs, digital casts, and a panoramic radiograph. Phase 2 records consisted of extraoral photographs, intraoral photographs, digital casts, panoramic radiograph, and a lateral cephalometric radiograph. The same seven-question survey was completed by each scorer for each of the 100 patients in the second phase and the responses between the two phases were then analyzed.

Record Presentation and Survey

Each patient record was presented digitally to the seven scorers with any patient identifying information concealed. The 100 cases were randomly ordered in both phases. Examples of each type of patient record presentation are shown in Figures 2 through 5.

Survey questions regarding orthodontic diagnosis and treatment planning consisted of the following:

1. After reviewing the patient record, how would you diagnose this type of malocclusion?
   - Skeletal malocclusion, Dental malocclusion, A combination of both skeletal and dental malocclusion
2. What do you think is the Angle classification of occlusion?
   - Class I, Class II, Class III
3. Would you need additional information to make a diagnosis?
   - No, Yes
4. If this patient does not have all teeth erupted, is there enough space for all teeth to erupt?
   - Yes, No
5. Would you extract teeth in this patient?
   - No, Yes

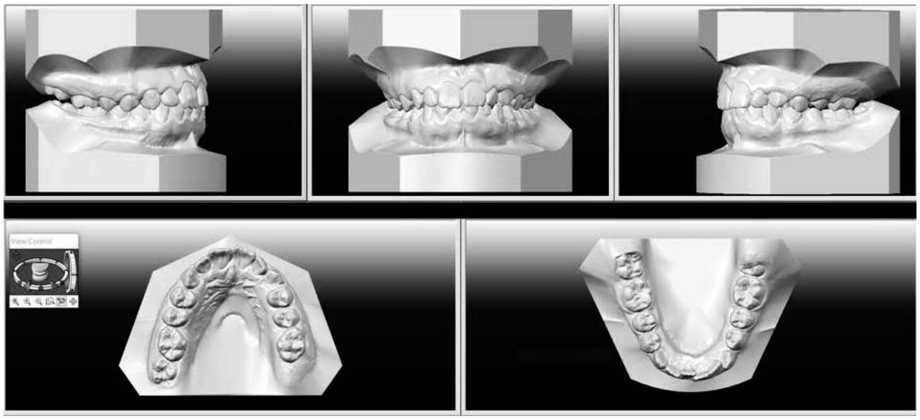

Figure 3. Presentation of digital casts.

6. Would you expand the upper arch?
   • Yes, No
7. Do you think this patient needs orthognathic surgery?
   • Yes, No

Each scorer was presented with 100 surveys in each phase, one for each patient. Each survey contained a code corresponding to each patient. Data analysis was performed at the end of the two phases to determine intrarater agreement and interrater agreement levels.

Data Analysis

Intrarater agreement among the observers between the phases was calculated using Cohen's kappa analysis. Kappa values ranging from 0.81 to 0.99 indicated almost perfect agreement, 0.61–0.80 indicated substantial agreement, 0.41–0.60 indicated moderate agreement, 0.21–0.40 indicated fair agreement, and 0.01–0.20 indicated slight agreement.[11] The total number and overall percentage of affirmative answers for each answer choice in each phase of the study were also calculated to illustrate the degree to which the survey answers changed between phases.

Interrater agreement among the observers within the phases was calculated using Cronbach's alpha. These values were calculated to quantify how well the scorers aligned with each other as an overall group to ensure they had similar approaches to treatment planning so that differences in treatment philosophies were not likely to contribute to any differences observed between the two phases. Acceptable values showing agreement with Cronbach's alpha ranged from 0.70 to 0.95.[12]

Data analysis to calculate Cohen's kappa and Cronbach's alpha analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA).

Figure 4. Presentation of panoramic radiographs.

RESULTS

Table 1 shows the range of kappa values for intrarater agreement calculated for the seven scorers

Figure 5. Presentation of lateral cephalometric radiographs in second phase of the study only.

Table 1. Kappa Values for Intrarater Agreement Levels Among Observers for Each Survey Question

	Kappa Value Range
Question 1: Malocclusion Diagnosis	0.430–0.592
Question 2: Angle Classification of Occlusion	0.685–0.976
Question 3: Necessity of Additional Information	0.490–1.00
Question 4: Space for Eruption	0.504–1.00
Question 5: Necessity of Extraction	0.498–0.720
Question 6: Necessity of Expansion	0.485–0.675
Question 7: Necessity of Orthognathic Surgery	0.486–0.787

Table 2. Cronbach's Alpha Values for Interrater Agreement Levels Among Observers for Each Survey Question

	Interrrater Agreement Value
Question 1: Malocclusion Diagnosis	0.710
Question 2: Angle Classification of Occlusion	0.913
Question 3: Necessity of Additional Information	0.757
Question 4: Space for Eruption	0.757
Question 5: Necessity of Extraction	0.741
Question 6: Necessity of Expansion	0.827
Question 7: Necessity of Orthognathic Surgery	0.746

for each question between the two phases of the study. Table 2 shows the range of Cronbach's alpha values for interrater agreement calculated for the seven scorers. Classifying occlusion had high values for kappa and Cronbach's alpha, indicating that there was good agreement for each scorer between the phases, and good agreement among the observers as an overall group. Determinations of whether there was space for eruption and whether the patient would require extractions also had relatively high kappa values for intrarater agreement. Differentiating between dental and skeletal malocclusion had the lowest values for both kappa and Cronbach's alpha; however, the overall agreement for Question 1 still fell into an acceptable range for both intrarater and interrater agreement.

All kappa value ranges for each question fell within moderate to almost perfect levels of agreement with no statistically significant differences between the two phases. No single question had a kappa value range below 0.41, which would have indicated only fair agreement. The moderate to high levels of agreement indicated by the resulting kappa values showed that all scorers were consistent among themselves, regardless of level of experience. All of the Cronbach's alpha values calculated for each question fell within the acceptable range of 0.7–0.9. Therefore, each scorer had similar approaches to treatment planning given that the group tended to make similar treatment planning decisions.

Figure 6 illustrates the percentage of affirmative answers for each answer choice between Phase 1 and Phase 2. The changes from Phase 1 to Phase 2 all fell below a difference of 10%, with the exception of the question as to whether additional information was necessary, where "yes" was more frequent by 16% in Phase 1. Figure 7 illustrates the same data in total number of affirmative answers for each answer choice between the phases.

DISCUSSION

Overall, intrarater and interrater agreement levels between the phase of the study involving lateral cephalometrics and the phase of the study excluding lateral cephalometrics was substantial. This was clinically significant in the context of ALARA (as low as reasonably achievable), the radiology principle of keeping radiation doses delivered to patients as low as reasonably achievable. The study findings agreed with findings in similar previous studies. As seen in Figure 6, there was a marked decrease in requests for additional information during Phase 2 when the lateral cephalometric radiograph was provided. This suggests that the scorers themselves wanted a lateral cephalometric in 36% of cases despite the two phases having overall good agreement, which reinforced findings from Durao et al.[7]

This study did not perfectly simulate diagnosing and treatment planning in reality, since scorers were provided with diagnostic records only. A clinical exam would not have been feasible to include in a study of this size, but it is possible that performing a clinical exam prior to developing a treatment plan could impact a scorer's responses to the survey questions. It is also important to note that, had a scorer been dissatisfied with the quality of one of the diagnostic records, such as a radiograph, retaking that radiograph would not have been an option during this study. Levels of experience among the scorers in this study ranged from a year of residency training to several years of experience as a practicing orthodontist. This could have been a potential limitation to the study if level of experience has a significant impact on a scorer's cephalometric analysis, which is a controversial topic. Durao et al.[7] conducted a similar study on the impact of lateral cephalometrics that showed that the least experienced orthodontist was the least consistent with skeletal classification while the most experienced orthodontist was the most consistent with skeletal classification. Scorers with fewer years of clinical training were included in this study because other studies determined that a cephalometric analysis on an individual basis was more dependent on a scorer's background rather than level of experience.[7,13] Several of the scorers in this study came from similar training backgrounds and the high interrater agreement levels

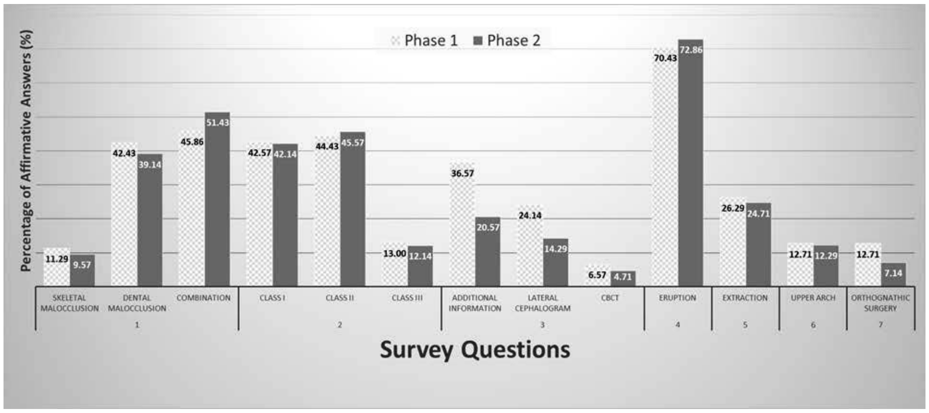

Figure 6. Percentage of affirmative answers for each survey question answer in each phase.

confirmed that the scorers had similar approaches to treatment planning. The patient cases were representative regarding the variance in cases presented to the scorers but the patient pool itself was 95% Caucasian and did not have racial generalizability to the overall population. Another potential limitation came from the survey. The survey questions were similar in topic and structure to those of previous studies but it may have been beneficial to include a question that asked if scorers would have wanted any additional information to develop a treatment plan, such as any other radiographs or clinical information.

The role that cone beam computed tomography (CBCT) technology has started to play in orthodontic diagnosis and treatment planning in the last two decades is an important consideration when determining how lateral cephalometric radiographs should be used. When a CBCT is indicated for a patient, synthesized two-dimensional (2D) films derived from the CBCT can provide diagnostic information that is reliable and often more accurate than a traditional 2D image.[14] Should a patient present with a condition that indicates a CBCT, an additional lateral cephalometric would not be necessary, as that would not provide any additional data and would expose the patient to further unnecessary ionizing radiation.[15] The additional ionizing radiation delivered by CBCT technology increases in significance when considering the evolving use of CBCT in orthodontic practice. Surveys from 2014 show that, out of 52% of postgraduate orthodontic residency programs in the United States and Canada that responded to the survey, about 82% used CBCT only when indicated for specific diagnostic purposes, while about 18% used CBCT routinely for every orthodontic patient.[16] The exact value addition of lateral cephalometrics becomes an even more prominent concern if they are being routinely derived from an imaging modality that delivers a higher ionizing radiation dose.

CONCLUSIONS

- The use of lateral cephalometric radiographs does not have a clinically significant impact on the diagnosis and treatment planning of orthodontic patients.
- Orthodontists of all levels of experience are not likely to change diagnosis and treatment planning decisions regardless of the presence of a lateral cephalometric image.

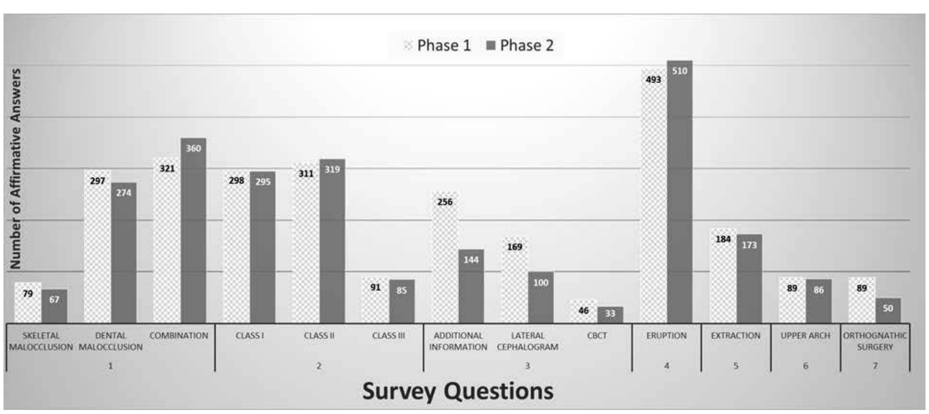

Figure 7. Total number of affirmative answers for each survey question answer in each phase.

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