The effect of the lateral cephalometric radiograph on orthodontists’ diagnosis and treatment decisions: a double-blind, randomised controlled trial

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Aims: To evaluate the influence of the lateral cephalometric radiograph on orthodontists’ diagnosis and treatment planning decisions.

Methods: Five patients with full pre-treatment records were selected to represent a spectrum of malocclusions. The records were provided in a web-based questionnaire emailed to 510 Australian registered orthodontists. Participants were asked to formulate a diagnosis and treatment plan for a randomised patient case. The control group received a lateral cephalometric radiograph whilst the intervention group did not. The two groups’ diagnostic accuracy was determined by a comparison with the formative diagnoses determined by five senior academic orthodontists. Their diagnosis and treatment planning decisions were also compared.

Results: A comparison of the orthodontists’ diagnoses revealed that the lateral cephalometric radiograph did not lead to an increase in the assessment accuracy of dental \( p = 0.797 \) and skeletal \( p = 0.273 \) relationships. Further analysis using logistic regression showed that the orthodontists’ years of experience did not influence the accuracy of skeletal diagnosis \( p = 0.177 \). A comparison between the orthodontists’ dental \( p = 0.689 \) and skeletal \( p = 0.321 \) determinations did not significantly differ between the two groups. An assessment of the vertical growth pattern \( p = 0.656 \) was also unaffected by the omission of the lateral cephalometric radiograph. When the two groups considered treatment planning options, there were no statistically significant differences related to the treatment options of growth modification \( p = 0.720 \), orthognathic surgery \( p = 0.101 \), and/or an extraction decision \( p = 0.840 \).

Conclusion: Lateral cephalometric radiographs did not significantly influence orthodontists’ diagnosis. There was also little evidence to demonstrate the radiograph’s efficacy in treatment planning cases with no skeletal discrepancy or no significant labiolingual incisor movement planned.

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Introduction

The lateral cephalometric (LC) radiograph is often used as a diagnostic tool in orthodontic treatment planning to assess a patient’s skeletal and dentoalveolar relationships.

However, it has been shown that case assessment information may be ascertained using a clinical examination alone.\(^2\)\(^5\)\(^6\) An earlier study has shown that, while the majority of orthodontists believed that the LC radiograph was important for routine cases, it had no significant influence on their treatment planning.\(^7\)

Since 2004, there have been guidelines placed on the prescription of LC radiographs in Europe following the findings that 74% of films did not alter the diagnosis...
or treatment planning decisions of orthodontists in routine cases. There are currently no specific guidelines for the use of orthodontic radiographs in Australia, other than the overarching Australian Radiography Guidelines ‘As Low As Reasonably Achievable’ (ALARA) principle. This has resulted in the perception that some orthodontists feel the need to prescribe LC radiographs for medicolegal rather than clinical reasons, which therefore reinforces the practice of requesting routine pre-treatment LC radiographs for all orthodontic cases.

The aim of this randomised controlled trial was to determine if the LC radiograph influenced orthodontic diagnosis or treatment planning decisions.

Materials and methods

The study involved a parallel-group, double-blinded, randomised controlled trial with a 1:1 allocation ratio that has been described according to the CONSORT guidelines for the presentation of clinical trials. Approval was attained from the Human Research Ethics Committee of James Cook University (H6837), and the study was registered with the Australian New Zealand Clinical Trials Registry (U1111-1193-2387).

The trial was conducted in Australia by participating orthodontists practicing in primary, secondary and university healthcare settings. Inclusion criteria included orthodontists whose contact information was available through key-word searches on a web-based search engine (Google, CA, USA) using the term ‘orthodontist’ and limited to Australian states and territories. The formulated list was checked against the online database of registered specialist orthodontists held by the Australian Health Practitioner Regulation Agency (AHPRA). Any orthodontist who did not appear in the database was excluded from the study.

Participants were randomised into two groups using computer-based randomisation software (WinPepi, Version 11.65). The control group and intervention group consisted of 259 and 251 orthodontists, respectively. The allocation was organised by a third party and concealed from the researchers until the completion of the study.

Electronic questionnaires were prepared using the clinical records of five patients selected from a database of James Cook University’s Dental School to represent a variety of routine malocclusions. Prior to dissemination, the questionnaires were validated by an expert panel of five senior academic orthodontists from Australia’s five accredited university postgraduate orthodontic programmes. The expert panel was also provided with the full case records of all five patients presented in the questionnaires and asked to determine a consensus orthodontic diagnosis for each patient.

All patients (or parents/guardians) signed a consent form for their records to be used for teaching/research purposes and records were de-identified before inclusion in the questionnaire. Control and intervention versions of the questionnaire were prepared for each of the five patients (10 surveys). Each control questionnaire consisted of a single patient’s records containing the patient’s age, extraoral and intraoral photographs, study models, and LC and panoramic radiographs (Figure 1), whilst the intervention version omitted the LC radiograph and asked the orthodontists if they would prefer lateral cephalometric radiograph for determining diagnosis and treatment options. Depending on their allocated group, the orthodontists received a randomly-selected intervention or control patient case and were asked to use the clinical information provided to formulate a diagnosis and treatment plan.

The questionnaires were completed using an online platform (SurveyMonkey, CA, USA) and were automatically recorded and de-identified. The surveys also captured the orthodontist’s gender and years of practicing experience. The blinding of participants was maintained by not revealing the research question and using standardised questionnaires for both groups, only omitting the radiograph for the intervention group without explanation. The orthodontists were recruited between June 2017 and August 2017. Following an initial mail-out, two reminder emails were sent by a third party to prompt orthodontists to complete the questionnaire. The trial concluded three weeks after the final reminder was sent.

Statistical methods

Power

The primary outcome measure was the percentage of correct diagnoses. With respect to sample size, 79 orthodontists in each group achieved 90% power to detect a difference in the percentage of correct diagnoses between the control and intervention groups of 20%. This assumes that the control group had 90% correct diagnoses, compared with 70% in
Figure 1. An example of patient records, including intra- and extra-oral photographs, panoramic and lateral cephalometric radiographs and study models.
LATERAL CEPHALOGRAMS’ INFLUENCE ON DIAGNOSIS AND TREATMENT PLANNING

Table I. Patient age and formative diagnosis.

| Patient | Sex | Age (y, m) | Description |
|---------|-----|------------|-------------|
| 1       | Female | 11, 4   | Class I on a mild Class II skeletal base. Meso-dolichofacial, upper and lower arch crowding. |
| 2       | Female | 14, 1   | Class II Division 1 on a skeletal II base. Mesofacial, increased overjet with anterior open bite. |
| 3       | Female | 14, 7   | Class II Division 2 on a skeletal II base. Mesofacial, increased overjet with deep bite. |
| 4       | Female | 11, 1   | Class II Division 1 on a skeletal II base. Brachyfacial, increased overjet with deep bite. |
| 5       | Male   | 23, 11  | Class III on a skeletal III base. Dolichofacial, decreased overbite and overjet. |

Table II. Descriptive statistics of participating orthodontists.

|                          | Control | Intervention |
|--------------------------|---------|--------------|
| Participant responses    |         |              |
| Patient 1                | 15      | 14           |
| Patient 2                | 11      | 14           |
| Patient 3                | 13      | 13           |
| Patient 4                | 12      | 10           |
| Patient 5                | 10      | 13           |
| Total                    | 61      | 64           |

| Gender               |         |              |
|----------------------|---------|--------------|
| Male                 | 45      | 56           |
| Female               | 16      | 8            |
| Total                | 61      | 64           |

| Years experience |         |              |
|------------------|---------|--------------|
| 1-5              | 16      | 8            |
| 6-10             | 6       | 9            |
| 11-15            | 6       | 9            |
| 16-20            | 4       | 10           |
| 21-25            | 5       | 11           |
| 26-30            | 13      | 5            |
| 31-35            | 7       | 9            |
| 36-40            | 4       | 1            |
| 41-45            | 0       | 2            |
| 46-50            | 0       | 0            |
| Total             | 61      | 64           |

| Primary place of practice |         |              |
|---------------------------|---------|--------------|
| Private practice          | 57      | 57           |
| University                | 0       | 3            |
| Other                     | 2       | 3            |
| Total                     | 61      | 64           |

Statistical analysis

To measure how the LC radiograph influenced orthodontists’ diagnoses, the accuracy of the two groups’ decisions were compared with the formative diagnoses provided by the expert panel. This was undertaken separately for each patient scenario, and then for all patient scenarios combined. Fisher’s exact tests were conducted due to small sample sizes of individual patient cases. Subsequent analysis of all cases combined were compared using a chi-squared test. Logistic regression was then applied to determine if an association existed between years of experience and accuracy of skeletal diagnosis in the intervention group. To measure if there was a difference in diagnosis and treatment planning decisions between the two groups, Fisher’s exact tests and chi-squared tests were again conducted. A cut-off of $p \leq 0.05$ was considered to be statistically significant. SPSS Statistics Version 25 was used to analyse the data.

Results

The expert panel’s diagnosis for each of the five patients featured in the questionnaires is shown in Table I. Of the 510 orthodontists contacted, 163 agreed to take part in the study (32%), of which 125 fully completed the questionnaire giving an analysed response rate of 77% (Figure 2). Table II shows the demographic information of the sample population including group allocation, gender, years of experience and primary place of practice. Of the orthodontists in the intervention group, 90.6% stated that they would prefer a lateral cephalometric radiograph for diagnosis and treatment planning of their allocated cases.
**Diagnosis**

When comparing the diagnoses of the two groups with the expert panel, there were no statistically significant differences (Table III). When assessing the correct dental ($p = 0.797$) or skeletal ($p = 0.273$) relationships of the five patients combined, no statistically significant differences were identified between the two groups. Logistic regression was undertaken to determine if an association existed between years of experience and correct skeletal diagnosis in the intervention group; however, no such association was found ($p = 0.177$).

The results of the orthodontic diagnosis of the five patients are shown in Table IV. There was no statistically significant difference between the two groups in the dental, sagittal skeletal and vertical skeletal diagnoses (Patient 1: $p = 0.682$, $p = 0.060$ and $p = 0.314$ respectively; Patient 2: $p = 0.487$, $p = 0.487$ and $p = 0.673$ respectively; Patient 3: $p = 0.645$, $p = 1.000$ and $p = 0.145$ respectively; Patient 4: $p = 1.000$, $p = 0.545$ and $p = 0.400$ respectively; Patient 5: $p = 1.000$, $p = 1.000$ and $p = 0.404$ respectively; and Combined: $p = 0.689$, $p = 0.321$ and $p = 0.656$ respectively).
### Table IV. Orthodontists’ diagnosis decisions.

|                  | Dental diagnosis | Sagittal skeletal diagnosis | Vertical skeletal diagnosis |
|------------------|------------------|----------------------------|-----------------------------|
|                  | Class I | Class II | Class III | Div I | Class I | Class II | Class III | Hypodivergent | Normodivergent | Hyperdivergent |
| Patients         | N %     | N %     | N %      | p value | N %     | N %     | N %      | p value | N %     | N %     |
| Patient 1        |         |         |          |         |         |         |          |         |         |         |
| Control          | 10 66.7% | 5 33.3% | 0 0.00%  | 0.00    | 3 20.0% | 12 80.0%| 0 0.00%  | 0.060  | 1 6.70% | 7 46.7% | 7 46.7%  | 0.314 |
| Intervention     | 11 78.6% | 3 21.4% | 0 0.00%  | 0.00    | 12 66.7%| 6 33.3% | 0 0.00%  | 0.00   | 10 71.4%| 4 28.6% |         |         |
| Patient 2        |         |         |          |         |         |         |          |         |         |         |         |
| Control          | 0 0.00%  | 11 100% | 0 0.00%  | 0.00    | 0 0.00% | 11 100% | 0 0.00%  | 0.00   | 2 18.2% | 8 72.7% | 1 9.10%  | 0.673 |
| Intervention     | 0 0.00%  | 12 85.7%| 2 14.3%  | 0.00    | 2 14.3% | 12 85.7%| 0 0.00%  | 0.00   | 1 7.10% | 11 78.6%| 2 14.3%  |         |
| Patient 3        |         |         |          |         |         |         |          |         |         |         |         |
| Control          | 0 0.00%  | 4 30.8% | 9 69.2%  | 0.00    | 1 7.70% | 12 92.3%| 0 0.00%  | 1.000  | 3 23.1% | 9 69.2% | 1 7.70%  | 0.145 |
| Intervention     | 0 0.00%  | 2 15.4% | 11 84.6% | 0.00    | 0 0.00% | 13 100% | 0 0.00%  | 1.000  | 7 53.8% | 4 30.8% | 2 15.4%  |         |
| Patient 4        |         |         |          |         |         |         |          |         |         |         |         |
| Control          | 0 0.00%  | 0 0.00% | 10 100%  | 0.00    | 0 0.00% | 10 100% | 0 0.00%  | 0.00   | 1 10.0% | 9 90.0% | 3 25.0%  | 0.400 |
| Intervention     | 0 0.00%  | 0 0.00% | 12 85.7% | 0.00    | 0 0.00% | 12 85.7%| 0 0.00%  | 1.000  | 1 8.2%  | 8 71.4% | 1 14.2%  |         |
| Combined         |         |         |          |         |         |         |          |         |         |         |         |
| Control          | 10 16.4% | 31 50.8%| 10 16.4% | 0.689   | 5 8.20% | 46 75.4%| 10 16.4% | 0.321  | 8 13.1% | 32 52.5%| 21 34.4%| 0.656 |
| Intervention     | 11 17.2% | 26 40.6%| 14 21.9% | 20.3%   | 10 15.6%| 41 64.1%| 13 20.3% | 0.314  | 12 18.8%| 33 51.6%| 19 29.7%|         |

### Table V. Orthodontists’ treatment decisions.

|                  | Orthodontists’ treatment selection |
|------------------|------------------------------------|
|                  | Extraction | Orthognathic surgery | Camouflage treatment | Growth modification | No treatment selected |
|                  | N %        | p value               | N %                 | p value              | N %                 |
| Patient 1        | 4 26.7%    | 0.651                 | 0 0.00%             | 1.000                | 9 60.0%             | 0.021*               | 3 20.0%             | 1.000                | 4 26.7%             | 0.066               |
| Control          | 2 14.3%    | 0.00                  | 2 14.3%             | 0.047*               | 5 38.5%             | 0.697                | 5 38.5%             | 1.000                | 2 4.00%             | 0.00                |
| Patient 2        | 4 30.8%    | 1.000                 | 4 30.8%             | 0.047*               | 10 76.9%            | 0.350                | 9 76.9%             | 0.00                 | 1 10.0%             | 0.404               |
| Control          | 4 30.8%    | 1.000                 | 10 76.9%            | 0.00                 | 3 25.0%             | 1.000                | 3 25.0%             | 0.00                 | 1 10.0%             | 0.00                |
| Patient 3        | 3 30.0%    | 0.293                 | 3 30.0%             | 0.047*               | 3 30.0%             | 1.000                | 3 30.0%             | 0.047*               | 1 10.0%             | 0.221               |
| Control          | 7 70.0%    | 0.214                 | 5 50.0%             | 0.650                | 6 60.0%             | 0.00                 | 6 60.0%             | 0.650                | 1 10.0%             | 0.00                |
| Patient 4        | 5 38.5%    | 0.214                 | 7 53.8%             | 1.000                | 10 76.9%            | 0.00                 | 1 10.0%             | 0.00                 | 1 7.09%             | 1.000               |
| Control          | 17 27.9%   | 0.840                 | 11 18.0%            | 0.047*               | 28 45.9%            | 0.473                | 26 46.4%            | 0.720                | 8 13.1%             | 0.801               |
| Patient 5        | 16 25.0%   | 0.101                 | 20 31.3%            | 0.473                | 25 39.1%            | 0.720                | 30 53.6%            | 0.720                | 10 15.6%            | 0.801               |

*Denotes statistical significance at p<0.05.*
Treatment planning

Table V shows a summary of the orthodontists’ treatment planning decisions. Overall there was no statistically significant difference in the prescribed treatment between the two groups (Growth modification, $p = 0.720$; Orthognathic surgery, $p = 0.101$; and Extraction decision, $p = 0.840$).

Table V shows the breakdown of the treatment planning decisions for each patient. At the individual case level, there were statistically significant differences between the intervention and control groups in the prescribed treatment for patients 1, 3 and 4. For patient 1, there was a preference in the control group for camouflage treatment ($p = 0.021$), in patient 3 there was a preference for the intervention group to choose orthognathic surgery ($p = 0.047$) and in patient 4 there was a preference for the intervention group to choose growth modification ($p = 0.015$).

Discussion

The present randomised controlled trial was performed to determine if the LC radiograph influenced orthodontists’ ability to diagnose and treatment plan a variety of orthodontic cases. There was no statistically significant difference between the intervention and control groups in the diagnosis of any of the five patients or in the accuracy of diagnosis when compared with an expert panel. These results suggest that a lateral cephalometric radiograph provides little additional information over a thorough extra-oral and intra-oral clinical examination for orthodontists to determine a dental and skeletal diagnosis. These findings are consistent with previously reported studies.6,13-16 Durão et al.15 showed that the omission of the LC radiograph affected the diagnosis of orthodontists of less clinical experience; however, this is not supported by the findings of the present study in which the number of years the orthodontist had been practicing had no effect on diagnosis.

Earlier studies have found that the LC radiograph does not affect treatment planning decisions for many malocclusions.7,14,16-18 The findings of the present study revealed that, for the patient group overall, there was no statistically significant difference in the proposed treatment between the control and intervention groups; however, at the patient level, there were significant differences between the two groups for three patients.

The first case records presented an Angle’s Class I malocclusion on a mild Class II skeletal base accompanied by upper and lower arch crowding. The control group preferred a camouflage treatment plan and there were a significant number of orthodontists in the intervention group who did not select a treatment option. It is possible that the lower incisor angulation was an important contributing factor in deciding whether the crowding could be resolved with or without extractions. As it is often difficult to determine lower incisor angulation without a lateral cephalometric radiograph, this may have been the reason why a significant number of the intervention group found it difficult to select a treatment plan for this case.

The two other cases presented a Class II malocclusion on a Class II skeletal base and there was a difference in planning between the intervention and control groups in the selection of orthognathic surgery or a growth modification appliance. It is possible that the addition of the LC radiograph enabled the control group to more accurately ascertain the extent of the skeletal discrepancy when compared with clinical photographs alone, which then influenced the treatment decision.

The number of orthodontists who did not complete the survey was similar for both the control and intervention respondents. However, the majority of orthodontists (90.6%) in the intervention group felt that they would have preferred a lateral cephalometric radiograph as part of their diagnosis and treatment planning assessment. This was greater than the findings of a British study in which only two-thirds of surveyed orthodontists would have preferred a lateral cephalometric radiograph.14 A possible explanation might be that the United Kingdom has guidelines8 determining when a lateral cephalometric radiograph is appropriate but there are no specific guidelines in Australia.11 The results of the present study suggest that patients who require lateral cephalometry include those with a skeletal discrepancy or when a treatment is likely to involve significant labio-lingual movement of the incisors.

There were a number of limitations associated with this study. Orthodontists were required to make their diagnosis and treatment plan based on digital records. Whilst it is considered acceptable within the profession to diagnose and treatment plan from records, the omission of a direct patient exam and physical study models may be considered a departure...
from traditional everyday practice. The electronic survey was also optimised for mobile phone viewing to ensure easy completion in order to try to maintain a high response rate. This meant that the records were likely to have been evaluated on a small screen for some of the questionnaires, which could have been a source of bias.

Finally, the list of treatment possibilities was not exhaustive and some orthodontists may have preferred other treatment options. The questionnaire was, however, validated by an expert panel of orthodontists who felt that the limited, generalised selection of available treatment options covered the majority of mainstream orthodontic care. Additional research is recommended to examine the influence that the LC radiograph has on a larger sample of varying malocclusions. This would provide an improved understanding of the circumstances in which a lateral cephalometric radiograph may be required for accurate diagnosis and treatment planning.

Conclusion
The lateral cephalometric radiograph is not considered a requirement for routine orthodontic diagnosis; however, the radiograph may be useful in the treatment planning of cases in which there is a skeletal discrepancy or where significant labio-lingual movement of the incisors is required.

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