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An Audit of the Quality of Lateral Cephalometric Radiographs for Orthodontic Treatment

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ABSTRACT

It is not uncommon for lateral cephalometric radiographs to be outsourced for orthodontic treatment, as not all orthodontic clinics in Malaysia have their own cephalometric radiograph machine. Since the quality of outsourced radiographs is not within the governance of the clinician, there is a need to monitor the quality of cephalometric radiographs received. Aim: To audit the quality of lateral cephalometric radiographs received at the Orthodontic Specialist Unit, Klinik Pergigian Cahaya Suria, Kuala Lumpur, Malaysia. Methodology: Lateral cephalometric records of patients with registration numbers up to 200 in 2015 were selected and assessed using a light box. The quality of good radiographs were based on 15 parameters: correct head position; presence of the scale; important structures centered on the film; patient’s name; date taken; patient’s identifier; label not obscuring radiograph; soft tissue visible; teeth in occlusion; good contrast; ‘A’ point identifiable; ‘B’ point identifiable; nasion
identifyable; sella identifiable; incisors visible and their angulation measureable. Standard was set at 100%, as radiographs received should contain all parameters. Results: Five records were excluded (2 had no radiographs, 2 had digital radiographs, and 1 record could not be traced). 64.5% radiographs had all 15 parameters, 30.3%, 3.9% and 1.3% with 14, 13 and 12 parameters, respectively. Patient’s name, identifier, date taken, soft tissue visible, ‘B’ point identifiable, nasion identifiable were present in all radiographs (100%). Incisor visible and their angulation measureable were present in 99%; good contrast and ‘A’ point identifiable in 98%; presence of scale, important structures centred on films and sella identifiable in 97%, label not obscuring radiographs in 96%; correct head position in 86%; and teeth in occlusion in 88% of radiographs. Conclusion: There is a need to liaise with the radiology unit to improve the quality of radiographs taken. Keywords: audit, lateral cephalometric radiograph, quality, parameters

INTRODUCTION
Lateral cephalometric radiograph is used to aid orthodontic assessment and treatment planning (1). The lateral cephalometric radiograph shows not only the underlying craniofacial hard tissue structures but also the soft tissue profile. The quality of the lateral cephalometric radiograph is important because poor quality radiographs would increase the inaccuracy during tracing and measuring. Thus good quality radiographs could avoid the need to repeat the radiograph, which would otherwise induce unnecessary radiation exposure to the patient (1). In addition, if the orthodontic practice does not have an in-house lateral cephalometric machine, the patient would also have to travel to other centres that provide the
service to take the radiograph, incurring additional cost and inconvenience to the patient.

The criteria of a good image quality radiograph depend on several factors, including contrast, image geometry, characteristics of the x-ray beam and image sharpness and resolution (1). In 2000, the Faculty of Dental Surgery, Royal College of Surgeons of England (RCSEng) proposed a guideline for good quality lateral cephalometric radiographs. The RCSEng suggested 13 parameters of a good quality lateral cephalometric radiograph, which include correct head position, important structures centered on the film, name and hospital number recorded, label not obscuring radiograph, soft tissue visible, teeth in occlusion, good contrast, ‘A’ point identifiable, ‘B’ point identifiable, nasion identifiable, sella identifiable, incisors visible and their angulation measurable (2).

These parameters are important landmarks in lateral cephalometric radiographs because:

i) Correct head position: The natural head position is a standardized and reproducible position of the head in an upright posture. The eyes focused on a fixed point in the distance at eye level (3, 4). This position complements the extra-oral assessment and the reproducibility is considered as clinically consistently acceptable (5).

ii) Important structures centered on the film: This will ensure that all selected landmarks can be used for the diagnosis and treatment planning.
iii) Name and hospital number: All the lateral cephalometric radiographs must have patient’s identifier to prevent misplacement of the lateral cephalometric radiographs and exchange with other patients.

iv) Good contrast: It will ensure the visibility of all the important landmarks.

v) Soft tissue visible: Soft tissue analysis enhances the maintenance of normal facial traits as the abnormal characteristics are corrected with orthodontics and surgery treatment (6).

vi) ‘A’ point: It is the deepest point on the curvature of the surface of the maxillary bone between anterior nasal spine and the alveolar crest of the upper central incisor (7). It is an important point to determine the position of the maxilla sagittally in relation to the cranial base.

vii) ‘B’ point: It is the most posterior point to a line from infradentale to pogonion on the anterior surface of the symphisisial outline of the mandible (7). It is an important point to determine the position of the mandible sagittally in relation to the cranial base.

viii) Nasion: It is positioned at the junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose (7). The position of nasion may influence the measurements of SNA, SNB and ANB (8).

ix) Sella: It is the center of the pituitary fossa of the sphenoid bone (7). This landmark is located within the craniofacial region and is used to measure the positions of maxilla and mandible in relation
to the cranium and to themselves (9).

x) **Incisors visible and their angulation measurable:** The evaluation of maxillary and mandibular incisor inclination is an important aspect of orthodontic treatment planning, assessment of treatment progress, as well as determination of treatment outcome (10).

The Orthodontic Specialist Unit, *Klinik Pergigian Cahaya Suria* is one of the busiest government orthodontic units in Kuala Lumpur. The clinic is based in *Bangunan Cahaya Suria*, Kuala Lumpur and comprised of two floors that accommodate the general dental practice and specialist units, which are the orthodontic, restorative and periodontal specialist units. However, since it is also one of the oldest government dental clinic in Klang Valley, there is little room for further extension. The clinic could not accommodate for a lateral cephalometric machine due to lack of space. Therefore, these radiographs are outsourced to the nearest government–based radiology centre, which is within the Hospital Kuala Lumpur (HKL). It was noted that some of the radiographs received were not satisfactory to the orthodontists. Thus there was a need to audit the radiographs received.

At present, there has been no audit on the quality of the lateral cephalometric radiograph received at the Orthodontic Specialist Unit, *Klinik Pergigian Cahaya Suria*. Therefore, the aim of this study is to investigate the quality of lateral cephalometric radiograph received by this orthodontic unit.

**AIMS AND OBJECTIVES**
• To investigate the percentage of lateral cephalometric radiographs that fulfilled the standard of good quality lateral cephalometric radiographs.
• To identify the parameters of the radiographs that did not achieve the standard.

The standard of a good quality lateral cephalometric radiograph was set at 100%, which have fulfilled all the required parameters.

MATERIALS AND METHODS
This retrospective audit was carried out at the Orthodontic Specialist Unit, Klinik Pergigian Cahaya Suria, Kuala Lumpur. Pre-treatment lateral cephalometric radiographs were selected from the first 200 patients registered in the year 2015. The registration numbers were coded from 1/15 to 200/15 in the year 2015. The lateral cephalometric radiographs were assessed using a light box in a dark room. Each cephalometric radiograph was assessed once by an orthodontist.

The parameters of lateral cephalometric radiographs that were assessed and recorded are as follows:
1. Correct head position
2. Important structures centered on the film
3. Name
4. Registration number recorded (Presence of patient identifier)
5. Label not obscuring radiograph
6. Soft tissue visible
7. Teeth in occlusion
8. Good contrast
9. ‘A’ point identifiable
10. ‘B’ point identifiable
11. Nasion identifiable
12. Sella identifiable
13. Incisors visible and their angulation measureable

Two further parameters were included, which were the date of lateral cephalometric tracing taken and presence of the lateral cephalometric radiograph scale.

Figure 1 shows an example of the parameters identified on a lateral cephalometric radiograph. All parameters except for registration number were assessed on the radiographs. The registration numbers were determined by labels placed by the dental surgical assistants (DSA) at the orthodontic unit.

Inclusion Criteria
Since the Radiology unit of Hospital Kuala Lumpur (HKL) was the main and nearest radiology centre for patients from this orthodontic clinic to take their radiographs, only pre-treatment lateral cephalometric radiographs taken from this hospital were included.

Exclusion criteria
To prevent outliers, radiographs from other institutions (referral cases), absent lateral cephalometric radiograph, and radiographs of patients who had been discharged were excluded.

The audit was registered with the National Medical Research Registration (NMRR-15-2248-24892).
RESULTS
Out of the 200 cases, 172 fulfilled the inclusion and exclusion criteria. More than half (60.5%) had fulfilled all 15 parameters, followed by 33.7% with 14 parameters, 5.2% with 13 parameters and 0.6% with 12 parameters.

Table 1 presents the outcome of the audit. The most common reasons for not fulfilling the standard were incorrect head position (23.3%) and
teeth not in occlusion (15.7%). About 1.7% had labels obscuring the radiographs while 1.2% had missing scale and identifiable sella. Five criteria were satisfactorily fulfilled in all cases. These include presence of the date taken and patient identifier, soft tissue visible, ‘B' point, and nasion identifiable. The rest of the criteria only had 1 radiograph (0.6%) that did not fulfil the requirement. Of the 172 radiographs, none were repeated. Figure 2 shows some examples of the missing criteria.

Figure 2. Lateral cephalometric radiographs with missing criteria
Table 1. Prevalence of the criteria that was fulfilled or did not meet the requirements for good quality lateral cephalometric radiographs

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Fulfilled criteria</th>
<th>Did not fulfil criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Head Position</td>
<td>132 (76.7%)</td>
<td>40 (23.3%)</td>
</tr>
<tr>
<td>Presence of Scale</td>
<td>170 (98.8%)</td>
<td>2 (1.2%)</td>
</tr>
<tr>
<td>Important Structures Centred on Film</td>
<td>171 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>Presence of Patient’s Name</td>
<td>171 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>Presence of Date Taken</td>
<td>172 (100%)</td>
<td></td>
</tr>
<tr>
<td>Presence of Patient Identifier</td>
<td>172 (100%)</td>
<td></td>
</tr>
<tr>
<td>Label Not Obscuring Radiograph</td>
<td>169 (98.3%)</td>
<td>3 (1.7%)</td>
</tr>
<tr>
<td>Soft Tissue Visible</td>
<td>172 (100%)</td>
<td></td>
</tr>
<tr>
<td>Teeth in Occlusion</td>
<td>145 (84.3%)</td>
<td>27 (15.7%)</td>
</tr>
<tr>
<td>Good Contrast</td>
<td>171 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>A Point Identifiable</td>
<td>171 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>B Point Identifiable</td>
<td>172 (100%)</td>
<td></td>
</tr>
<tr>
<td>Nasion Identifiable</td>
<td>172 (100%)</td>
<td></td>
</tr>
<tr>
<td>Sella Identifiable</td>
<td>170 (98.8%)</td>
<td>2 (1.2%)</td>
</tr>
<tr>
<td>Incisor Visible and Their Angulation Measurable</td>
<td>171 (99.4%)</td>
<td>1 (0.6%)</td>
</tr>
</tbody>
</table>
DISCUSSION

Lateral cephalometric radiograph shows the skeletal structures in two-dimension. The evidence on the role of the cephalometry in orthodontic treatment planning has been a subject of debate (11) but it is still a common practice for orthodontists to have it reviewed prior to treatment planning. Since the field of view involves vital organs of the head and neck, it is important to ensure that high quality radiographs are taken only when needed to justify the radiation exposure. Poor quality radiographs may be unsuitable for diagnosis and treatment planning. Both clinicians and radiographers have the ethical obligation to ensure that the quality is monitored periodically.

In this audit, the authors added 2 parameters, which were 1) presence of the scale and 2) date of when the lateral cephalometric radiograph was taken, on top of the 13 parameters of important quality criteria recommended by the RCSEng. The scale of the lateral cephalometric radiograph should be standardized, to ensure the accuracy of lateral cephalometric radiograph measurements and to calculate the magnification of the structures on the radiograph. The error inherent in radiographic magnification is too great to be ignored (12). In addition, the date of the radiograph was included as another parameter because it records the information related to the timeline of patient’s treatment. It is possible that these two parameters were not included in the RCSEng guideline due to the assumption that the radiographic machine used in the United Kingdom would have these two parameters incorporated within the setting, while the radiographic machine in some Malaysian centres may not have similar function. Thus, these parameters were included in this study as parameters to assess the quality of cephalometric radiographs.

This is the first audit conducted at this orthodontic unit to assess the
quality of the lateral cephalometric radiographs received. Only 60.5% of the radiographs achieved the standards of this audit, which were based on the criteria set by the RCSEng (2). The information may not have been disseminated outside of the United Kingdom and the radiographers at the hospital may not be aware of these criteria.

Although some of the radiographs did not fulfil all criteria, none of the patients were sent back to repeat the procedure. Under such circumstances, the clinicians are faced with the dilemma that if radiographs should be retaken, the patients would be subjected to additional radiation exposure, in addition to inconvenience for having to travel back to the radiology centre. The lateral cephalometric radiographs in this audit that did not fulfil all criteria were still deemed acceptable by the orthodontists. Orthodontists were still able to devise treatment plans for the patients based on the available data obtained from the radiographs received. It may be assumed that the radiographic information was used to aid the diagnosis process, while decision for treatment planning must still be based on clinical investigation, assessment of the available data from all diagnostic tools, as well as clinicians’ experience and expertise. This concurs with the outcome by Durao et al, (2015) who found that the majority of Portuguese orthodontists perceived that lateral cephalometric radiographs alone did not seem to influence their orthodontic treatment planning, although its use is still important to aid this process (13).

In this audit, incorrect head position and teeth that were not in occlusion were the parameters that were mostly not adhered to. Failure to comply to this standard criteria may affect the quality of the lateral cephalometric radiographs, as correct (in natural) head position
(NHP), is recognised as the basis of cephalometric analysis (14), where it has been shown to be the most accurate and reproducible head position (5). Using NHP, facial planning can be based directly on the face and is not influenced by the cranial base variability. NHP (not Frankfort plane) is the head position which most patients use habitually. True mandibular position can be recorded if the cephalometric radiograph is taken at NHP with centric relation wax bite in place (15). Inconsistency in the yaw and roll of the head position would affect the superimposition of the bilateral landmarks, making it harder to be identified, while the antero-posterior assessment would be influenced by incorrect pitch position.

Orthodontic assessment is usually done in intercuspal position, unless there is mandibular displacement. The cephalometry should reflect the clinical assessment. When the teeth are not in occlusion, the mandible would rotate backwards. This will cause the ‘B’ point to displace more posteriorly and increase the ANB value, making the patient appears to have a more retruded mandible. The menton would also be displaced vertically downwards, affecting the vertical relationship, making the patient to appear more high angled, as the Frankfurt–mandibular plane angle or maxillary–mandibular plane angle are increased or seem to have a higher lower anterior face height ratio than he/she actually has. Few occasions would cause the cephalometry to be taken with the teeth apart, such as in open bite cases where the occlusion truly does not meet or when there is more than 2mm mandibular displacement. The latter may be requested by the clinician in such cases as previous study had recommended the mandible to be positioned in centric relation for correct orthodontic diagnosis (16). In this audit, none of the cephalograms were requested with the patient in retruded contact position since none of the cases had patients with
more than 2mm mandibular displacement, and did not include patients with anterior open bite.

Two of the lateral cephalometric radiographs did not have the scale but the lateral cephalometric radiographs were not repeated because angular measurements would not be affected by the absence of the scale. However, it should be noted that the magnification of the linear measurements had to be assumed based on other radiographs received from the same outsourced hospital.

The authors felt that there is a need to liaise with the radiology unit to have an improved quality of radiographs taken by radiographers at the hospital. Such liaison may include conducting a local audit meeting between the two units to discuss methods to improve the quality of lateral cephalometric radiographs. For example, to improve the correct head positioning procedures, instructions for proper positioning should be reaffirmed to the radiographers, who may be restricted with time constraints in busy radiology units. The clinical staff including the orthodontists, nurses and DSA from the orthodontic unit could make it a routine procedure to explain and inform the importance of taking lateral cephalometric radiographs to the patients before sending them for the lateral cephalometric radiograph. They can instruct or demonstrate to the patients the proper way to position themselves when the radiograph is taken. A checklist may also be prepared to guide radiographers with the important criteria to be achieved in producing good quality lateral cephalometric radiographs. When the patient is positioned at the lateral cephalometric machine, the radiographers may ensure that the correct positioning of the patients’ head based on the NHP. Some machines may have light beam markers
that may aid to confirm the head position. In addition to the positioning of head, concerns over the amount of radiographic exposure need to be taken into account, especially on younger patients who constitute the major patient pool for orthodontic treatment at this specialist dental unit. The appropriate use of paediatric settings and collimation should be recommended when taking cephalograms for younger patients (17).

CONCLUSION
Only 60.5% of radiographs fulfilled the standard set of criteria consisting of all 15 parameters. Since this was the first audit to be conducted at this orthodontic unit, a re-audit is recommended after steps are taken to establish and implement the recommended criteria.

RECOMMENDATIONS
i. To liaise with the radiographic unit in establishing a standardised criteria in radiograph–taking, aimed at improving the quality of radiographs taken by radiographers at the radiology unit of Hospital Kuala Lumpur, and any radiology centre.
ii. To train radiographers at the radiology unit of Hospital Kuala Lumpur, any radiology centre to correctly position the patients for taking lateral cephalometric radiographs.
iii. To train staff at the orthodontic unit to explain and inform the importance of taking lateral cephalometric radiographs correctly before sending the patient to external radiology centres for taking of lateral cephalometric radiograph.
iv. To repeat the audit for the quality of the lateral cephalometric radiographs after one year of intervention.
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