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Do We Really Know Where the Molar Teeth are on the Lateral Headfilm? A Recommendation for a More Precise Way to Locate the Molars on the Lateral Headfilm

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Abstract

Objective: The aim of this study demonstrates an improved method for determining the exact molar positions on the lateral headfilm. Previously this position was located by visual inspection of the headfilm. We are testing the precision of visual determination compared to using occlusogram measurements. Materials and Methods: In a sample of 34 subjects treated for Class II malocclusion, we examined the pre and post treatment headfilms and compared molar positions determined by visualization with occlusogram measurements. Results: Our data showed that in 15% of the cases there were no differences between the two methods, in 50% the differences were 1 mm or greater. In 10 % of the subjects this difference was between 4 and 5 mm. Conclusion: Our conventional way of determining the exact position of the posterior teeth on a lateral headfilm is insufficient and in some case imprecise. Using occlusogram to locate molars indirectly can provide a more reliable and precise technique for evaluating molar movements on the lateral headfilm.

Keywords

structural superimposition; metallic implant analysis; occlusogram analysis; molar location

Original Article

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Materials and Methods: In a sample of 34 subjects treated for Class II malocclusion, we examined the pre and post treatment headfilms and compared molar positions determined by visualization with occlusogram measurements.

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Conclusion: Our conventional way of determining the exact position of the posterior teeth on a lateral headfilm is insufficient and in some case imprecise. Using occlusogram to locate molars indirectly can provide a more reliable and precise technique for evaluating molar movements on the lateral headfilm. ***(Taiwanese Journal of Orthodontics. 30(1): 04-11, 2018)***

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INTRODUCTION

In the process of analyzing facial growth and treatment changes in their orthodontic patients, the orthodontist often has difficulty in locating the first molars precisely on the lateral cephalometric headfilm. Most clinicians have in the past determined the position of these teeth by visualizing the molars on the x-ray, and found that in some instances this was difficult, for several reasons. Sometimes the left and right molars would be at different mesio distal positions either in the maxilla or mandible or both, in other cases there would be a vertical difference between the teeth of the two sides. In some cases, one molar would appear smaller than the other due to rotation of the tooth, all adding to difficulty in precisely locating the teeth. To determine how often these errors

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are present and to what degree the teeth are incorrectly located, no study so far seems to have reported. This is a common problem but could be important when reporting on treatment outcomes. With this concern for accuracy in molar location we conducted a study of treated cases where both pre and post treatment headfilms were available.

From the studies of facial growth, using metallic implants by Björk (1963) we know that he recognized the problem with precise molar location early on.[1] When analyzing his patients' growth changes over time, Björk found that he needed a more precise method for location the tooth position than just visualizing the teeth on the headfilm. To better be able to locate the teeth he developed a technique where he projected the study cast onto a flat surface on a table and traced the outlines of the teeth. He also made sure that the magnification of the traced casts matched the magnification of the headfilm tracing, to more precisely analyze the changes. Later, as Björk and Skieller (1983) developed this technique more practically to use a regular flatbed scanner to analyze clinical orthodontic patients. Where Björk used the metallic radiographic markers to precisely analyze the growth changes and tooth movements, later a so-called "structural superimposition" was proposed when analyzing the changes in the molar tooth positions during treatment.[3] Two examples from Björk's studies seen in Figure 1 demonstrate the differences in tooth movements where the superimpositions are made on metallic implants in the mandible.[1] In the case seen in Figure 1A, the teeth migrate mesially and the incisors tip forward during the observation period. In the other case 1B the posterior teeth erupt vertical and the incisors also erupt vertically and retrocline. To determine such differences in tooth movements precisely, an accurate method for locating the molar teeth is necessary.

Based on the perceived need for an accurate technique for determining the exact position of the first molars on the lateral headfilm, we performed a study comparing the precision of locating the molars on the lateral headfilm by visually locating the teeth, and by using measurements of scanned the study casts, following the recommendations by Björk et al.[4]

METHODS AND MATERIALS

The sample for our study included cephalometric headfilms and study casts of 34 subjects with Class II malocclusion. The sample originated from a previous study of the dental and skeletal effects of the *Teuscher* high-pull headgear appliance.[5] The original materials included pre and post treatment records of 40 patients with Class II, Div. 1 malocclusions. In 6 patients the headfilms were not of sufficient quality to allow the molar positions to be precisely determined, so they were excluded from this study. The models and headfilms for each patient were all taken at the same time point. We used both the pre and post treatment lateral headfilms of the subjects, and then hand traced all headfilms and model scans on matte acetate.

The study casts were first scanned on a flatbed scanner, where a ruler had been placed next to the models to ensure no magnification was present in the scanned images of the teeth, and then traced manually on matt acetate. The distance, indicated by lines (Figure 2), placed at the incisors and at the mesial of the first molars and at right angles to the midline, was measured to determine the molar position. In the maxilla the midline was the raphe median plane. If there was less than half a cusp difference between the molars on the left and right side this difference was divided and the mean value used. However, in cases where there was more than half a cusp the difference both sides were measured and marked on the headfilm tracing and then both molars were traced. The measurements of the scanned casts were performed before tracings were made and corrected for magnification, which in these head films was 5.6 %.

Figure 1A

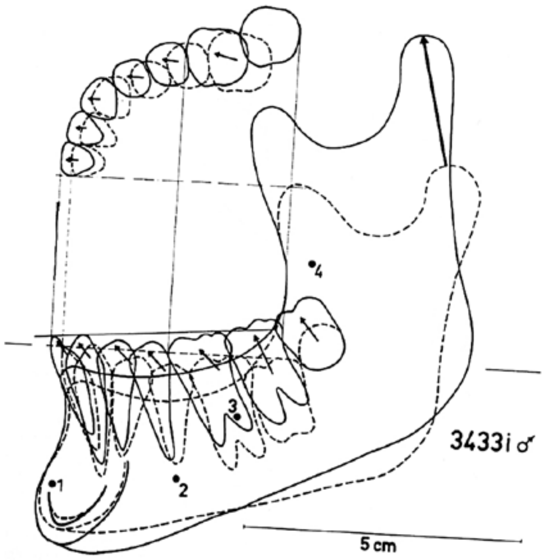

Figure 1B

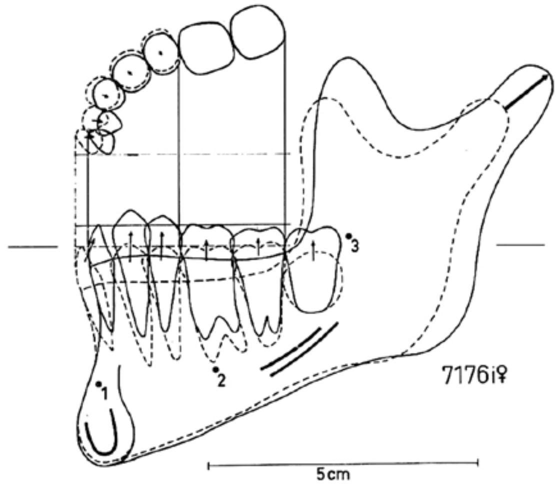

Figure 1. *From Björk, A. Variations in the growth pattern of the human mandible: Longitudinal radiographic study by the implant method. J. Dent. Res.: 42; 400, 1963. Two examples of mandibular growth and tooth movement from Björk 1963. The cases demonstrate differences in modeling of the mandible during the six-year growth period around puberty shown.*
A. *shows upward forward condylar growth with mesial migration of the posterior teeth and proclination of the incisors.*
B. *Shows upward and backward condylar growth with vertical eruption of the posterior teeth and retroclination of the incisors.*

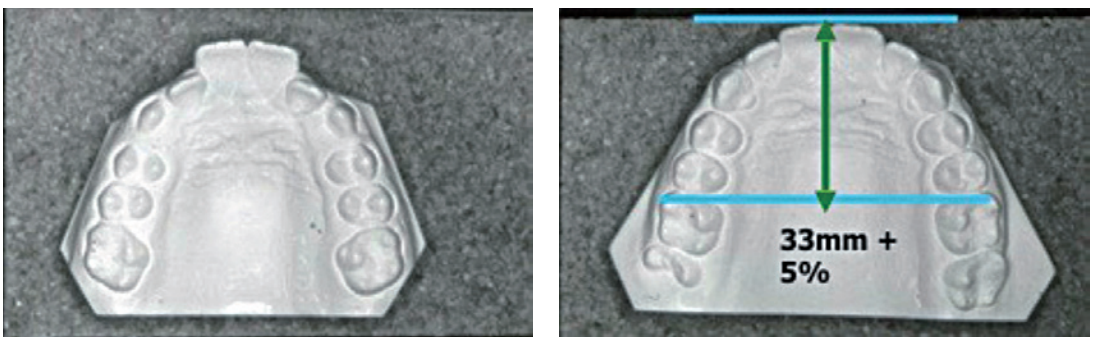

Figure 2. *Scanned study casts before and after treatment. The first molar position on the lateral headfilm is determined by the distance between a tangent to the incisors and the first molars both at right angles to the midline. The measurement is then adjusted for magnification.*

In order to simplify the tracings only a limited number of structures in maxilla and mandible were included (Figure 3). The tracings included the crowns and tooth axis of the upper and lower incisors, the initial occlusal plane as well as the mesial surface of the first molars traced with direct visualization or derived from the number of incisor to molar from occlusogram. For each case, the tracings were superimposed for each method and the differences between direct and visualized were calculated. The same procedures were repeated with a new set of tracings post treatment.

The measurements with numbers being run down to nearest 0.5 mm, were repeated twice a week apart and no significant differences were noticed. Numbers of differences were subjected to two-tailed t test. A *p* value less than 0.05 was set as statistical significance.

We then constructed a graphic representation of the difference between direct and indirect determination of the molars position in the form of a percentile graph where each individual was represented by a vertical bar (Figure 4A, 5A). Data had been rearranged with respect to the difference being either in a distal or a mesial direction (Figure 4B, 5B).

The study tracings of two patients and their pre and post treatment headfilms were shown in (Figure 3). They were superimposed on stable structures in the anterior and median cranial base but the molar was located using different methods: from occlusogram measurement or visualization. A case seen in Figure 3A showed the molar movements during treatment and here the molar position was determined by measurements of the occlusogram. The tracing seen in Figure 3B showed a patient where

Figure 3A ***Figure 3B***

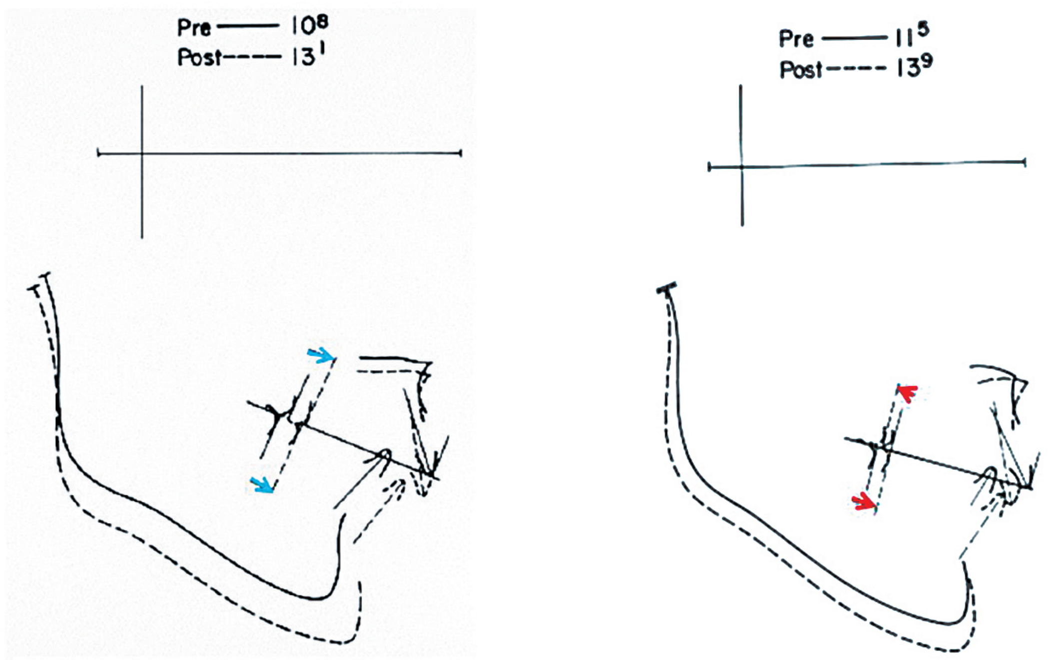

Figure 3. *Simplified tracings used for analysis show the tooth movements during orthodontic treatment with functional appliances with two different molar location methods.* ***A.*** *A case shows the molar change when the movements were measured and projected on to the cephalogram, and mesial movements of the molars are seen.* ***B.*** *Movements of the molars in this case were determined by visualization. Distalization of upper molars was an unrealistic distal movement as these teeth were not actively distalized in the maxillary arch during treatment.*

Figure 4A

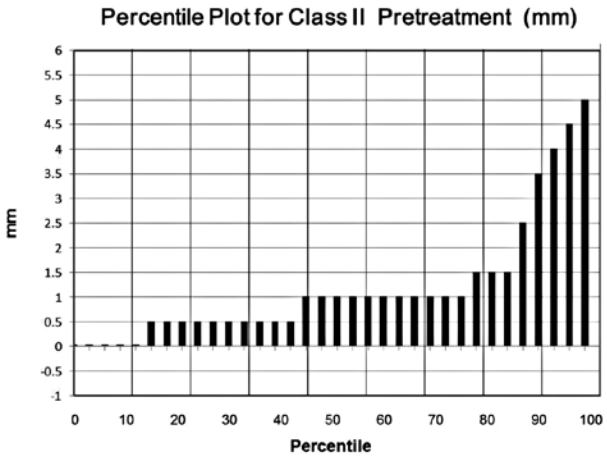

Figure 4B

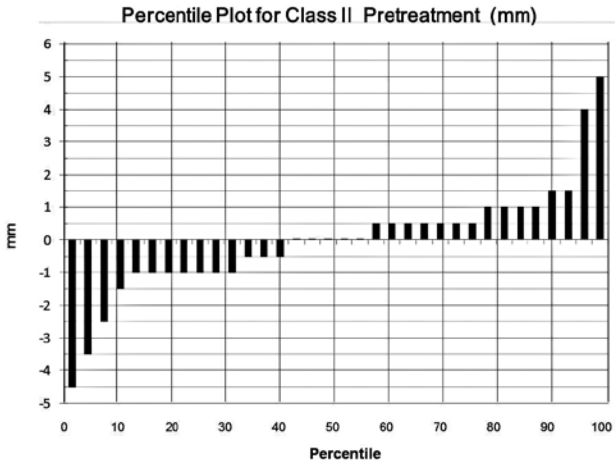

Figure 4. A. *Percentile plots showing individual differences in molar position between visual and the measured position based on occlusograms irrespective of direction before treatment.* ***B.*** *shows the same data arranged with respect to direction of the differences.*

Figure 5A

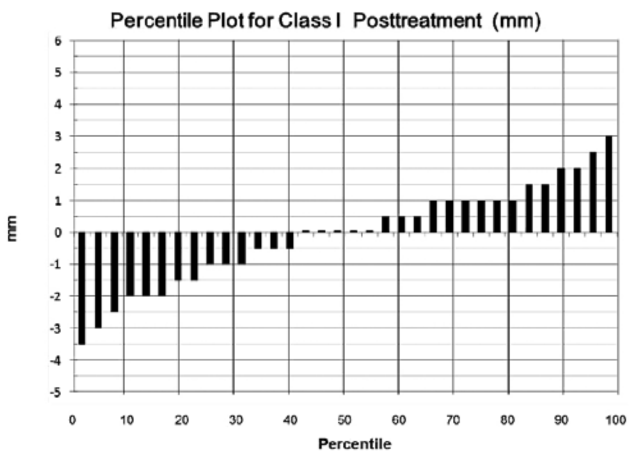

Figure 5B

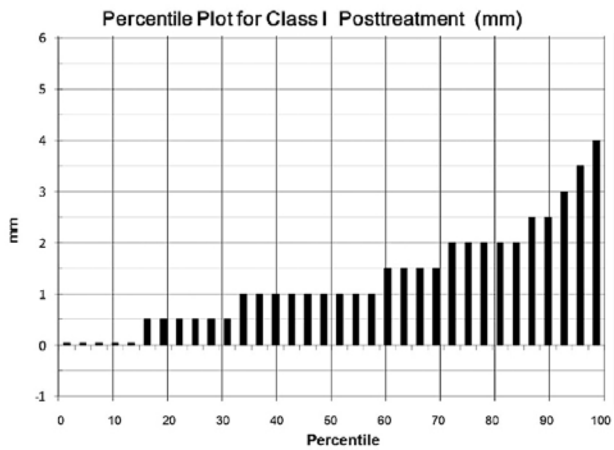

Figure 5. A. *Percentile plots of differences between visual and measured determination in first molar position after treatment.*
B. *The same data arranged with respect to direction of the differences.*

Figure 6A

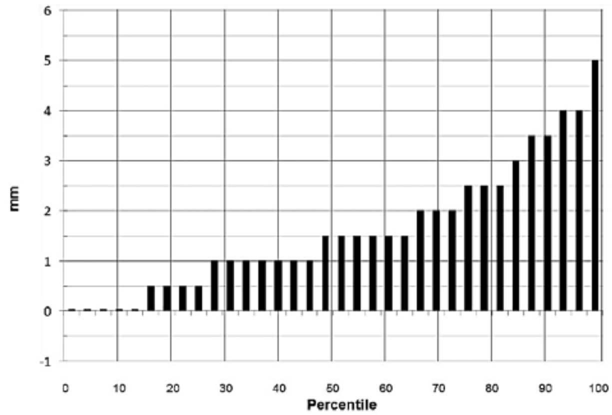

Figure 6B

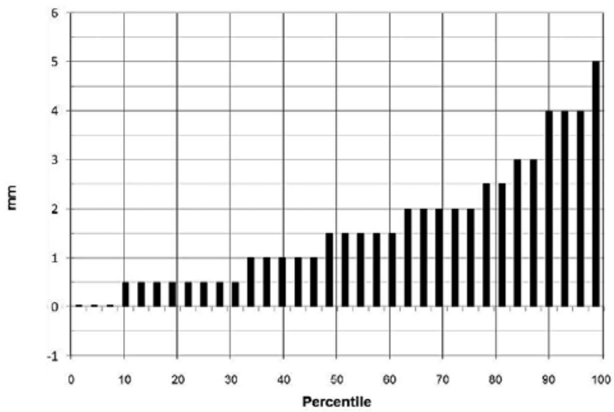

Figure 6. *Percentile plots of molar movements in maxilla* ***(A)*** *and mandible* ***(B)*** *during treatment.*

the molar movement was visualized and revealed the molar movement in the maxilla was incorrectly in a distal direction which could not possible be with the treatment mechanics used. By measuring the tracings, made for each of the two techniques, we then determined the differences between direct observation and the measured position of the molars before and after treatment (Figure 6). Numbers were arranged as for maxilla and for mandible and subjected to two-tailed t test. A *p* value less than 0.05 was set as statistical significance.

RESULTS

The visualized molar positions on the pre-treatment tracings were indeed different from the calculated molar positions (mean ± SE = 1.18 ± 0.22, $p < 0.0001$, 95% confidence interval: 0.73-1.62). Our pretreatment data from the 34 Class II cases showed that in about 15 percent of the patients there was no difference between the direct and indirect molar location (Figure 4A). In about 40% of the patients, however, the difference was greater than 1 mm. In 10% of the cases this difference was as much as 3-5 mm. It was important also to determine if this difference was only in one direction, so the data was reorganized into cases in which the difference was in a mesial direction or in a distal direction. The results in Figure 4B show that the differences between direct versus indirect molar location and the effect on the Class II molar relationship are similar in both mesial and distal direction, suggesting these errors are true differences. As the distribution shows it was equally divided between the two, there was no directional bias. The differences of molar positions on the post treatment tracings, after a Class I occlusion had been achieved, were also significantly different between these two methods (mean ±SE = 1.28 ± 0.17, $p < 0.0001$, 95% confidence interval: 0.93-1.63). The variations were shown in detail (Figure 5A, B). Here again we found that the differences between direct and indirect molar location were evenly distributed in terms of error towards either the mesial or the distal.

Finally, we looked at the differences in molar movements in the maxilla and mandible between the two techniques during treatment (Figure 6A, B). Our results showed that the errors seem to accumulate in locating the molars from two tracings in maxilla (mean ±SE = 1.60 ± 0.22, $p < 0.0001$, 95% confidence interval: 1.15-2.06) and in mandible (mean ±SE = 1.60 ± 0.22, $p < 0.0001$, 95% confidence interval: 1.15-2.05) when treatment effects were evaluated. More importantly, the error is 1.5 mm or greater in about 50% of the patients.

DISCUSSION

This study was intended to provide evidence for the fact that our conventional way of determining the exact position of the posterior teeth on a lateral headfilm is insufficient and in some case imprecise. Using occlusogram to locate molars indirectly provides a more reliable and precise technique for evaluating molar movements. In this study we examined the differences between these two methods using the same set of data, we found that the error is considerable for a number of patient's headfilms when visualizing the position of these teeth. Either in pre- treatment or post treatment, maxilla or mandible, for about half of the chances, there is at least 1 mm difference, and the extreme value seen is 5 mm. The errors would also accumulate to higher values when treatment effects need to be evaluated from two tracings (pre and post treatment) in Figure 6. For 1.5 mm and above, 50% of the cases carry this amount of difference. This would warrant our precautions.

Björk recognized this problem many years ago in his early studies of facial growth and tooth movement.[1-3] He therefore developed a technique for locating the teeth precisely based on scanned study casts. Björk found that the solution to the problem of determining correct tooth positions was to make occlusogram tracings of the study casts and trace the outlines of the teeth, and after correcting for magnification relate these tracings to the lateral headfilm tracing. Later the hand tracings have been replaced by scanning the study casts.[4]

There is ample evidence in the literature that demonstrate that previous techniques are inadequate in providing reliable information about the precise tooth movements, and it is our contention that the introduction of occlusograms is a more precise technique for determining the actual positions and movements of the teeth.[6,7]

As the statistics of our data was shown to reach statistical significance, the data variations also warrant our daily clinical analysis based on visualization of molar positions. Our results showed differences of ≥ 3 mm in about 10% of the patients, and smaller differences ≥1 mm in about 50% which are all above our reliability of cephalometric measurement (0.5 mm). The most common source of error is incorrect head position in the cephalostat, where even a slight head rotation can result in left and right differences, or double contours, of the molars. Tilting of head in the cephalostat can similarly result in vertical differences that make correct molar location difficult. Poor image quality with blurred images of the teeth is another source of problems, and slight head movements during the exposure can further add to difficulty in molar location. Therefore, using direct visualization for molar location on a lateral headfilm is not reliable when 1 mm error was present at least in more than half of the measurement. This amount of error would accumulate and make differences in evaluating most orthodontic tooth movement in individual clinical cases questionable.

Our preliminary study supports the recommendation that a reliable way of determining the precise position of the molars in both maxilla and mandible is to use occlusograms made by scanning the study casts. On the occlusogram the distance from the incisors to the mesial of the first molars is measured and this measurement is then corrected for magnification. This measurement is then transferred to the headfilm tracing and the mesial of the molars is marked on the occlusal plane. The tracing is then superimposed on the actual headfilm, or image thereof, and the molar can now be traced with the appropriate inclination as seen on the headfilm but in the correct mesio-distal location. In the current 3D era, molar positions can be easily identified on scanned models and located on the CBCT images and superimposition of CBCT images can provide undistorted evaluation of molar positions in all three planes of spaces. However, not all patients have CBCTs taken as part of the routine orthodontic records as we have to follow ALARA (As Low as Reasonably Achievable) on radiation safety principles. Analyzing and measuring treatment changes on 3D images require a great amount of extra effort and a very time consuming. Alternatively, intraoral direct scanning of the teeth, or scanning of the dental casts can provide and easy way to measure the molar position relative to the incisors. The measurements can be then be transferred to the lateral cephalometric headfilm tracing, and the molars precisely marked. Whether molar positions are derived either from 3D or 2D image would in any case make our clinical analysis more accurate, however, further and more thorough studies are encouraged.

** Correction for magnification is only needed if conventional headfilms are used, when using digital headfilm or a lateral headfilm formatted from a CBCT no adjustment is needed.*

CONCLUSIONS

Our conventional way of determining the exact position of the posterior teeth on a lateral headfilm is insufficient and in some case imprecise. The differences between locating the molar teeth visually teeth and indirectly by using measurements of occlusograms are variable and reached clinical significant level in evaluating these growing cases. Our results showed differences of 2.5 mm ≥ in about 10% of the patients, and smaller differences 1.5 mm ≥ in about 50% for locating molars when treatment changes were compared in two tracings in growing patients. As our data was based on a fairly limited number of cases; we recommend that further studies should be conducted on larger samples.

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