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ORIGINAL

USEFULNESS OF PANORAMIC RADIOGRAPHIC FINDINGS FOR INEXPERIENCED OBSERVERS IN DIAGNOSING CLEFT PALATE IN PATIENTS WITH CLEFT ALVEOLUS

CHIAKI KUWADA[1)], TAKESHI FUJII[1)], YUKIKO IWASE[1)], NATSUHO TAKATA[1)], KOICHIRO TABATA[1,2)], AKI KIRIDOSHI[1)], TAKUMA KINOSHITA[1)], YOSHITAKA KISE[1)], MIZUHO MORI[1)], MUNETAKA NAITO[1)] AND EIICHIRO ARIJI[1)]

[1)] *Department of Oral and Maxillofacial Radiology, School of Dentistry, Aichi Gakuin University, Nagoya 464-8651, Japan*

[2)] *Department of Community Oral Health, School of Dentistry, Asahi University, Gifu 501-0296, Japan*

ABSTRACT

The aim of this study was to verify the usefulness of radiographic features for diagnosing the presence or absence of cleft palate (CP) in patients with unilateral cleft alveolus (CA) on panoramic radiographs. The two features investigated were 1) the upper line in the palatal region formed by the junction between the nasal septum and the nasal floor, and 2) the medial inclination of the lateral incisor.

Two dental residents assessed 100 panoramic radiographs before and after attending a lecture on the two characteristic features for determining which CA patients had CP. The area under the curve of the combined results of the two dental residents was significantly different before and after the lecture (0.66 and 0.78, respectively). The two features were verified as useful in the diagnosis of CP in patients with CA on panoramic radiographs.

Key words: cleft palate, panoramic radiographs, diagnosis

INTRODUCTION

Cleft lip and palate is a frequently-observed congenital condition in the maxillofacial region, with an incidence of approximately 1 case per 700 newborns[1,2)]. For patients with a cleft alveolus (CA), a bone graft is generally required after the maxilla has grown enough to withstand the surgery[3,4)]. Therefore, physical examinations and imaging are performed at regular intervals. Panoramic radiography is the most commonly used imaging modality because of its low radiation exposure and low cost compared with computed tomography (CT) and cone-beam CT (CBCT).

Various classifications of cleft status are reported depending on the location of the cleft[5)], usually based on physical examinations together with reference to three-dimensional images. However, oral and maxillofacial radiologists routinely prepare reports from clinical images, predicting patients' physical characteristics from the images without any physical examination.

Although CA is easily detected on panoramic radiographs, diagnostic criteria based on distinct image findings have not been established to differentiate CA patients with cleft palate (CP) from those without CP on panoramic radiographs. In a previous study, we analyzed panoramic findings focusing on the differences between CA patients with and without CP[6)]. On panoramic radiographs of a healthy subject taken at ordinal head position with the Frankfort horizontal plane parallel to the floor, two horizontal lines (the upper and lower lines) can be observed in the palatal region[7,8)]. The upper line is formed mainly by the junction of the nasal septum and the nasal floor, together with the posterior

Corresponding author at: Chiaki Kuwada, Department of Oral and Maxillofacial Radiology, School of Dentistry, Aichi Gakuin University
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part of the hard palate and the nasal floor, while the lower line is formed by the junction of the lateral nasal wall and nasal floor[9,10]. Taking these anatomical features into account, the upper line may be different in patients with CP. The upper line was clearly visible in 83% of unilateral CA patients without CP and in 88% of bilateral CA patients without CP, while it was obscure or invisible in all unilateral CA patients with CP and 90% of bilateral CA patients with CP (Figure 1)[6]. Additionally, the proportion of patients with medial inclination in the affected side maxillary lateral incisor was higher in unilateral CA patients with CP than in those without CP. These findings were expected to be effective for differentiation between CA with CP and CA without CP. However, the efficacy of these findings has not been verified. In general, when the efficacy of some characteristic appearances should be verified in interpretation of diagnostic images, one of most beneficial ways is to clarify that even inexperienced observers can arrive at the correct diagnosis using such appearances.

The aim of this study was to verify the diagnostic effectiveness of the upper line and the lateral incisor inclination for inexperienced observers in diagnosing CA patients with or without CP on panoramic radiographs.

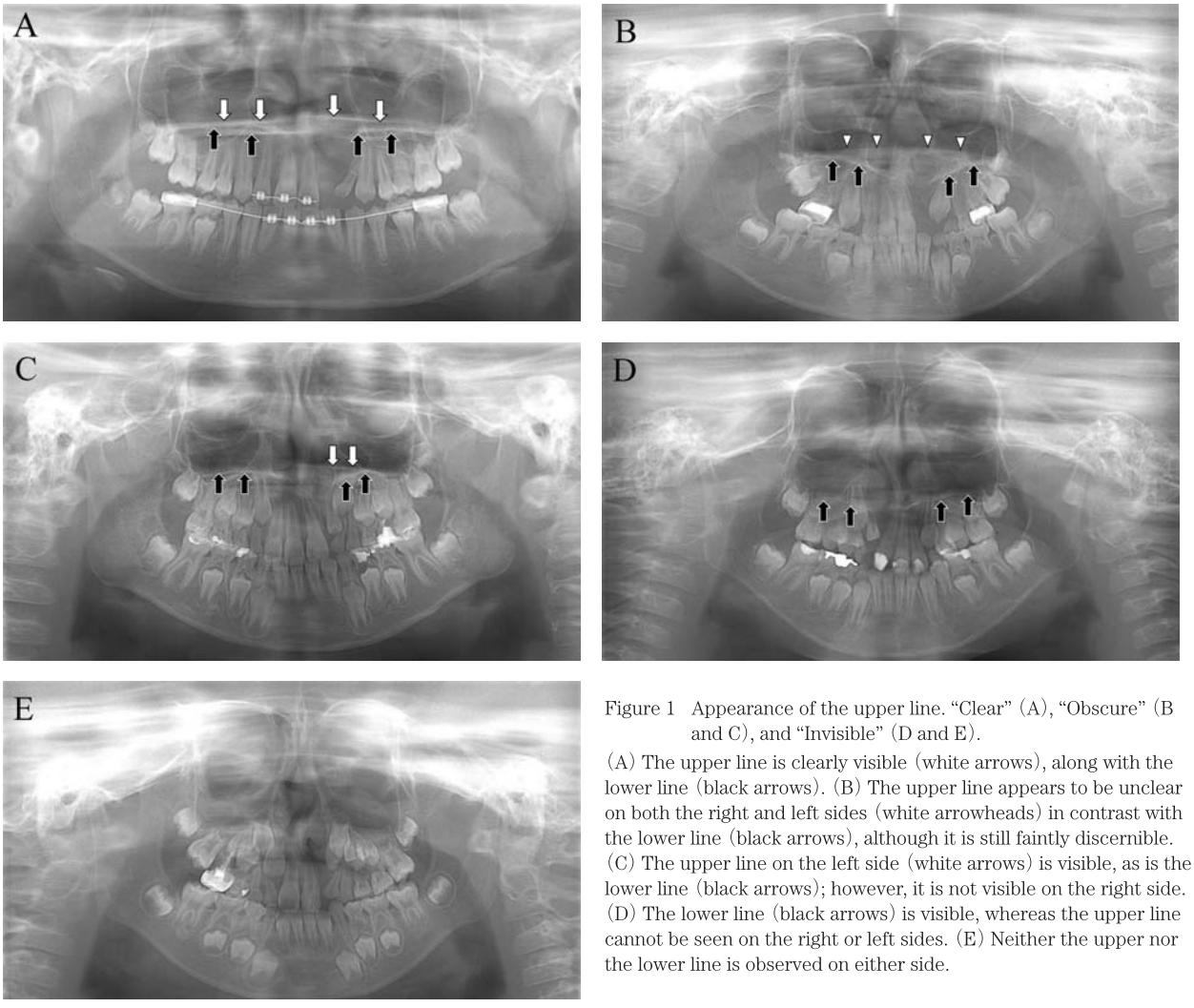

Figure 1 Appearance of the upper line. "Clear" (A), "Obscure" (B and C), and "Invisible" (D and E).

(A) The upper line is clearly visible (white arrows), along with the lower line (black arrows). (B) The upper line appears to be unclear on both the right and left sides (white arrowheads) in contrast with the lower line (black arrows), although it is still faintly discernible. (C) The upper line on the left side (white arrows) is visible, as is the lower line (black arrows); however, it is not visible on the right side. (D) The lower line (black arrows) is visible, whereas the upper line cannot be seen on the right or left sides. (E) Neither the upper nor the lower line is observed on either side.

Materials and Methods

This study was approved by the ethics committee of the School of Dentistry, Aichi Gakuin University (approval No. 649) and was performed in accordance with the Declaration of Helsinki.

Subjects

Two dental residents with less than 1 year of clinical experience after graduation from dental school agreed to participate in this study. The residents, who had received no special training in interpreting radiographic appearances, evaluated 100 panoramic images twice – before and after a lecture by an oral and maxillofacial radiologist. In this lecture, the radiologist presented characteristic findings that could differentiate unilateral CA patients with CP from those without CP.

Contents of lecture

Based on the results of our previous study[6], the radiologist described the appearance of the upper line formed by the junction between the nasal septum and nasal floor and the appearance of the maxillary lateral incisors. The details of the findings lectured were as follows:

・The upper line tended to disappear in CA patients with CP.

・The medial inclination ratio of the lateral incisor was higher in unilateral CA patients with CP than in those without CP.

The residents were asked to primarily use the first feature, with the second feature as an additional aid.

Image evaluation by residents

The residents evaluated panoramic radiographs of 100 patients with unilateral CA (41 females and 59 males, mean age 9.28 years). Respective 50 radiographs with or without CP were randomly selected from 200 radiographs collected for our previous study between August 2004 and July 2020 and stored in a database at Aichi Gakuin University Dental Hospital[6]. When the patients received two or more examinations, the radiographs taken just before bone graft surgery were selected. The panoramic images were taken by one of two panoramic machines installed in our department. One was Veraviewepocs unit (J Morita Mfg Corp., Kyoto, Japan), with a tube voltage of 75 kV, tube current of 8 mA, or exposure time of 16.2 s, and another was an AUTO III NTR unit (Asahi Roentgen Industry, Kyoto, Japan), with a tube voltage of 75 kV, tube current of 12 mA, and exposure time of 12 s.

The residents were asked to classify the images into one of four categories: “presence of CP”, “probable presence of CP”, “probable absence of CP” and “absence of CP”.

The diagnostic performance was assessed by combing the results from two residents and calculating sensitivity, specificity, and accuracy with “presence of CP” and “probable presence of CP” being positive. Furthermore, receiver operating characteristic (ROC) analysis was performed using these four categories. It shows the relationship between sensitivity and specificity at every threshold.

The inter-rater reliability was also evaluated between the two residents before and after the lecture[11]. Cohen’s kappa statistics was used to quantify the level of agreement between the raters by taking into account the agreement that could be expected by chance alone. Of the four categories diagnosed by the resident, " probable presence of CP " was classified as " presence of CP " and " probable absence of CP " was classified as " absence of CP ". The κ value was determined by the ratio of "true agreement" to "inevitable agreement " and the following formula was used:

$\kappa = Po\text{-}Pe \,/\, 1\text{-}Pe,$

where

・*Po is the observed agreement, which is the proportion of times the raters agree,* and

・*Pe is the expected agreement by chance, which is the proportion of times the raters would be expected to agree by random chance.*

Statistical analysis

The observer agreements were classified as poor when $\kappa < 0.2$, fair when $0.2 \leq \kappa < 0.4$, moderate when $0.4 \leq \kappa < 0.6$, good when $0.6 \leq \kappa < 0.8$, and very good when $0.8 \leq \kappa$[12].

The differences between the area under the ROC curve (AUC) values were tested before and after the lectures for the two residents using the Delong test. The significance level was set at $p < 0.05$.

Results

The interobserver agreements (kappa values) for before and after the lecture were 0.09 and 0.40,

respectively. The agreement before the lecture was classified as poor, while the agreement for after the lecture was classified as moderate.

The diagnostic performance is shown in Table 1 and Figure 2. The AUC values before and after the lecture were 0.66 and 0.78, respectively, and the difference was significant ($p = 0.007$).

Discussion

Anatomical variations could affect the upper line findings in CA patients with CP. The nasal septum of CA patients may attach to the palatal bone on the left or right side, or on neither side. In some cases, the cleft in the palatal bone might be anterior-posteriorly incomplete. Actually, in the previous study, a substantial number of cases showed an obscure appearance of the upper line. Therefore, care should be taken in such cases to avoid misdiagnosis.

The interobserver agreement (kappa values) increased from 0.09 before the lecture to 0.40 after the lecture, suggesting that the features used in this study might have some influence on the diagnosis. However, the relatively low kappa value of 0.40 even after the lecture suggests that the features might be difficult to

Table 1 Diagnositic performance of residents (The values of combined with two residents)

	Sensitivity	Specificity	Accuracy	AUC
1st (without lecture)	0.52	0.70	0.61	0.66*
2nd (with lecture)	0.78	0.67	0.73	0.78*

AUC: Area Under the Curve
＊：significant difference between them by the chi-square test with $p < 0.01$.

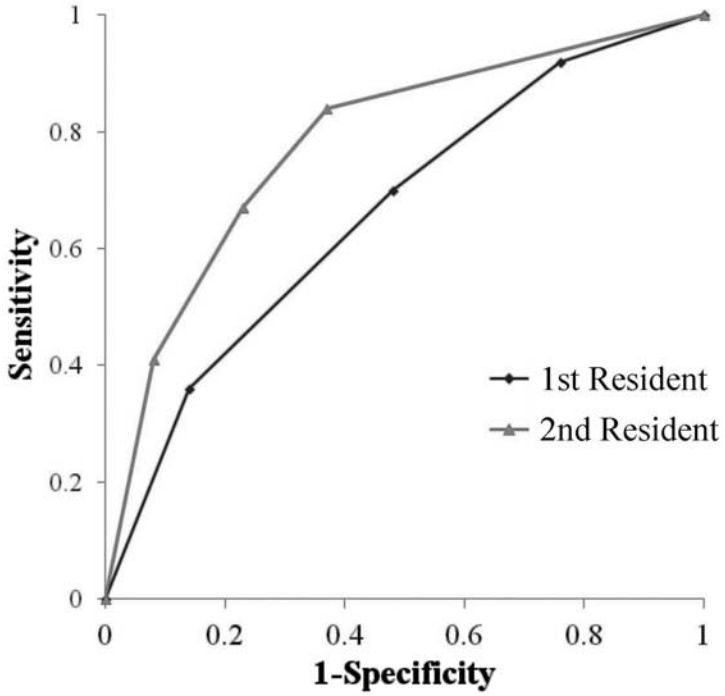

Figure 2 Receiver operating characteristic (ROC) curves for diagnosis of the presence or absence of cleft palate by two residents (results combined).

diagnose for inexperienced residents. The AUC improved from 0.66 to 0.78 with a significant difference between before and after the lecture. In a previous study, the diagnostic performance of two oral and maxillofacial radiologists with 5 and 6 years of experience was compared with a deep learning system for diagnosing the presence or absence of CP [13]. The AUC was 0.70 for both radiologists. Although these radiologists did not have the benefit of the lecture used in our study, their performance was almost comparable to that of the dental residents after the lecture. This finding indirectly verifies the usefulness of the features used in this study, although the performance of both the maxillofacial radiologists and the residents could not reach the level of artificial intelligence with deep learning techniques [13]. The specificity was regarded as no change even after the lecture, while the sensitivity was markedly improved because the clarified appearances might contribute to increase the correct positive evaluations indicating the association of cleft palate.

The purpose of this study was to clarify the effective appearance during panoramic image interpretation for observers who could not perform physical examinations. The AUC value was significantly improved by an inexperienced observer who received the lecture on the appearance of the upper line and the lateral incisor inclination. This suggested that these findings were useful in the diagnosis of CP. However, the effect may be limited to observers because CP can be generally diagnosed by physical examination. As for dental education, the findings may be beneficial in understanding the basic rule of panoramic image construction. Moreover, it is expected that the findings would be effective in differentiating other radiolucent lesions from cleft area in the palatal region.

This study had some limitations. First, only unilateral CAs were evaluated. It is possible that bilateral CA may produce different results. In future research, the findings in cases of bilateral cleft alveolus should be evaluated. Second, we used high-quality panoramic radiographs taken by experienced technicians. The positioning of the panoramic image layer in the incisor region can significantly affect the quality of panoramic radiographs, and poorly positioned imaging may lead to different findings for the upper line, which may lead to misdiagnosis. Third, the study subjects were only two residents. In future research, we need to conduct our evaluations using more subjects, and we need to verify whether our findings are effective in dental education and clinical practice. Fourth, since the characteristic image findings used in this study were qualitatively evaluated findings, the possibility of bias in the observer's subjective evaluation cannot be ruled out, and there is potential bias due to the influence of the lecturers' expertise.

Conclusion

In patients with a unilateral cleft alveolus, the upper line and the inclination of the lateral incisor may be useful findings in detecting CA on panoramic radiographs even for inexperienced observers, such as dental residents.

The authors have no financial conflict of interest to disclose concerning the paper.

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