# Automated contralateral subtraction of dental panoramic radiographs for detecting abnormalities in paranasal sinus

Takeshi Hara, Shintaro Mori\*, Takashi Kaneda\*, Tatsuro Hayashi Akitoshi Katsumata\*\*, and Hiroshi Fujita

Department of Intelligent Image Information, Graduate School of Medicine, Gifu University 1-1 Yanagido, Gifu, Gifu 501-1194, Japan \* Department of Radiology, Nihon University School of Dentistry at Matsudo, Japan 2-870-1 Sakaemachi-nishi, Kashiwa, Chiba 271-8587, Japan \*\* Department of Oral Radiology, Asahi University School of Dentistry, Japan 1851-1 Hozumi, Mizuho-shi, Gifu 501-0296, Japan

# ABSTRACT

Inflammation in the paranasal sinus is often observed in seasonal allergic rhinitis or with colds, but is also an indication for odontogenic tumors, carcinoma of the maxillary sinus or a maxillary cyst. The detection of those findings in dental panoramic radiographs is not difficult for radiologists, but general dentists may miss the findings since they focus on treatments of teeth. The purpose of this work is to develop a contralateral subtraction method for detecting the odontogenic sinusitis region on dental panoramic radiographs. We developed a contralateral subtraction technique in paranasal sinus region, consisting of 1) image filtering of the smoothing and sobel operation for noise reduction and edge extraction, 2) image registration of mirrored image by using mutual information, and 3) image display method of subtracted pixel data. We employed 56 cases (24 normal and 32 abnormal). The abnormal regions and the normal cases were verified by a board-certified radiologist using CT scans. Observer studies with and without subtraction images were performed for 9 readers. The true-positive rate at a 50% confidence level in 7 out of 9 readers was improved, but there was no statistical significance in the difference of area-under-curve (AUC) in each radiologist. In conclusion, the contralateral subtraction images of dental panoramic radiographs may improve the detection rate of abnormal regions in paranasal sinus.

Keywords: dental panoramic radiographs, paranasal sinus, and contralateral subtraction

# 1. INTRODUCTION

Inflammation in the paranasal sinus is often observed in seasonal allergic rhinitis or with colds. However, paranasal inflammation may also be indicative of carcinoma of the maxillary sinus or maxillary cyst. Radiologists can easily detect these findings from dental panoramic radiographs. However, since general dentists focus on treatments of teeth, they may miss the findings. Computerized image analysis methods may be effective tools for detecting abnormalities by enhancing differences of opacities between contralateral sides in paranasal sinus. The concept of a subtraction technique has been reported as an image analysis method in chest radiographs. Kano et al. reported a temporal subtraction technique for enhancing the opacity differences between previous and current chest radiograms [1]. Li et al. reported a novel technique for an automated comparison method for the right and left lung region in chest radiographs [2], and they defined the technique as a contralateral subtraction. Tsukuda et al. reported the effectiveness of the contralateral subtraction method for detecting lung nodules on digital chest radiograms [3]. These image-processing methods may be applied to other modality images [4-6].

Medical Imaging 2011: Computer-Aided Diagnosis, edited by Ronald M. Summers, Bram van Ginneken, Proc. of SPIE Vol. 7963, 79632R · © 2011 SPIE · CCC code: 0277-786X/11/\$18 · doi: 10.1117/12.878581

<sup>\*</sup>Corresponding author information: E-mail: takeshi.hara@mac.com, Telephone: +81-58-230-6511

The purpose of this study was to apply the contralateral subtraction method to dental panoramic radiographs for detecting the odontogenic sinusitis region and to evaluate the efficiency of providing the contralateral subtraction image during image interpretations. Figure 1 shows an example of dental panoramic radiographs. An X-ray source and a line x-ray detector or an imaging plate with a slit rotates on a patient's head. Normal paranasal sinuses are shown as translucent area over maxillary region in Fig. 1 (b), but abnormal opacity with a faint white area is shown in right paranasal sinus (Fig. 1 (c)). A contralateral subtraction method can be applied to enhance the difference in density between the left and the right paranasal sinuses because the abnormal regions in the right paranasal sinus may be recognized as an asymmetric opacity.



Fig.1 Dental panoramic radiographs

(a) Methodology of panoramic imaging (b) Normal cases (c) Abnormal cases (right paranasal sinus)



Fig.2 Overview of our contralateral subtraction method

# 2. MATERIALS AND METHODS

### 2.1 Contralateral subtraction

The contralateral subtraction technique consisted of 3 steps; image filtering of the smoothing and sobel operation for noise reduction and edge extraction, image registration of the mirrored image by using mutual information, and image display method of subtracted pixel data. The overview of our approach is shown in Figure 2. After the original images were obtained, smoothing and edge extraction image filtering techniques were applied. Each filtered image was flipped vertically, and image registration techniques based on mutual information were applied to find a matched location between original and the flipped image. We obtained two vectors of ( $\Delta$ sx,  $\Delta$ sy) and ( $\Delta$ ex,  $\Delta$ ey) that were registration results from smoothed and edge images respectively. Comparison of distances of ( $\Delta$ sx,  $\Delta$ sy) and ( $\Delta$ ex,  $\Delta$ ey) were used to determine the parameters of  $\Delta$ x and  $\Delta$ y that were used to create the final subtraction image.



(a) Smoothed image with Gaussian blur (b) Edge image with sobel operator (c) Presentation image to readers after the registration parameters were determined

### 2.2 Database

Fifty-six cases (32 abnormal and 24 normal) were employed. A board-certified oral radiologist verified the locations of abnormal regions on panoramic radiographs using other modalities such as CT scan images. CT scan images verified that the paranasal sinus of normal cases had no abnormal opacities.

#### 2.3 Observer study

A sequential test method in a receiver operating characteristic (ROC) study with continuous confidence levels was used for the observer study to confirm the usefulness of providing contralateral subtraction images to readers. In the sequential test, readers interpreted a patient image without the subtraction image first. After the confidence levels of the image were determined, subtraction images were provided. The readers interpreted the cases using both the panoramic radiograph and the subtraction images before determining another confidence level with the subtraction image. The order of presenting cases was randomized before the interpretation. Areas under the ROC curves (AUC) were determined to

compare the readers' interpreting performance without and with the subtraction images. True-positive rates at 50% of the confidence level (TP50) for readers were also determined.

### 3. RESULTS AND DISCUSSIONS

The designed observer performance study comparing the reading conditions of "without subtraction image" and "with subtraction image" were performed by 9 dentists. Readers #1 to #3 were board-certified oral radiologists. Readers #4 to #9 were general dentists. Area-under-the-curve (AUC) and the sensitivity at 0.5-confidence level of each reader were obtained to compare the diagnostic results. Table 1 shows the detection performance of each reader. The performance of the board-certified readers was higher than that of the general dentists. By comparing the AUC of "without subtraction image" with "with subtraction image," a small decrease was confirmed in both board-certified readers and general readers; however, there was no statistical significance. On the other hand, small increases were shown in the sensitivity. The ROC curves for 9 readers are presented in Figure 4.

Figure 5 shows cases where the subtraction images were beneficial for readers. Figure 5 (a) shows the most beneficial case for board-certified readers. The average confidence level (CL) for the board-certified readers was increased from 0.28 to 0.51 in Fig. 5 (a), while the CL of the general dentists changed from 0.68 to 0.95. Figure 5 (b) shows the most beneficial cases for general dentists. The average CL in the general readers was increased from 0.68 to 0.95, while the change of CL in board-certified readers was increased from 0.93 to 0.99.

Figure 6 shows the subtraction images that were detrimental for readers. Figure 6 (a) shows the most detrimental case for board-certified readers. These cases have normal paranasal sinuses as verified by an oral radiologist by using CT scan images. The average CL of the experts was increased from 0.16 to 0.61, but was incorrect. The change in CL of general dentists was from 0.28 to 0.47. Figure 6 (b) shows the most detrimental case for general dentists. The average CL of general dentists was increased from 0.25 to 0.60 but was incorrect. However, the change in CL of board-certified oral radiologists was from 0.39 to 0.52; hence, the expert reader could distinguish the normal structures that general dentists could not recognize with high confidence levels.





(a) Without subtraction image (b) With subtraction image

#### Proc. of SPIE Vol. 7963 79632R-4



(a) (b)
Fig.5 Cases where the subtraction images were beneficial
(a) Beneficial for board-certificated readers (b) Beneficial for general dentist



(a) (b)
Fig.6 Cases where the subtraction images were detrimental
(a) Detrimental for board-certificated readers (b) Detrimental for general dentist

# 4. CONCLUSION

The changes of AUC without and with subtraction image during image interpretation did not show statistical significance. However, the sensitivity of general dentists was increased. The contralateral subtraction images of dental panoramic radiographs may improve the detection rate of abnormal regions in paranasal sinus.

# ACKNOWLEDGMENT

This study was partly supported by CAD projects for dental panoramic radiography in Regional Innovation Cluster Program of the Japanese government.

## REFERENCES

- <sup>[1]</sup> A. Kano, K. Doi, H. MacMahon et al., "Digital image subtraction of temporally sequential chest images for detection of interval change," Med Phys, 21(3), 453-61 (1994).
- <sup>[2]</sup> Q. Li, S. Katsuragawa, T. Ishida et al., "Contralateral subtraction: a novel technique for detection of asymmetric abnormalities on digital chest radiographs," Med Phys, 27(1), 47-55 (2000).
- <sup>[3]</sup> S. Tsukuda, A. Heshiki, S. Katsuragawa et al., "Detection of lung nodules on digital chest radiographs: potential usefulness of a new contralateral subtraction technique," Radiology, 223(1), 199-203 (2002).
- <sup>[4]</sup> S. G. Armato, 3rd, D. J. Doshi, R. Engelmann et al., "Temporal subtraction of dual-energy chest radiographs," Med Phys, 33(6), 1911-9 (2006).
- <sup>[5]</sup> J. Shiraishi, D. Appelbaum, Y. Pu et al., "Usefulness of temporal subtraction images for identification of interval changes in successive whole-body bone scans: JAFROC analysis of radiologists' performance," Acad Radiol, 14(8), 959-66 (2007).
- <sup>[6]</sup> Y. Ikedo, D. Fukuoka, T. Hara et al., "Development of a fully automatic scheme for detection of masses in whole breast ultrasound images," Med Phys, 34(11), 4378-88 (2007).