A computerized system for identifying osteoporotic patients on dental panoramic radiographs

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Purpose

Osteoporosis is a disease of bones that leads to an increased risk of fracture, and its early detection is a key to preventing future fractures and disability. To date, some screening methods for the identification of osteoporotic patients have conducted.

However, some papers indicate that osteoporosis screening rates remain low [1, 2]. In addition, osteoporosis is a silent disease with few symptoms in its early stage. For that reason, the identification of osteoporotic patients is still a challenging task. To overcome these problems, Dr. Taguchi proposed a new screening pathway via dental clinics [3] (Fig. 1 on page 2).

Panoramic radiography is widely used in clinical dentistry. Findings of panoramic images have shown that mental index (MI), which is the mean width of the lower border cortex below the two mental foramina, may be useful as the radiomorphometric indicator of possible osteoporotic patients (Fig. 2 on page 3). As shown in Fig. 2 on page 3, decrease in the cortical thickness is one of radiographic signs of osteoporosis. Therefore, the MI measurement could be used for screening osteoporosis.

Until now, two clinical trials by trained dentists have been conducted in Japan [4, 5]. These trials suggested that the preliminary screening by dentists was useful for identifying osteoporotic patients. However, there are some specialized fields in dentistry such as dental radiologist, dental surgeon, endodontist, exodontist, and so on. I mean, not all dental practitioners are familiar with image interpretation.

Computer-aided detection (CAD) may be useful for such dental practitioners. Although some CAD schemes were designed [6-9], no CAD systems have been put to practical use to date.

Purpose of this study was

- to develop a CAD system for the measurement of the MI on the panoramic radiographs
- to evaluate its clinical usefulness

Images for this section:
**Fig. 1:** Screening pathway for identifying patients with osteoporosis.

**Fig. 2:** Examples of the measurement of mental index (MI) on panoramic images.
Methods and Materials

A new screening pathway via dental clinics

A new screening pathway in collaboration with radiologists, dentists, and computers is presented in Fig. 3 on page 5. It works as follows:

1. Panoramic radiographs are used to examine dental diseases in the routine work, as usual.
2. Dentists send the images to the CAD system as an extra task.
3. Once upon receiving the images, our CAD system automatically runs the image analysis, and the resulted images and reports are sent to dentists.
4. With reference to the CAD results, the dentists do the preliminary screening of osteoporosis.
5. The dentists provide an information about the risk of osteoporosis to patients.
6. If the patients desire, the dentists will refer to the medical clinics.

Our CAD system for the MI measurement on panoramic images

The following steps were implemented to develop a CAD system.

• Design of the computerized scheme for the MI measurement
• Development of the application software

Step 1. Design of the computerized scheme for the MI measurement

Fig. 4 on page 5 shows a computerized scheme we designed. Details on our scheme were described in [10]. The outline of our scheme was as follows.

1. The mandibular contour is the key structure on the panoramic radiography. It is extracted by use of image processing techniques such as edge detection and pattern matching.
2. Regions of Interest (ROI) associated with mental foramina are set on the basis of the mandibular contour.
3. The value of the MI is determined based on the grayscale profile on ROI.

These processings were integrated as one DLL module.

Step 2. Development of the application software

Fig. 5 on page 6 illustrates a prototype CAD system we developed. It is an application software with a simple interface, which is called "Dental Viewer". The "Dental Viewer"
can run on a general personal computer (Fig. 6 on page 6). Dentists can use our scheme easily by use of this software. Usage of this software is shown as follows.

1. Click-hold on the panoramic image and drag-and-drop it anywhere on the screen of this software. In a moment, it is registered in a database.

2. Select target images from a database, and then click the "Run" button. Soon after, the target images are processed by our scheme, and the results will be produced after about 1 minute per case.

3. You can check the MI of the target images by viewing the CAD results. When click on the result image, you can also check the intermediate process.

Images for this section:

Fig. 3: A new screening pathway in collaboration with radiologists, dentists, and computers.
Fig. 4: A computerized scheme that measures the MI on panoramic images.

Fig. 5: Application software "Dental Viewer".
Fig. 6: Examples of our prototype CAD system in which "Dental Viewer" was installed.
Results

Performance evaluation by use of a private dataset

Panoramic images were taken with the standard positioning of the head such that the Frankfort horizontal plane was used as a reference line. The automatic mode was used to control the x-ray exposure. The resultant DICOM images were stored on a computer. Test cases were selected at random. In this way, 27 osteoporotic cases and 73 control cases were included in the dataset. Note that dual-energy X-ray absorptiometry (DXA) scan was also used to provide the evidence of osteoporosis.

Such dataset was used to evaluate the performance of our CAD system. Fig. 7 on page 9 shows a receiver operating characteristic (ROC) curve. Area under the curve (AUC) was 0.946. When threshold length of the MI was set to 2.8 mm, True positive fraction (TPF) and false positive fraction (FPF) were 0.901 and 0.169, respectively.

Multi-institutional clinical trial by dental practitioners

In collaboration with Gifu Prefecture Dental Association, multi-institutional clinical trial was conducted. 5 dental practitioners were joined in this trial and 223 cases were processed by our system. Measurement results are shown in Fig. 8 on page 9. When threshold length of the MI was set to 2.8 mm, all suspected cases were detected and specificity was 81.3 %.

Discussions

Advantages

10 million panoramic images are obtained per year in Japan. It's a very large resource. That's why preliminary examination by dental practitioners has a potential to accelerate early detection of osteoporosis.

To date, 4 asymptomatic patients with suspected osteoporosis were detected in our initial trial. It was suggested that our new screening pathway was useful to identify osteoporotic patients.

Limitations

Digital panoramic scanners are rapidly spreading in dental clinics.
As it stands now, there are large variations in the image quality of panoramic images. Fig. 9 on page 10 shows some image examples of the large variations in image quality. It should be noted that such variations lead to poor performance of the CAD system.

**Images for this section:**

**Fig. 7:** Receiver operating characteristic (ROC) curve of our CAD system by use of the private dataset.
**Fig. 8:** Measurement results of the MI at the multi-institutional clinical trials.

**Fig. 9:** Image examples of the large variations in image quality.
Conclusion

A CAD system for measuring MI on panoramic radiography was developed. Our initial clinical trials revealed that our new screening pathway could identify asymptomatic patients with osteoporosis. Development of the algorithm that reduces the image-quality variation in panoramic images is needed to improve the performance of our CAD system.

References


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