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TITLE: Improvement of the accuracy of bone segmentation procedures applied to CBCT images

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Abstract To improve the accuracy of bone segmentation procedures in dental CBCT images, several two- and three-dimensional (2D & 3D) filtering methods were examined. The comparison with the processing for MDCT images was also done. CBCT images having high and isotropic spatial resolution, but the noise is comparatively high. By reducing the noise in images, the attempt to improve the MPR image quality was carried out. And the 3D region growing method was examined for the volumetric data of CBCT images for the bone segmentation. CBCT and MDCT examinations were taken using CB Throne (Hitachi Medical Systems, Japan) and Somatom Plus 4 (Siemens, Germany), respectively. Principal exposure parameters were as follows; I-mode, 10 cm FOV in diameter, 120 kV, 15 mA, 0.2 mm in slice thickness and 10 s exposure time (CBCT) and 120 k V, 130 effective mAs, 0.5 mm slice thickness (MDCT). Two-D and 3D filtering procedures for Gaussian smoothing, Laplacian sharpening, etc. were applied for the improvement of MPR images of both CT modalities. Images processed were a clinical case of Mucocele in the maxillary sinus. The 2D and 3D filtering procedures for Gaussian smoothing, Laplacian sharpening worked for the improvement in the different way. In comparison with MDCT images, the difference was not large. The effect of the simple noise reduction filter is seemed to be no changes in bone segmentation in spite of extreme reduced noise. Due to the example which the Sobel filtering, noise-resistant edge-detection filter, was applied as either 2D or 3D local operator, the difference was appeared less significantly in CBCT images than MDCT images. For the imaging of dento-alveolar and maxillary sinus regions, the depiction of thin bone structure with the high accuracy is important. Three-D filtering methods have the possibility to improve the accuracy of bone segmentation in three-dimensional displaying of CBCT images. Based on these finding 3D region growing method was examined for 3D visualization. The bone region on CBCT images was extracted using the 3D region growing method.

Keywords bone segmentation, cone beam CT, 3D filter, region growing

Introduction

To improve the accuracy of bone segmentation procedures in dental CBCT images, several two- and three dimensional filtering methods were examined. The comparison with the processing for MDCT images was also done. CBCT images having high and isotropic spatial resolution, but due to the low exposure noise level is comparatively high. By reducing the noise in images, the attempt to improve the MPR image quality was carried out. And the three-dimensional region growing method was examined for the volumetric data of CBCT images for the bone segmentation.

Methods

CBCT and MDCT examinations were taken using CB Throne (Hitachi Medical Systems, Japan) and Somatom Plus 4 (Siemens, Germany), respectively. Principal exposure parameters were as follows; I-mode, 10 cm FOV in diameter, 120 kV, 15 mA, 0.2 mm in slice thickness and 10 s exposure time (CBCT) and 120 k V, 130 effective mAs, 0.5 mm slice thickness (MDCT). Two- and three-dimensional filtering procedures for Gaussian smoothing, Laplacian sharpening, etc. were applied for the improvement of MPR images of both CT modalities. Images processed were a clinical case of Mucocele in the maxillary sinus. The three-dimensional processing and displaying software for medical images, both Amira (ZIB Berlin, Mercury Computer Systems, USA) and OsiriX were used for 3D displaying.

The 3D region growing method for 512 slices of CBCT images and 130 slices of MDCT images. As usual the region growing was started at the seed point. Six neighboring voxels in 3D space was evaluated for either being extracted and integrated as the bone region or not. The extraction condition was set as the threshold value at various CT numbers. The closing procedure, the repeat of dilation and reduction was carried out.

Results

2D and 3D filtering procedures for Gaussian smoothing, Laplacian sharpening worked for the improvement in the different way (Fig. 1). In comparison with MDCT images, the difference was not large. The effect of the simple noise reduction filter is seemed to be no changes in bone segmentation in spite of extreme reduced noise. Due to the example which the Sobel filtering, noise-resistant edge-detection filter, was applied as either 2D or 3D local operator, the difference was appeared less significantly in CBCT images than MDCT images.

The 3D region growing method using six neighboring voxels in 3D space worked well for not only MDCT images also CBCT images (Figs. 2 & 3). The CBCT image's voxels have 'CT numbers' which are proportional to bone mineral contents of objects. Several threshold CT numbers were examined for the optimization of the region growing. The resultant 3D image by the volume rendering were shown in Fig. 4.

Conclusion

For the imaging of dento-alveolar and maxillary sinus regions, the depiction of thin bone structure with the high accuracy is important. Three-D filtering methods have the possibility to improve the accuracy of bone segmentation in three-dimensional displaying of CBCT images. The processing on the superior-inferior direction in 3D filtration worked effectively. The bone region on CBCT images was extracted using the 3D region growing method, but the limitation for the thin and fine structure depiction. The combination with the 3D filtration as pre-processing procedures will improve the quality of the bone segmentation.

References

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Figures

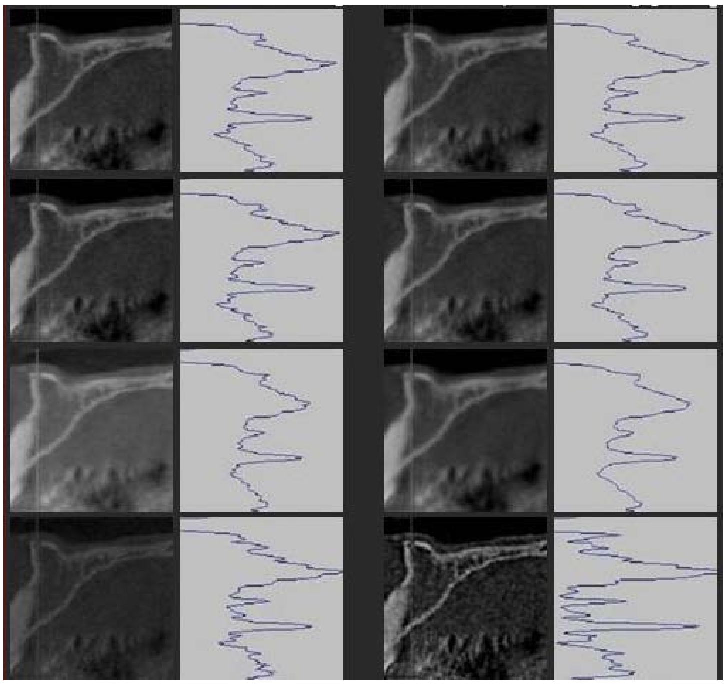

Fig 1. The comparison of 2D filter (left column) and 3D filter (right).
Four filtration procedure, uniform smoothing, Median, Gaussian smoothing and Laplacian sharpening (from top to bottom) were compared.

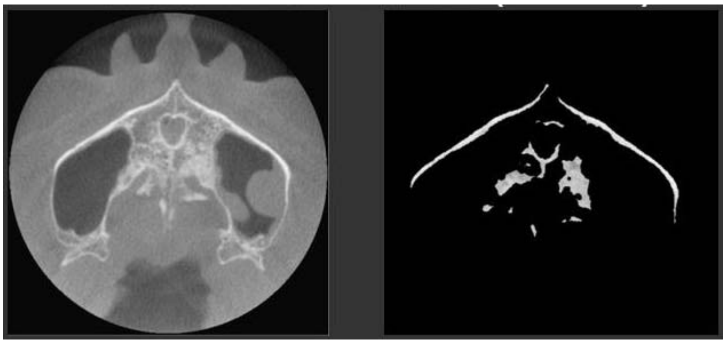

Fig 2. An original CBCT image and the processed image by region growing (thresho ld CT value: 500).

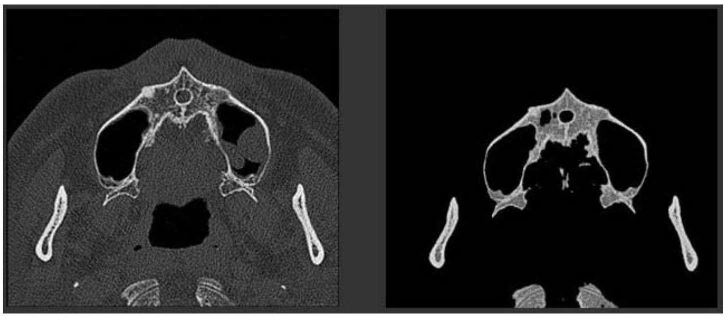

Fig 3. An original MDCT image and the processed image by region growing (threshold CT value: 500).

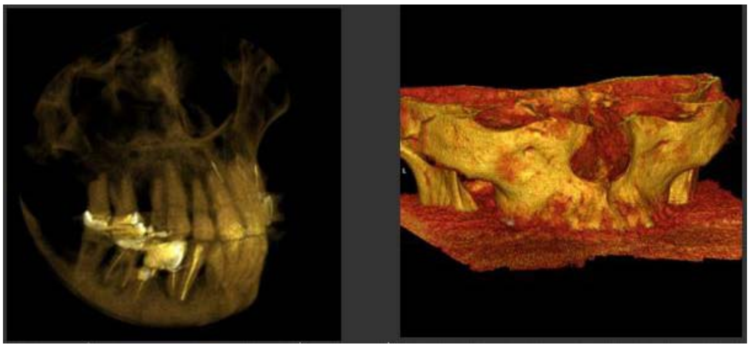

Fig 4. The volume rendering image on which the bone regions were extracted by the region growing method.