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ORIGINAL ARTICLE

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Development of a simple image viewer designed for small X-ray field CT equipment 3DX

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Abstract

Objectives. To develop a simple image viewer that utilizes image files in general-purpose formats that are written from the original 3DX volume data.

Methods. We used FLASH MX2004 for Macintosh to develop a simple image viewer. In developing the software for the simple image viewer, we decided that the viewer should provide the following features: (1) be available to both Windows OS and Mac OS, (2) allow interlocking of the 3D images, (3) display image enlargement, and (4) allow distance measurements. The accuracy of the distance measurements was evaluated.

Results. The procedure was as follows: (1) write 3D images in jpeg format to a folder on i-VIEW; (2) place the folder containing the 3D images into the directory of the simple image viewer software on a PC; (3) start the software and open the window to input the folder name containing the 3D images; and (4) display the 3D images. Our viewer had features such as image enlargement, interlocking 3D images, drawing, and distance measurements. No significant differences were shown between the measurements made by our simple viewer and the actual values of the images in any direction.

Conclusions. Our image-viewing software for 3DX is beneficial for clinical use.

Key words Cone beam-CT · Image viewer · Three-dimensional imaging

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Introduction

A small radiation field X-ray Computed Tomography (CT) system, 3DX multi-Image Micro CT (3DX; J. Morita, Kyoto, Japan)[1–3] which was developed by Arai et al. (1998), is very effective for radiological diagnosis in oral and maxillofacial surgery and otolaryngology as well as in dentistry. The use of this equipment has been spreading in university dental hospitals and in general dental clinics because the radiation dose is substantially lower than with conventional medical CT.[4,5]

3DX uses cone-beam X-rays, rotates 360° around a subject, and irradiates for 17 s to obtain imaging volume data.[6] Arbitrary three-directional (horizontal, sagittal, and coronal) images are then reconstructed from the data for use in managing apical lesions, dental implants, impacted teeth, and temporomandibular joints.[7–9]

Three-dimensional (3D) images are reconstructed by the i-VIEW dedicated viewer software on a PC connected to the 3DX. i-VIEW allows the user to set the angle and thickness of slices, and it is also possible to interlock the three-directional (horizontal, sagittal, and coronal) reconstructed images on i-VIEW. i-VIEW is an integrated image-processing software that provides various image-processing functions such as a displaying histograms, distance and angle measurements, and density measurements.

We have used 3DX since July 2004 and have examined about 500 patients. The diagnosis reports and the image data should be submitted to the client's department; however, the images in raw data format cannot be observed without the i-VIEW software. The client must purchase expensive software. i-VIEW has made it possible to write to magneto-optical disk or CD-R in a variety of general-purpose formats such as JPEG, DICOM, PICT, and TIFF, but each of the three-dimensional (horizontal, sagittal, and coronal) images is output as a single image file; a total of 114 images are created for a slice thickness of 1 mm. It is difficult to find the required image among this enormous number of images. Although we add the file name of a key image to the diagnosis report, clients are still unable to observe images of the lesion in 3D, thereby negating the benefits of the 3DX. It was not cost effective to install i-VIEW in each client's department. Writing data to CD-Rs in a general-purpose format was the most realistic option. Therefore, we decided to develop a simple image viewer for 3D image observation that utilizes the image files in general-purpose format written from the original volume data.

Methods

We used FLASH MX2004 for Macintosh (Macromedia, San Francisco, CA, USA) and a Power MAC G4 (Apple Computer, Cupertino, CA, USA) to develop the simple image viewer.

We resliced the images with a 1-mm slice thickness from the 3D imaging volume data for optimal viewing on i-VIEW and wrote these images in an 8-bit JPEG format. It would be ideal to write out data in an uncompressed or a reversibly compressed image format, but we used irreversibly compressed JPEG because the FLASH MX2004 software only supports the JPEG image format.

In developing the software for the simple image viewer, we decided that the viewer should provide the following features:

be available to both Window OS and Mac OS
permit interlocking of 3D images
display image enlargements
allow distance measurements.

We evaluated the accuracy of the measurement feature using a test phantom of four columns that we created (Fig. 1). After imaging the test phantom, we measured the length of four columns on a radiogram by i-VIEW and with our simple viewer and compared the measurements to the actual lengths measured with vernier calipers. Three dentists and two radiological technicians performed the measurements five times each.

The measurement values from the five observers were compared to assess interobserver agreement, which was expressed as Kendall's coefficient of concordance. We then analyzed the measurement results statistically using the Dunnett test. A P value of less than 0.05 was considered statistically significant. Statistical analyses were performed with the statistical software SPSS, ver.10.01 (SPSS, Chicago, IL, USA).

Results

Procedure

1. Write 3D images in JPEG format to a folder on i-VIEW.
2. Place the folder that contains the 3D images into the directory for the simple image viewer software on a PC.
3. Start the simple image viewer software, and open the window to input the folder name that contains the 3D images (Fig. 2).
4. Display the 3D (horizontal, sagittal, and frontal) images (Fig. 3).

The simple viewer can be used on either Windows-OS or Mac-OS because FLASH supports multiple platforms.

Displaying the 3D images

Three (horizontal, sagittal, and coronal) directional images are displayed in a single basic window of the software, as in

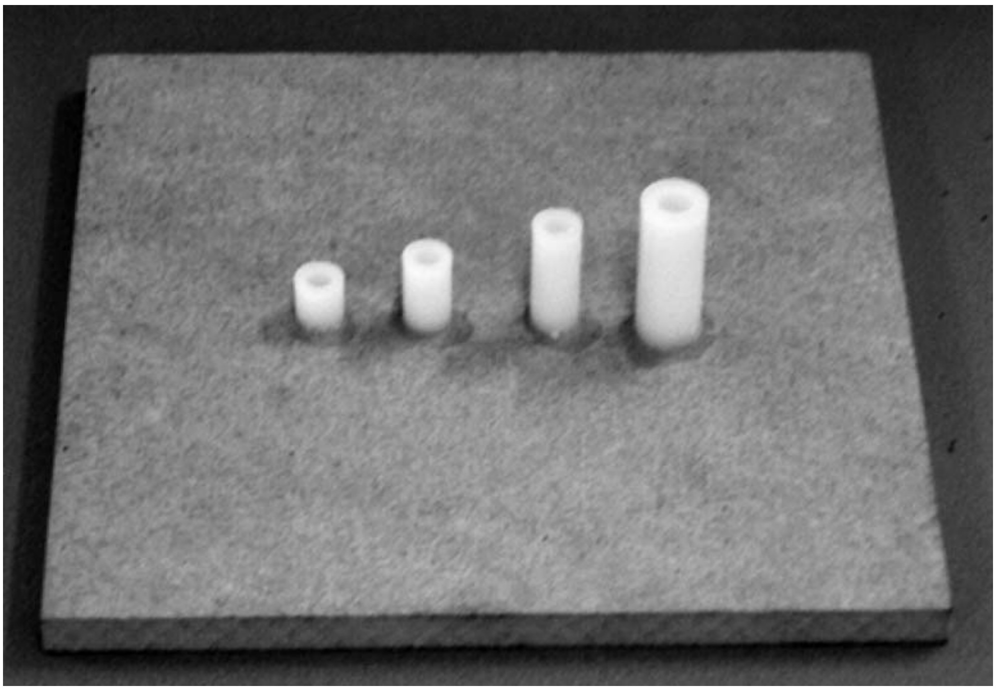

Fig. 1. Test phantom consisting of four acrylic columns of different lengths

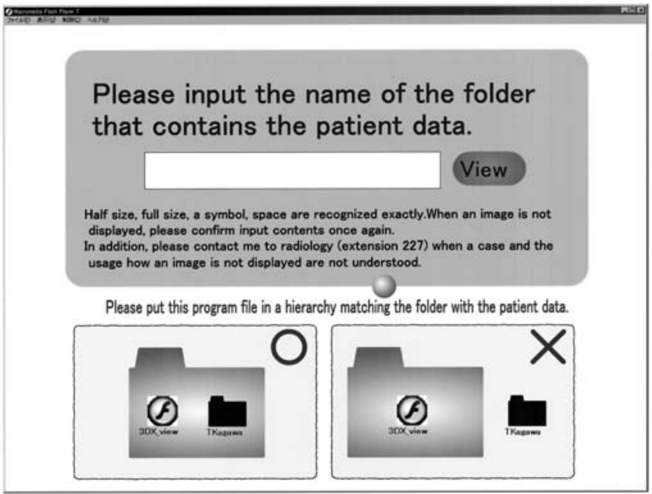

Fig. 2. Folder name input window. Input the name of the folder that stores the image data to the field in the window. Then, click the [View] button to open the image display window

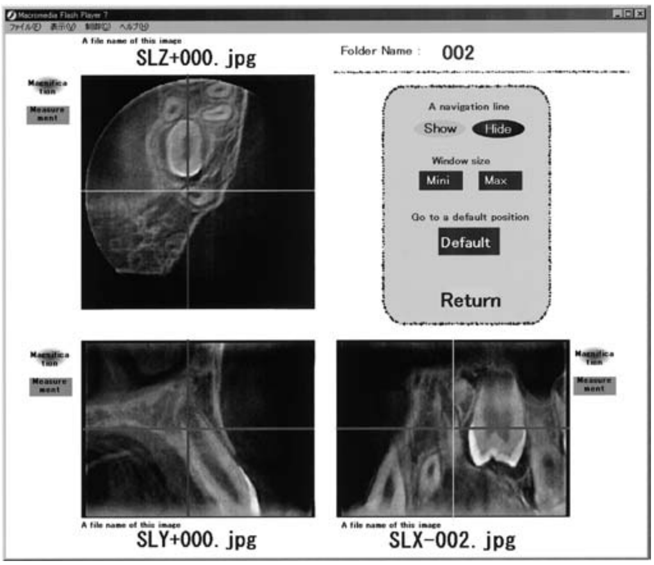

Fig. 3. Image display window. 3D (horizontal, sagittal, and frontal) images can be displayed. Crosshairs on each image can be dragged to display different parts of the reconstructed images, allowing the observation of interlocked images in each direction

i-VIEW. Crosshairs on each image can be dragged in any direction to display different parts of the reconstructed images, allowing the observation of interlocked images in each direction (Fig. 3). The crosshairs can be hidden while observing the images. The file names of the images currently shown in the window are displayed next to the images, making a file search easy. Windows can be maximized or minimized.

Enlargement and drawing features

By clicking the [Max] button next to an image in the basic window, the image is enlarged to the full screen (Fig. 4).

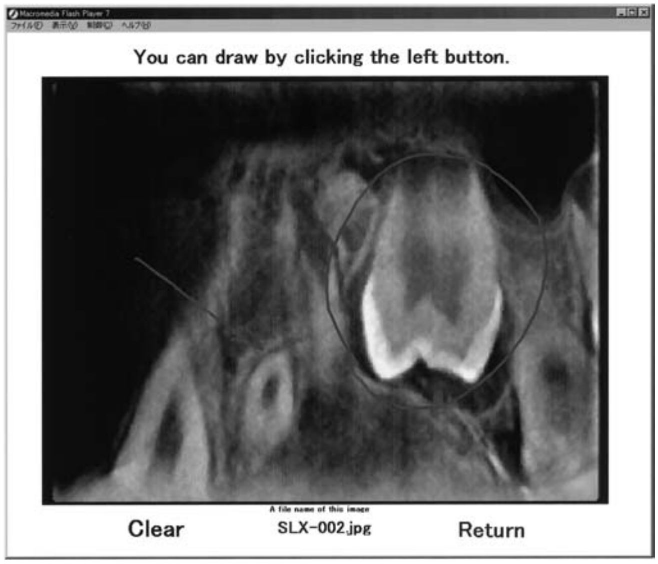

Fig. 4. Enlarged display window. When an image is enlarged to full screen, the mouse can be used to draw on the image by clicking and dragging the cursor

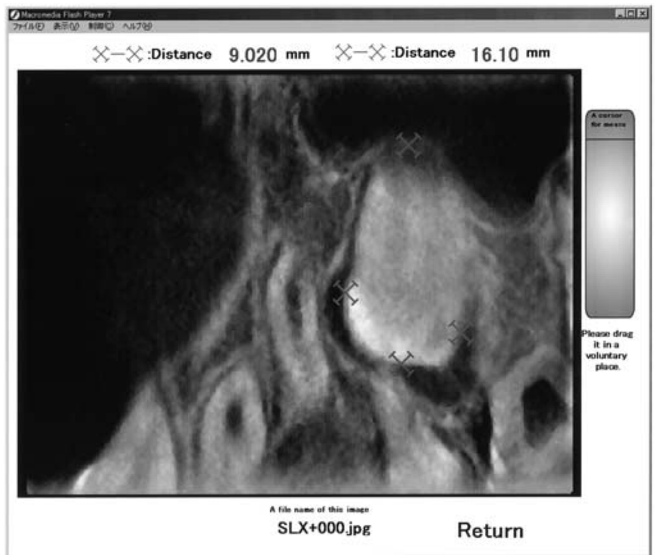

Fig. 5. Distance measurement window. By dragging the crosshair cursor within an arbitrary area in the window, the distance between two points is measured. Two distances can be measured at a time

When the image is enlarged, the mouse can be used to draw freely on the image by clicking and dragging the cursor (Fig. 4). This feature is useful when explaining the image to a patient.

Distance measurement feature

Clicking the measurement button in the basic window opens the measurement window. By dragging the crosshair cursor in an arbitrary area in the window, the distance between two points can be measured (Fig. 5). Two distances can be measured at one time.

Table 1. Comparison of the distance measurement results between i-VIEW, our viewer, and the actual lengths of four columns of our phantom

	Our viewer			i-VIEW			An actual value	
	Avg. (mm)	SD	*P* value	Avg. (mm)	SD	*P* value	Avg. (mm)	SD
Bar 1	20.2	0.2	0.661	20.0	0.2	0.990	20.0	0.0
Bar 2	14.9	0.1	0.992	14.9	0.2	0.681	15.0	0.0
Bar 3	10.0	0.1	0.481	10.0	0.2	0.584	10.0	0.1
Bar 4	5.90	0.1	0.587	5.80	0.2	0.496	5.90	0.0

No significant differences were observed among the measurements (Dunnett test)

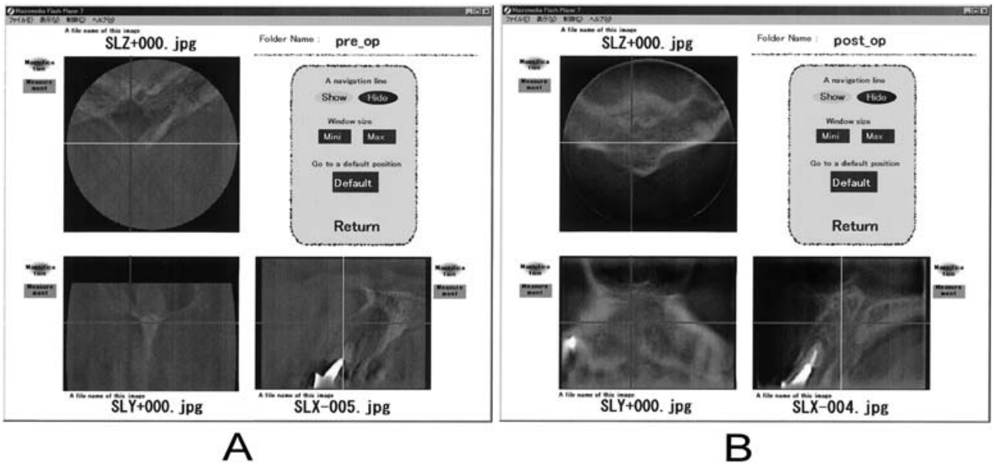

Fig. 6A, B. 3DX radiograms before (**A**) and after (**B**) surgery for a radicular cyst. The new viewer can open multiple images at a time, thereby allowing easy comparison of pre- and post-surgery images

The actual, i-VIEW, and our viewer's respective W values in Kendall's coefficient of concordance were 1 (P = 0.001) for the measurements of the lengths of four columns on a radiogram. No significant differences were observed in the measurement values between our simple viewer, i-VIEW, and the actual lengths of the four columns of our phantom (Dunnett test; Table 1).

Discussion

Although the newly developed simple image viewer designed for 3DX has a very simple structure, it provides the minimum features required for clinical practice. It allows 3D image observation in a department or dental clinic without the need for a dedicated, expensive copy of i-VIEW, and is very useful. Our viewer can open multiple folders at a time, thereby providing a means for easily comparing measurements before and after an operation (Fig. 6).

Currently, we submit a CD-R that stores the image data of every clinical case, the viewer, and the diagnosis report to the client's department. However, the images at any angle for optimum viewing must be resliced in i-VIEW in advance, because the images cannot be reconstructed by our viewer. Therefore, it is necessary to understand the purpose of the 3DX examination in each case. We have had to restructure images on i-VIEW in some cases owing to the lack of communication with a client physician.

Furthermore, our viewer has the following disadvantages, although these are scheduled to be improved in future revisions:

1. The contrast and brightness cannot be changed.
2. The pitch of the reconstructed images is set at 1 mm.
3. Only horizontal sections can be rotated.

Conclusion

We have developed a simple image viewer for 3DX that allows 3D image observation in an environment with no dedicated viewer for 3DX. This software is useful for clinical use when image density, contrast, and the direction of the slices are reconstructed in advance in i-VIEW, the dedicated viewer for 3DX.

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