Improved Software to Browse the Serial Medical Images for Learning

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The thousands of serial images used for medical pedagogy cannot be included in a printed
book; they also cannot be efficiently handled by ordinary image viewer software. The
purpose of this study was to provide browsing software to grasp serial medical images
efficiently. The primary function of the newly programmed software was to select images
using 3 types of interfaces: buttons or a horizontal scroll bar, a vertical scroll bar, and a
checkbox. The secondary function was to show the names of the structures that had been
outlined on the images. To confirm the functions of the software, 3 different types of
image data of cadavers (sectioned and outlined images, volume models of the stomach,
and photos of the dissected knees) were inputted. The browsing software was
downloadable for free from the homepage (anatomy.co.kr) and available off-line. The
data sets provided could be replaced by any developers for their educational achievements.
We anticipate that the software will contribute to medical education by allowing users to
browse a variety of images.

Keywords: Visible Human Projects; Cadaver; Anatomy; Body Image; Computer Software

INTRODUCTION

In the clinical setting, countless serial images are obtained and
reviewed, including those from computed tomography (CT)
and magnetic resonance imaging (MRI). To view these images
on a personal computer, existing image browsers (e.g., MRIcro
[Neuropsychology Lab, Columbia, SC, USA]) are not appropri-
ate. For example, the browsers lack the ability to automatically
label the outlined anatomical structures (1-3).

The Visible Korean research team has developed software to
view serial sectioned images of a cadaver with convenience and
efficiency. Specifically, the software has the ability to display
the names of outlined structures, which would aid students in
learning sectional anatomy (4-6). Additionally, the team has ac-
cumulated raw images and processed images of different sub-
jects, anatomical regions, and organs. The image data include
color-filled images, volume models, and photographs from ca-
davers (7-9). To view a variety of images, previous software hav-
ing one scroll bar is insufficient.

The purpose of this study was to help medical trainees grasp
numerous serial images by providing the advantageous brows-
ing software. For that purpose, the new software was programmed

to be equipped not only with buttons, scroll bars, and checkbox
to select images, but also with other improved functions such
as zoom capability. To confirm applicability of the software, 3
different types of image data were inputted into the software
and then examined.

MATERIALS AND METHODS

### Manufacture of the software

The new browsing software consisted of program files and data
files. The program files in the main folder were composed by
the C# language of Microsoft Visual Studio.NET 2013 (Microsoft
Corporation, Redmond, WA, USA; www.microsoft.com). The
accessory text files such as config.txt (Table 1), color.txt, and
help.txt were also put in the main folder.

The software title shown on the window and the color (red
[R], green [G], and blue [B] values) shown on the margin of the
images were listed in config.txt (Fig. 1; Table 1). The essential
function of the software was to select the desired images using
3 types of interfaces. The first interface on the x-axis was but-
tons or a scroll bar, of which one was selected in config.txt. In
the case of buttons, the number and names of the buttons were

Table 1. Significant variants in config.txt of the 2 browsing software packages

Variables	Functions	Software of horizontal images	Software of stomach images
Software_title	Software title, shown on the window	Browsing software (Male whole body, male head, female pelvis, ver. 2.0)	Browsing software (Male - Peeled and piled stomach, ver. 2.0)
Margin_red_value	R value of the software margin	0	255
Margin_green_value	G value of the software margin	0	255
Margin_blue_value	B value of the software margin	0	255
X_axis_scroll_bar	Buttons (0) or scroll bar (1) on the x-axis	0	1
X_axis_button_number	No. of buttons (maximum 10)	3	-
X_axis_button_name_1	Name of the 1st button	Male whole body	-
X_axis_button_name_2	Name of the 2nd button	Male head	-
X_axis_button_name_3	Name of the 3rd button	Female pelvis	-
X_axis_initial	Value on the x-axis in the initial view	1	0
Checkbox_off_folder_name	Folder name of the images that appear with checkbox off	Sectioned images	Volume models
Checkbox_on_folder_name	Folder name of the images that appear with checkbox on	Color-filled images	Reference sectioned images
Y_axis_initial	Value on the y-axis in the initial view	851	0

R = red, G = green, B = blue.
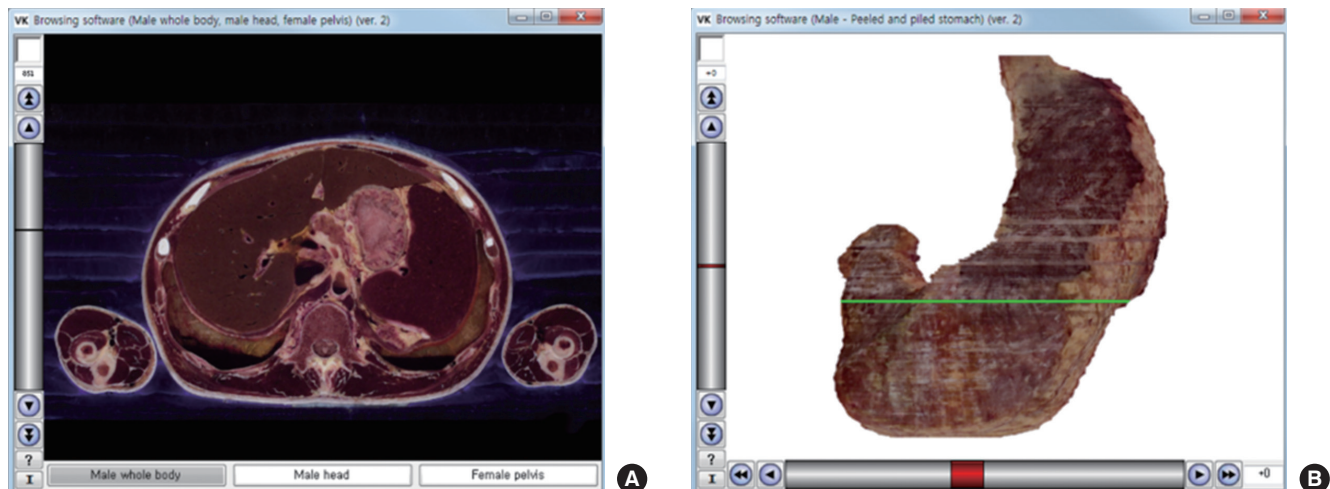
Fig. 1. Initial views of the 2 new browsing software packages. (**A**) The software shows horizontal sectioned image with the x-axis represented by the 3 buttons. The image file shown in the initial view is named "1_851.png." The "1" indicates the first button (male whole body), and "851" indicates the 851st sectioned image. (**B**) The software shows stomach volume model with the x-axis as the scroll bar. The image file shown in the initial view is named "0_0.png," where the first "0" indicates 0 degrees of rotation and the second "0" indicates the volume model with no peeling or piling.

**Table 2.** Significant variants in config.txt of the 2 browsing software packages

Data sets	X-axis (horizontal direction on screen)	Y-axis (vertical direction on screen)	Checkbox
Horizontal images	To select one among male whole body, male head, female pelvis (buttons)	To select levels of images (scroll bar)	To show color-filled images
Stomach images	To rotate stomach (scroll bar)	To peel and pile stomach (scroll bar)	To show a reference sectioned image
Knee images	To select one among slightly dissected knee, moderately dissected knee, much dissected knee, and flexed knee of embalmed cadaver (buttons)	To rotate knee (scroll bar)	To show images of fresh cadaver

fixed in config.txt. To decide the initial view, the code of x-axis button (value 1) or coordinate of the x-axis scroll bar (value 0) was designated in config.txt (Fig. 1; Tables 1 and 2).

The second interface on the y-axis was the scroll bar. The third interface located above the y-axis scroll bar was a checkbox. The folder names of the images appearing with checkbox off/on were listed in config.txt. To decide the initial view (checkbox off), the y-axis coordinate (value 851 or 0) was designated in config.txt (Fig. 1; Tables 1 and 2).

Apart from the program files, the data files refer to the image files to be shown on the software. Five major image formats were readable using this software: portable network graphics (PNG), bit map (BMP), graphics interchange format (GIF), joint photographic experts group (JPEG), and tagged image file format (TIFF). It was because most of viewer software used the 5 standardized formats; these formats were reliable for creating and using software because they had an authorized library.

The image files in 2 corresponding folders were named based
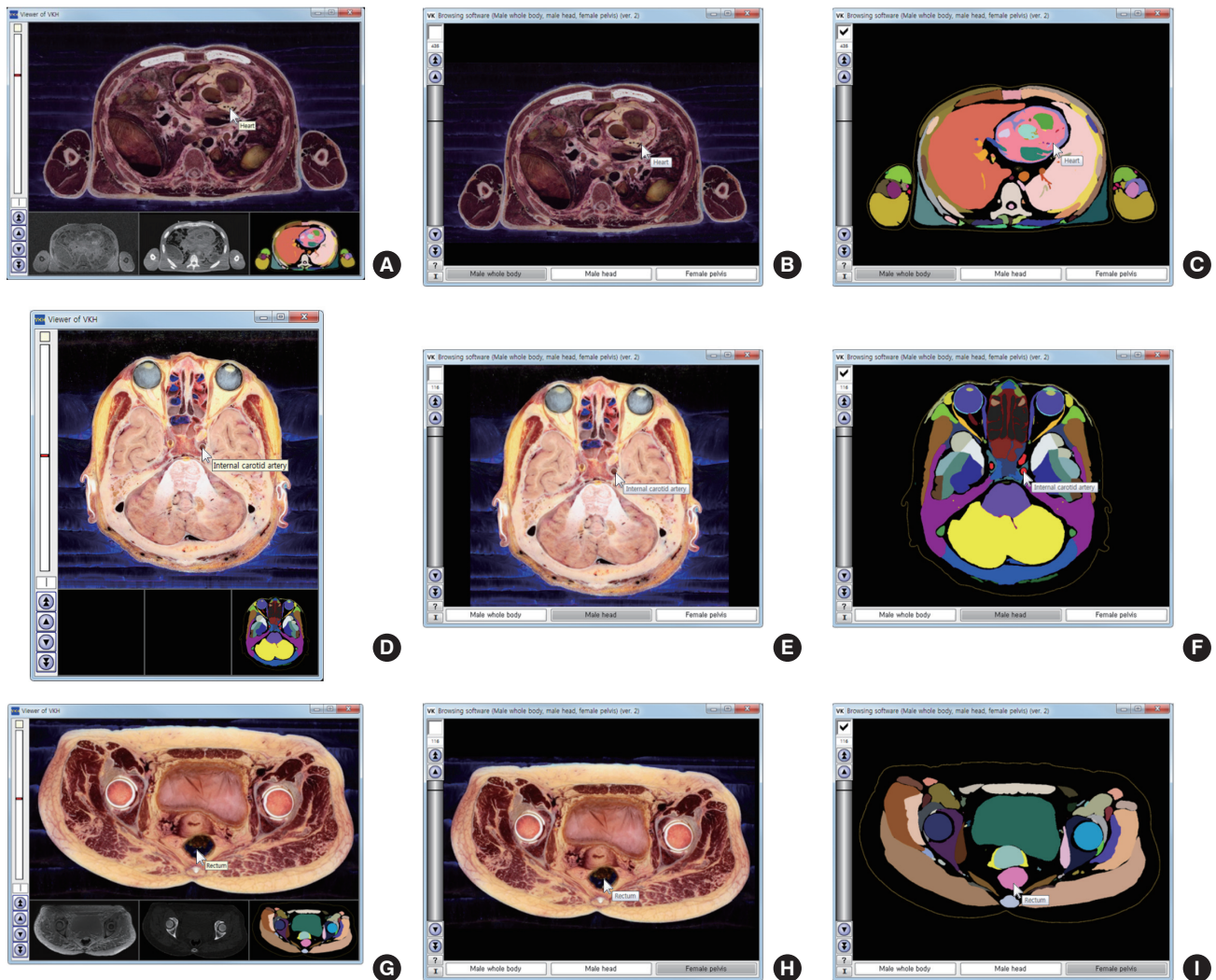
Fig. 2. Comparison of previous and new software that automatically label the names of the outlined structures of 3 cadavers. (**A**, **B**, **C**) Male whole body. (**D**, **E**, **F**) Male head. (**G**, **H**, **I**) Female pelvis. (**A**, **D**, **G**) Previous software to simultaneously show the sectioned and color-filled images. (**B**, **E**, **H**) New software to show the sectioned images when the checkbox is off. (**C**, **F**, **I**) New software to show the color-filled images when the checkbox is on.

on the x-axis interface. If the x-axis used buttons, the image file name (e.g., 1_851) consisted of the x-axis button code (value 1) and the y-axis coordinate (value 851). If the x-axis used the scroll bar, the image file name (e.g., 0_0) consisted of the x-axis coordinate (value 0) and the y-axis coordinate (value 0) (Fig. 1; Table 1).

One powerful function of the software was to automatically label the names of the outlined structures (Fig. 2). This was possible by referring to both the color-filled images and color.txt. In color.txt, every color-filled structure's name and its red, green, and blue values were listed. Two software packages of the stomach and knee images did not include the color-filled images, so this function was not feasible, and color.txt was meaningless (Figs. 3 and 4; Table 2).

The software also had a help function so that clicking the "?" button at the left bottom (Fig. 1) revealed help.txt. The txt file was written not only about how the software could be used by clients but also about how the image data and config.txt could be changed (Table 1) by other investigators.

After the software programming was finished, 3 data sets of the images, prepared in the Visible Korean laboratory, were inputted (Table 2).

Input of the horizontal images

The sectioned images and color-filled images of the male whole body (10), the male head (11), and the female pelvis (12) were inputted into the software. The software was configured such that the x-axis buttons were used to select one of the 3 subjects (male whole body, male head, and female pelvis). The serial sectioned images (intervals of 1 mm) were selected using the y-axis scroll bar. The sectioned images and corresponding color-filled images were selected using the checkbox (Fig. 2; Tables 1 and 2).
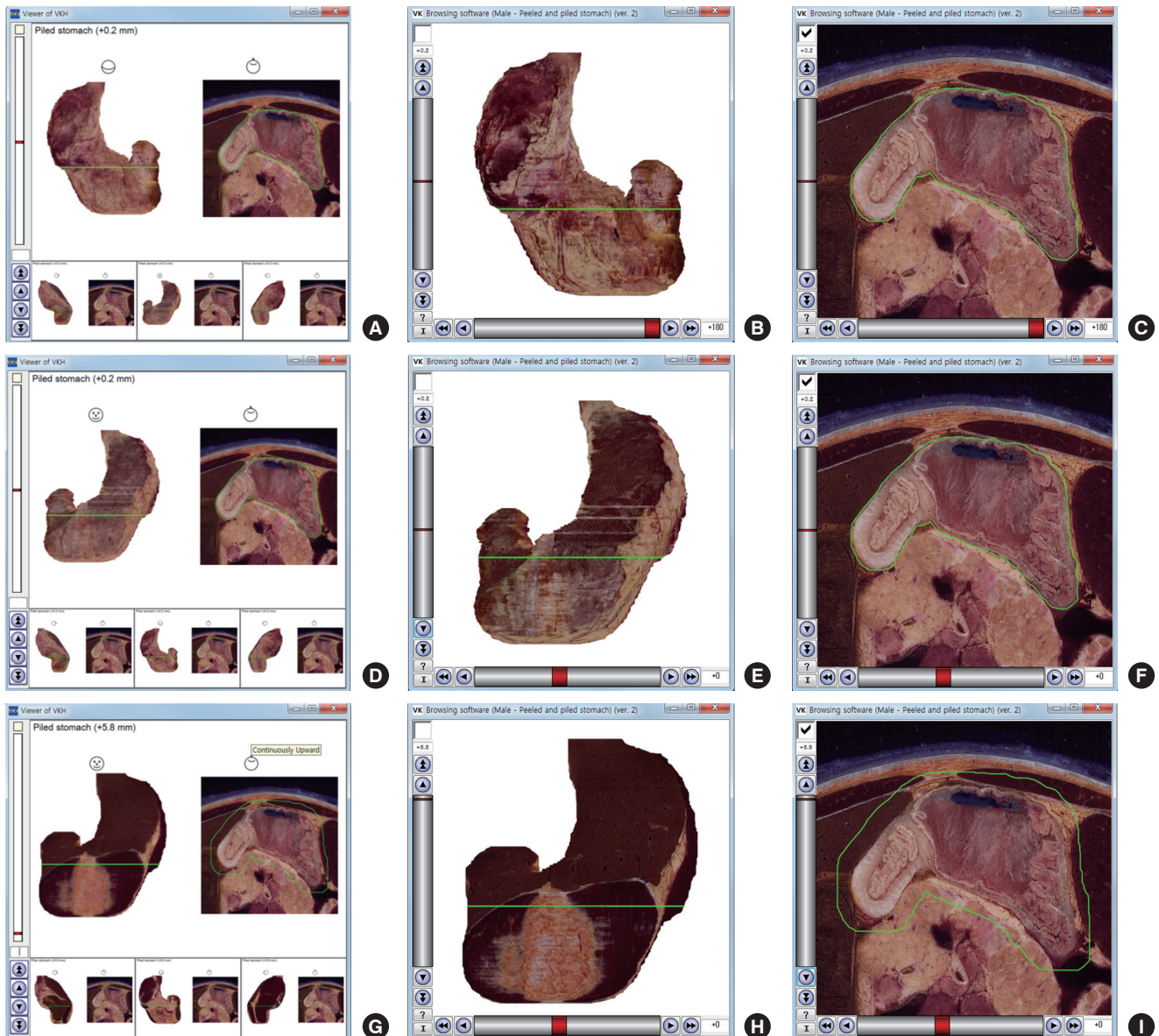
Fig. 3. Comparison of previous and new software that show the volume models and sectioned images of stomach. (**A**, **B**, **C**) Posterior view of stomach. (**D**, **E**, **F**) Anterior view of stomach. (**G**, **H**, **I**) Anterior view of piled stomach. (**A**, **D**, **G**) Previous software to simultaneously show the volume models and the sectioned image of the stomach. (**B**, **E**, **H**) New software to alternatively show the volume models when the checkbox is off. (**C**, **F**, **I**) New software to alternatively show the sectioned image when the checkbox is on.

Input of the stomach images

The peeled and piled volume models of the stomach, accompanied by a reference sectioned image (13), were inputted into the software. The serial rotated volume models (intervals of 30 degrees) were selected using the x-axis scroll bar. The piled and peeled volume models (intervals of 0.4 mm) were selected using the y-axis scroll bar. The piling and peeling thickness was designated with plus (+) and minus (−) signs. The checkbox was used to display the reference sectioned image with a green line to indicate the extent of piling and peeling (Fig. 3; Tables 1 and 2).

Input of the knee images

Images of dissected and then flexed knees from 2 subjects (em-balmed and fresh cadavers) (7) were inputted into the software. The x-axis buttons were used to select views of the slightly dissected knee, moderately dissected knee, much dissected knee, and flexed knee. The y-axis scroll bar selected serial rotated views of the knee (intervals of 5 degrees). The checkbox was used to select either the knee from the embalmed cadaver (initial view) or the knee from the fresh cadaver, which did not necessarily correspond to one another (Fig. 4; Table 2).

RESULTS

Three new browsing software packages (compressed as ZIP files) could be freely downloaded from our homepage (anatomy.co.
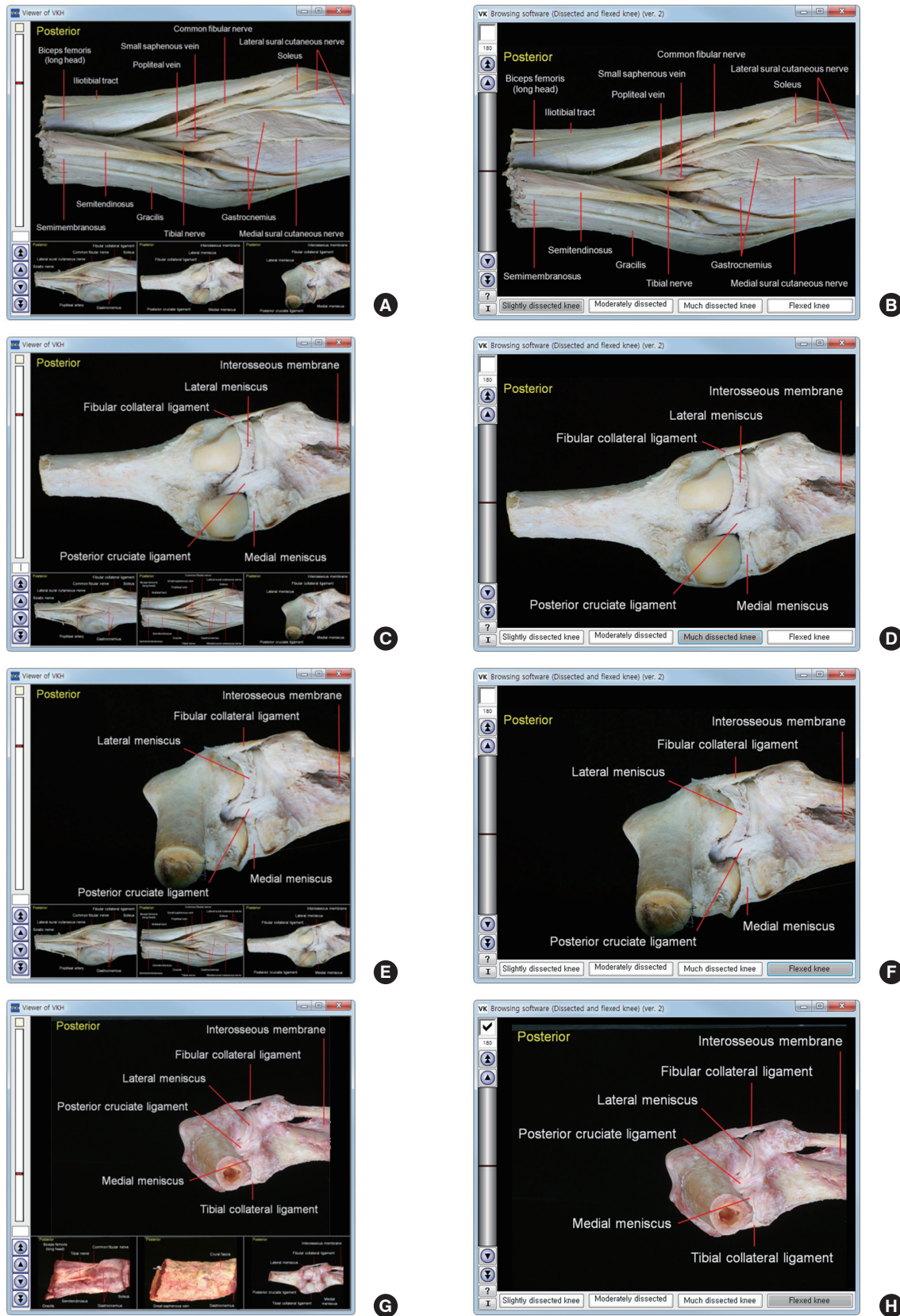
Fig. 4. Comparison of previous and new software that show cadaveric knees. (**A**, **B**) Slightly dissected knee of embalmed cadaver. (**C**, **D**) Much dissected knee of embalmed cadaver. (**E**, **F**) Flexed knee of embalmed cadaver. (**G**, **H**) Flexed knee of fresh cadaver. (**A**, **C**, **E**, **G**) Previous software. (**B**, **D**, **F**, **H**) New software.

kr) without registration: male whole body, male head, and female pelvis (ver. 2); male peeled and piled stomach (ver. 2); and dissected and flexed knee (ver. 2). Once the compressed ZIP files were extracted, the programs could be used on the Microsoft Windows environment without installation. Each software package consisted of the program files, config.txt (Table 1), color.txt, help.txt and the 2 folders containing image files.

Images could be selected by clicking the buttons or using the scroll bar. The chosen button was highlighted; the x- and y-coordinates of the selected image were shown on the 2 axes. The scroll bar function could be substituted by typing an image number. The neighboring images could be browsed stepwise or continuously by clicking the arrow buttons. If the checkbox was clicked, the image switched to the corresponding one. At any time, the initial image was brought back by clicking the "I" button on the left bottom corner of the window (Figs. 1-4; Table 2).

In the case of the stomach, serial rotated images were browsed with the x-axis scroll bar because the rotation axis was vertical (Fig. 3). However, in the case of the knee, serial rotated images were browsed with the y-axis scroll bar because the rotation axis was horizontal (Fig. 4; Table 2).

The selected image could be zoomed in or zoomed out by rolling the mouse wheel. The zoomed in image was shifted by moving the mouse with its left button pressed.

If the user located the mouse pointer on a structure in the color-filled image, the structure's name was shown as the tool tip text beside the mouse pointer. The structure's name could also be seen in the sectioned image because the 2 images were equivalent with each other (Fig. 2).

All the software testing was performed in real time because the software was operated off-line rather than on-line and because the image files were saved as PNG files with a small file size and a reduced image resolution. Nevertheless, in the case of horizontal images, the reduced resolution (1,920 × 1,080) was as good as that of a high-definition television (Fig. 1A).

The software supported dynamic windows of various resolutions. It also supported window dragging mode in the corner or either side of monitor. If the window was dragged from either side; the buttons, scroll bars, and check box were dynamically changed.

DISCUSSION

The software we designed is an improvement over tools traditionally used for displaying medical images. In this study, the software contains 4,376 (= [1,702 + 235 + 251] × 2) horizontal images, 8,784 (= 72 × 61 × 2) stomach images, or 576 (= 4 × 72 × 2) knee images. The numerous serial medical images cannot be displayed easily in a printed book or in existing viewer software, which shows pictures one by one.

The new software features 2 axes (Table 1) compared to a single y-axis found in previous software (Fig. 2). The x-axis buttons function to choose the subjects (male whole body, male head, and female pelvis). These buttons enable us to unite 3 individual software packages (4-6) into one (Fig. 2).

On the other hand, the x-axis scroll bar has the merit to browse numerous images conveniently. The x-axis scroll bar allows a view of the stomach for every 30 degrees of rotation relative to every 90 degrees in the previous software (Fig. 3) (13). It is also possible to use the x-axis scroll bar with the 3 subjects, in which case the scroll bar handle elongates to occupy one-third of the length (Fig. 5).

Installation of the setup file results in production of the image data, which can then be copied and utilized freely (e.g., lecture slide or examination). The authors have kept the images available free of charge for the benefit of medical education.

Any investigators can change the software by replacing the included image data with their own images. For example, CT and MRI data of normal and diseased persons could be inputted into the software. Such flexibility might be useful for various needs in medical education (14,15).

In order to replace data, it is necessary to follow the procedure described. First, image file names should be labeled with an x-axis value and a y-axis value (Fig. 1). Second, config.txt should be modified using Table 1 as a guide. Third, for the color-filled images, color.txt should be filled with structure names and their color values. Finally, help.txt can be modified to meet the needs of the users.

The previous software (ver. 1) has the ability to simultaneously show 4 corresponding images, which can be easily compared

Fig. 5. Experimental software to show the sectioned images of 3 cadavers with the x-axis scroll bar. (**A**) Male whole body. (**B**) Male head. (**C**) Female pelvis.

with one another (4-6); this is not possible with the new software (version 2), which alternatively shows 2 corresponding images using the checkbox (Figs. 2-4). Other developers can select either software package, considering the characteristics of their own images to be inputted. Therefore, we still offer the previous software on the same website.

Totally different way is for other researchers to develop new software with enhanced features. In the case of non-commercial products, it would be useful to allow data replacement as we have done with our software.

The present study describes the development of new software to browse medical images with convenient functions and describes in detail the methods of using and modifying the software. We expect that the software will contribute to medical education and possibly to other kinds of pedagogy, for example, to teach people about the human body as part of an exhibit in a science museum or natural history museum.

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DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Conceptualization: Kwon K, Chung MS, Park JS, Shin BS, Chung BS. Data curation: Kwon K, Chung BS. Formal analysis: Kwon K, Chung BS. Investigation: Kwon K, Park JS. Writing - original draft: Kwon K, Chung MS, Park JS, Shin BS, Chung BS.

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