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Volume Measurement of Various Tissues Using the Image J Software

Eun Young Rha, MD, Ji Min Kim, MD, and Gyeol Yoo, MD, PhD

Abstract: Various methods have been introduced to assess the tissue volume because volumetric evaluation is recognized as one of the most important steps in reconstructive surgery. Advanced volume measurement methods proposed recently use three-dimensional images. They are convenient but have drawbacks such as requiring expensive equipment and volume-analysis software. The authors devised a volume measurement method using the Image J software, which is in the public domain and does not require specific devices or software packages. The orbital and breast volumes were measured by our method using Image J data from facial computed tomography (CT) and breast magnetic resonance imaging (MRI). The authors obtained the final volume results, which were similar to the known volume values. The authors propose here a cost-effective, simple, and easily accessible volume measurement method using the Image J software.

Key Words: Breast, image J, orbit, volume measurement

Volumetric evaluation is one of the most important steps in planning for plastic and reconstructive surgery. The aesthetic aspects of breast and craniofacial reconstruction have been well recognized compared with other areas of soft-tissue reconstruction because they are the representative areas in which symmetry should be considered. The assessment of the volume change of the orbital cavity for orbital content is important for the correction of enophthalmos.[1,2] In breast reconstruction, preoperative measurement of the breast volume is essential for symmetric and aesthetic reconstruction.[3]

Various strategies for volume measurement have been reported. Recently, advanced methods using three-dimensional (3D) reconstructed images have been introduced.[2,4] To calculate the volume using these methods, surgeons should use specific devices such as laser scanning machines, camera, or the software packages that reconstruct images into a 3D model or automatically calculate the volume based on computed tomography (CT) or magnetic resonance imaging (MRI). These devices are convenient to use and can verify accuracy, but are expensive and require specific volume-analysis software.

We suggest a novel and easily accessible method for volume assessment using the freely available Image J software.

TECHNICAL NOTE

The authors used the "Image J" software, which is a public domain, Java-based image processing software package developed at the National Institutes of Health (NIH)[5] to measure tissue volume. The process of volume assessment consisted of 3 steps. The first step is to calculate the pixel number per unit area (1 cm^2). The second step is to measure the area of the region of interest (ROI) using the ratio of pixel number per unit area. The final step is to calculate the volume using the method of the Integral (Fig. 1).

The selected images were opened using Image J and the number of pixels in each image was determined. A regular square with the same side length (5 cm) of the reduced scale was drawn. The area of the regular square was 25 cm^2. Next, the pixel number (P) in this square was counted. When P was divided by 25 cm^2, the pixel number per 1 cm^2 (P_1) was obtained (Fig. 2). After the ROI was established using a free-line drawing tool, the pixel number (P_{ROI}) was also determined (Figs. 3-4). Next, we calculated the ROI area as P_{ROI}/P_1 cm^2. The ROI area was multiplied by the thickness of the images to calculate the volume of each section. All of the sections were calculated in the same way, and the values were summed.

From the Department of Plastic and Reconstructive Surgery, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea.

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Address correspondence and reprint requests to Gyeol Yoo, MD, PhD, Department of Plastic Surgery, Yeouido St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 10, 63 ro, Yeoungdeungpo-Gu, Seoul 150-713, Republic of Korea;
E-mail: psyg@catholic.ac.kr

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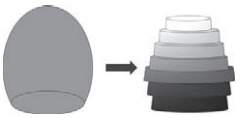

FIGURE 1. The principle of the integral. To calculate the volume, the bell-shaped model is divided into many cylinders. The volume is approximated by the sum of volume of each cylinder.

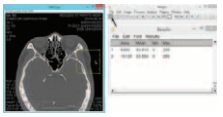

FIGURE 2. Calculation of the pixel number per unit area using the Image J software. A square with the length of the reduced scale (5 cm) in an axial section of a computed tomography image was drawn. The number of pixels inside the square was calculated to be 15,129 using the rectangular selections tool (black arrow). The number of pixels per unit area (1 cm^2) was 605.16.

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Orbital Volume

Axial images of the orbit were obtained from facial CT. The pixel number of the regular square with the length of the reduced scale (5 cm) was counted as 15,129 (Fig. 2). The pixel number of 1 cm^2 was 605.16. Next, we established the ROI by drawing a line and calculated the pixel numbers of the ROI in each section (Fig. 3). To calculate the area of the ROI, the pixel number of the ROI was divided by 605.16. The resulting value was multiplied by 0.15 cm, which is the thickness of each section of the CT scan. The volumes of all of the orbit sections were summed. The final volume was measured as 30.13 mL, which agreed with the known orbital volume of ~30 mL.

Breast Volume

Axial images of the breast were obtained from breast MRI of a patient whose breast volume had been measured as 880 mL after modified radical mastectomy. The pixel number of the regular square with the length of the reduced scale (5 cm) was counted as 5625. The pixel number of 1 cm^2 was 225, and the pixel number of the ROI was 21,129 (Fig. 4). The final area of the ROI was 93.906. The resulting value was multiplied by 0.4 cm, which is the thickness of each section of the breast MRI. The volumes of all of the breast sections were then summed. The final volume was measured as 892.60 mL, which was an approximation of the known breast volume.

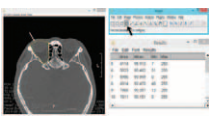

FIGURE 3. Orbital volume measurement using the image J software. A curved line (white arrow) was drawn along the orbit on the axial section of a computed tomography image using the freehand selection tool (black arrow). The number of pixels inside the region of interest was determined.

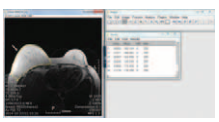

FIGURE 4. Breast volume measurement using the Image J software. We established the ROI of the breast tissue on axial sections of magnetic resonance images by drawing a line (white arrow). The number of pixels inside the ROI was determined. ROI, region of interest.

DISCUSSION

The increasing importance of the accurate assessment of tissue volume in plastic surgery has resulted in considerable progress in calculating the volume.[2,4] Among the natural shape methods, the stereological method, geometrical methods, and mathematical modeling methods, 3D data obtained from CT or MRI and 3D scanners were recently recognized as the most accurate and reliable method.[6,7] However, when suitable instruments or volume analysis software are not available, and only CT or MRI images can be obtained, if the ROI area is known, the volume can be calculated using the integral. We devised the current volume measurement method based on the calculation of the ROI area using Image J, a method commonly used in the laboratory.

Image J was designed with an open architecture that provides extensibility via Java plugins and recordable macros.[8] User-written plugins make it possible to solve many image processing and analysis problems, from 3D live-cell imaging to radiological image processing, and multiple imaging system data comparisons to automated hematology systems.[9,10]

Volume assessment using the Image J software is easily available because it is public-domain software, and it is cost effective because no expensive device or volume analysis software is required. Additionally, for our patients, volume assessment using the Image J software was also accurate because the final volume results were in agreement with known volumetric data of orbits and breasts, although the accuracy and reliability should be verified.

This method has the difficulty in the setting of anatomical boundaries as with the other methods using CT or MRI, which can lead to inaccurate results. Because the calculation of the ROI should be performed on all of the selected images, the method is time consuming. The thickness of image sections can affect the accuracy of the results. Thinner images are more accurate but more inconvenient to use. Although this method has several limitations, volume assessment using the Image J software is a cost-effective, simple, and easily accessible method. We recommend it as an alternative method for volume measurement in various regions.

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