Computed Tomography Technique for Evaluation of the Nasal Valve

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Objective: To compare measurements of the nasal valve on computed tomographic images obtained in the traditional coronal imaging plane with those obtained using the Nasal Base View (NBV) for evaluation of the sinonasal cavities.

Methods: Thirty computed tomograms of the sinuses were evaluated retrospectively. Coronal re-formations were performed in a plane perpendicular to the hard palate at the most anterior aspect of the nasal bones at the nasal dorsum. Re-formations of the NBV were performed in a plane perpendicular to the anterior aspect of the estimated acoustic axis. Measurements of the nasal valve angle were performed for both imaging planes in each patient.

Results: Nasal valve angles measured in the traditional, coronal plane were found to have an angle of $8.3^\circ \pm 2.0^\circ$ (mean ± SD). Nasal valve angles measured in the NBV had an angle of $11.4^\circ \pm 2.6^\circ$. A significant difference was demonstrated ($P < .001$).

Conclusions: The traditional coronal computed tomograms of the sinonasal cavities may underestimate the true nasal valve angle. The NBV may provide a more accurate assessment of the nasal valve, as the measured angles of the nasal valve in this plane were found to be more consistent with classic descriptions of $10^\circ$ to $15^\circ$.

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COMPUTED TOMOGRAPHY (CT) has been proposed to be an objective test that can be used to measure the nasal valve and airway. However, it has not gained universal acceptance in terms of clinical usefulness. It can provide needed anatomical information, but the traditional coronal scanning plane is not at an optimal angle for accurate assessment of the nasal valve (Figure 1). Depending on the scan plane and the specific image chosen for measurement, the nasal valve can be poorly estimated. These images not only have the potential for misleading rhinologists and facial plastic surgeons, they also correlate poorly with the anterior rhinoscopy performed on clinical examination.

Cakmak et al established a nasal airway model to study the acoustic axis of the nasal airway and applied this to coronal CT images of the nasal passage. The acoustic axis represents an arc in the middle of the nasal passage, corresponding to the pathway of nasal airflow as measured by acoustic rhinometry. This arc represents the natural physiologic airflow through the nasal vault. Air enters at the level of the nares and gently arcs superiorly above the head of the inferior turbinate, with the main flow of air traversing the area of the middle meatus (Figure 2). Cakmak et al’s study demonstrated that CT images obtained in a plane perpendicular to the acoustic axis showed a higher correlation between the findings of acoustic rhinometry and the nasal valve area than images obtained in a plane perpendicular to the floor of the nasal cavity (hard palate).

The objectives of our study were to further evaluate this method of assessing the nasal valve using a CT scan plane perpendicular to the acoustic axis of the nasal passage, referred to as the Nasal Base View (NBV), and then to compare measurements of the nasal valve angle obtained in that plane with those obtained using the traditional coronal scan plane.

**METHODS**

Thirty high-resolution axial CT studies (60 nasal valves) of the sinonasal cavities obtained for image-guided sinus surgery were retrospectively reviewed. The axial CT studies were obtained with late-generation, 16-channel, multislice CT scanners (LightSpeed; General Electric Medical Systems, Milwaukee, Wis) at a slice thickness of 1 to 1.25 mm in bone algorithm. Axial slices were obtained from the top of the frontal sinuses to the bottom of max-
illary incisors. The studies were chosen randomly, and no correlation to diagnosis or indication was made. Patients with significant prior facial trauma were excluded from the study.

The axial data were transferred for postprocessing to a commercially available workstation (General Electric Medical Systems). Reformatted images in the standard coronal plane and in the NBV were made at 1-mm intervals and at a slice thickness of 0.5 mm. The standard coronal reformatted images were obtained perpendicular to the hard palate (Figure 1A). The acoustic axis was then estimated on a sagittal reformatted image based on the results of Cakmak et al,3 who showed that the axis passes through the center of the nasal passage in an arc (Figure 2A). The reformatted images of the NBV were obtained perpendicular to the anterior aspect of the estimated acoustic axis (Figure 2).

Once the appropriate plane and location of the nasal valve were identified on sagittal images, attention was turned to the coronal reformatted images. Measurements of the nasal valve angle were made from the anterior-most edge of the soft tissue on the image, through the nasal airway, averaging the irregularities in the medial and lateral soft tissues (Figures 1B and 2B). Two of us (D.M.P. and B.O.M.) reviewed each image simultaneously for each nasal valve.

A paired t test was performed to compare the mean values of the nasal valve angles obtained in the NBV with those in the traditional coronal plane.

The data were reviewed and compiled, with comparison of the traditional coronal plane and the NBV. Nasal valve angles measured in the traditional coronal plane were found to have a range of 3.8° to 15.8°, with an angle of 8.3±2.0° (mean±SD). Nasal valve angles measured in the NBV had a range of 5.6° to 16.5°, with an angle of 11.4±2.6°. A significant difference between the nasal valve angles obtained from the 2 imaging planes was demonstrated using a paired t test (10.04; P<.001).

Scans obtained using the NBV demonstrated imaging features that more closely approximated the view obtained on anterior rhinoscopy (Figure 3). Qualitatively, the NBV offered a sharper image of the nasal valve region, with less soft tissue distortion due to volume-averaging effects.

The nasal valve area represents the most narrow segment of the nasal airway. It is defined as the area bounded...
by the caudal end of the upper lateral cartilage, cartilaginous nasal septum, piriform aperture, floor of the nose, and head of the inferior turbinate. The nasal valve, which is a portion of the nasal valve area, is the area of highest airway resistance. The nasal valve angle is the angle between the upper lateral cartilage and the nasal septum. Anatomical studies have shown that in the white nose this angle classically ranges between 10° and 15°. Improving or correcting the nasal valve angle has been an active area of interest for surgeons who perform functional rhinoplasties.

The initial evaluation of the nasal valve occurs with the clinical examination. Anterior rhinoscopy with a nasal speculum, the Cottle maneuver to evaluate nasal valve collapse, and endoscopy are all used clinically to assess nasal airflow. However, all of these methods are subject to examiner variability and therefore lack objectivity. Computed tomographic imaging can provide needed anatomical information, but conventional coronal scans are not performed at the optimal angle to accurately assess the nasal valve. Also, the nasal valve region is often missed during traditional CT scanning of patients to evaluate the sinuses and septum, as it is quite anterior in location and may not be included in the imaging field.

Previous studies have evaluated the nasal valve and the nasal valve angle with coronal CT images; however, many of these studies using CT and magnetic resonance imaging have been performed to validate other objective test results, not to aid in clinical decision making. These studies have used various imaging parameters with no universal standardization of either the plane of the image or the landmarks that are used as anterior and posterior guides. Of those studies that specify the anatomical landmarks that are used to standardize the imaging, the most commonly referenced are the anterior nasal spine and the tip of the nose. The imaging plane that is most commonly referred to is a coronal plane that is perpendicular to the hard palate; however, there have been other studies that have based the imaging plane on the acoustic wave. Depending on the specific image that is chosen in a study in which the traditional coronal CT plane is used, the true nasal valve angle may be underestimated because of the plane in which the image is obtained. These images not only have the potential for misleading rhinologists and facial plastic surgeons, they also correlate poorly with the anterior rhinoscopy findings. In contrast, the NBV is essentially a representative image of the nasal valve region taken perpendicular to the view that is obtained during anterior rhinoscopy with the patient's head positioned as during photography of the nasal base (Figure 3). Anatomical information presented in this image plane may be more familiar and clinically useful to the surgeon. Interestingly, the studies that have used CT images obtained perpendicular to the estimated or calculated acoustic wave rather than the traditional coronal plane show a higher correlation with objective measures such as acoustic rhinometry.

We believe that the NBV may provide a more accurate assessment of the nasal valve, as, in the present study, the measured angles of the nasal valve in the NBV were found to be more consistent with the classic anatomical descriptions of 10° to 15°. Computed tomography is a safe, noninvasive method of imaging the nasal valve. High-quality reformatted images in any plane can easily be obtained if the original data are obtained at thin slice thicknesses (0.5-1.25 mm). Accurate measurements of the nasal valve angle can then be obtained from these reformations. Also, the NBV provides a more focused view of the nasal valve, with less soft tissue artifact, and more closely represents the view of the nasal valve region that is seen by the examiner in the clinic and operating room settings.

Limitations of the CT technique include the subjective nature in which angle measurements are taken. The NBV is based on the subjective approximation of the acoustic axis. The reproducibility of the NBV has not yet been addressed and must be established before the technique can be applied to clinical practice. Also, the lack of correlation between patient symptoms and nasal valve measurements currently limits the clinical applicability of this technique. Another limitation of the present study is the selection bias that was involved in the patients who were included in the study. All individuals were patients of the otolaryngology clinic and
underwent CT imaging of the sinuses for various indications. This study cohort may not be truly representative of the normal adult population.

Despite these limitations, we believe that the NBV may be a valuable new tool that can be used to evaluate the nasal valve objectively and to provide the clinician with valuable anatomical information. Future studies are needed to correlate the NBV with clinical examination findings, patient symptomatology, and disease-specific quality-of-life scores. Also, longitudinal studies should be carried out in which the NBV would be used as the primary outcome measure for evaluating the ability of various nasal valve surgery techniques (eg, spreader grafts) to alter the nasal valve angle.

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