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Gia Oscherwitz and Julia Denys
Advised by Dr. Samuel Oyer and Dr. Patrick Cottler

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Establishing a Quantitative Method for Evaluating Nasal Valve Collapse to Guide Surgical Outcomes

Gia Oscherwitz[1,2], Julia Denys[1], Dr. Sam Oyer,[2] and Dr. Patrick Cottler[2]

[1] University of Virginia Department of Biomedical Engineering
[2] University of Virginia Health System, Department of Otolaryngology

Abstract

Nasal valve collapse (NVC) is a major contributor to nasal airway obstruction, affecting nearly five million individuals in the United States annually. Despite its prevalence, current diagnostic methods—such as the modified Cottle maneuver and patient-reported symptoms—lack objective, reproducible metrics, resulting in variability in clinical decision-making and surgical outcomes. This study aimed to develop and evaluate a caliper-based system for measuring nasal valve width as a quantifiable marker of nasal valve function in both clinical and operative settings. A pilot study was conducted in an academic otolaryngology clinic involving adult patients diagnosed with NVC and scheduled for nasal valve repair. Nasal valve width was measured using a Castroviejo caliper at two anatomical zones: Zone 1 (internal nasal valve) and Zone 2 (external nasal valve). Measurements were obtained at four timepoints: the initial pre-operative visit at rest, during the modified Cottle maneuver, intraoperatively after surgical repair, and at the 1-week post-operative follow-up. Data were captured using a custom REDCap database designed to support structured, multi-variable clinical data collection. Post-operative results demonstrated consistent increases in nasal valve width across patients, typically ranging from 0.5 to 2.0 mm. In Zone 1, width gains were variable and often fell short of modified Cottle-predicted values, likely reflecting anatomical constraints or comorbidities. In contrast, Zone 2 exhibited larger and more consistent gains, frequently surpassing pre-operative predictions and remaining stable at the 1-week follow-up. These trends support the modified Cottle maneuver as a predictive tool for Zone 2 but not Zone 1. Usability testing of the Castroviejo caliper revealed high scores in sterilization, reliability, and portability, but lower ratings in ergonomics and ease of use. This system therefore shows promise for standardizing surgical planning and diagnosis, particularly in resource-limited settings. Future work will validate this approach in larger cohorts and refine device design for clinical integration.

Keywords: Nasal Valve Collapse (NVC), Nasal Airway Obstruction, Objective Surgical Assessment, Modified Cottle Maneuver, Caliper-Based Measurement, Facial Plastic Surgery, Otolaryngology, Cartilage Grafting, Clinical Usability Testing

Introduction

Every year, nearly 20 million people across the United States experience nasal airway obstruction, with one in four diagnosed individuals attributing their symptoms to Nasal Valve Collapse (NVC).[1,2] NVC can occur due to injury, surgery, or anatomical differences, causing patients to experience trouble breathing, nasal congestion, and may change the appearance of the nose.[3,4] This is due to the narrowing of the airway, as the tissue—mainly cartilage—in the nose weakens or extensive inflammation, swelling, or scar tissue extends into the nasal cavity.[5] NVC can occur in Zone 1—higher on the nose, where sidewall movement involves the upper lateral cartilage and scroll region, an area that flexes more during breathing—or in Zone 2, lower down near the nostril, which resembles the more traditional form of external valve collapse (Figure 1).[6] The current assessment of nasal valve patency is largely subjective, relying on clinical assessments, patient descriptions, and visual reports without reliable quantitative metrics. Physicians typically use the Nasal Obstruction Symptom Evaluation (NOSE) questionnaire—which allows a physician to score a patient's clinical presentation on a scale from mild to severe based on medical history and symptoms—and the Standardized Cosmesis and Health Nasal Outcomes Survey (SCHNOS), which allows the patient to evaluate functional and cosmetic nasal issues.[7,8] A physical exam may include the modified Cottle maneuver—where a nasal swab is placed inside the nostril and pulled laterally to provide support while the patient breathes in—and/or a nasal endoscopy.[9] These techniques provide limited, qualitative insights into the presentation of NVC. However, the lack of quantitative methodology indicates that there is a pressing need to develop and validate a simple set of metrics that can objectively evaluate the severity of NVC across a diverse set of patient demographics.

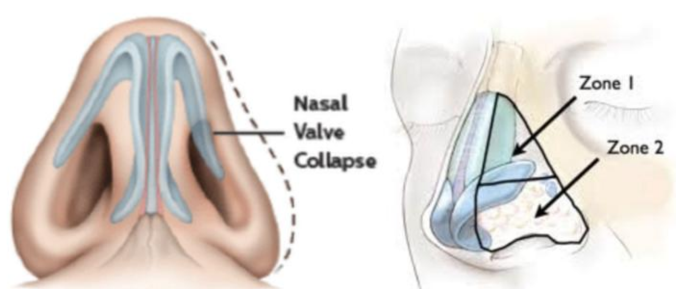


Fig. 1. Visualization of NVC and relevant nasal anatomy. Illustration of NVC presentation and the anatomical locations of Zone 1 (internal) and Zone 2 (external) collapse, where the condition commonly occurs.[4,6]

Since NVC often requires surgical intervention in the context of rhinoplasty, a patient may require structural reconstruction in the form of a cartilage graft, implant, or suture suspension.[4,10] Grafting— normally an Alar Batten, Lateral Crural Strut, or Rim graft—involves harvesting cartilage or bone from an area of the body, typically the ear or rib, and the insertion of this cartilage in the nostril to widen and shape the nasal valve.[10,11] Implants—typically devices or injectables—are designed to support weakened and narrowed cartilage in the nose, while suture suspension anchors the nasal valve tissue to the area beneath the eye for improved structural integrity.[4] Surgeons rely on their expertise and clinical judgement to determine if additional support in the form of cartilage is necessary, leaving room for error and increasing the need for revision surgeries.[10,12] A critical challenge in grafting procedures is therefore the absence of an objective method to assess how much cartilage is required to adequately prevent recurring NVC. Thus, there is a critical need to develop a device that can be used both in the clinic and operating room to enhance surgical planning, thereby improving both functional and aesthetic outcomes for patients.

Several diagnostic tools have been explored to address this need, but each faces significant limitations. High-resolution imaging technologies, such as computed tomography (CT) and magnetic resonance imaging (MRI), are widely used in otolaryngology to visualize nasal anatomy in detail.[13] CT scans in particular allow for accurate measurement of nasal structures, including the nasal valve, and can reveal structural abnormalities contributing to NVC.[14] However, these imaging modalities are expensive, lack functional data on airflow or resistance, and are impractical for routine use due to cost and limited accessibility.[14]

Computed fluid dynamics (CFD) modeling has emerged as an important research tool for simulating airflow dynamics within the nasal cavity, which provides insights into airflow patterns, resistance, and areas of turbulence.[15] CFD enables the simulation of nasal airflow under various conditions and is increasingly used for preoperative planning in complex cases of nasal obstruction. Studies show that CFD models allow clinicians to visualize airflow patterns and predict surgical outcomes more accurately, meaning CFD serves as a surgical planning tool. Although CFD modeling is informative, it requires detailed imaging input, specialized software, and training in software use, making it expensive and time-consuming.[15] Moreover, CFD modeling functions proactively or retrospectively rather than as a real-time diagnostic tool, limiting its use in clinical and surgical settings.

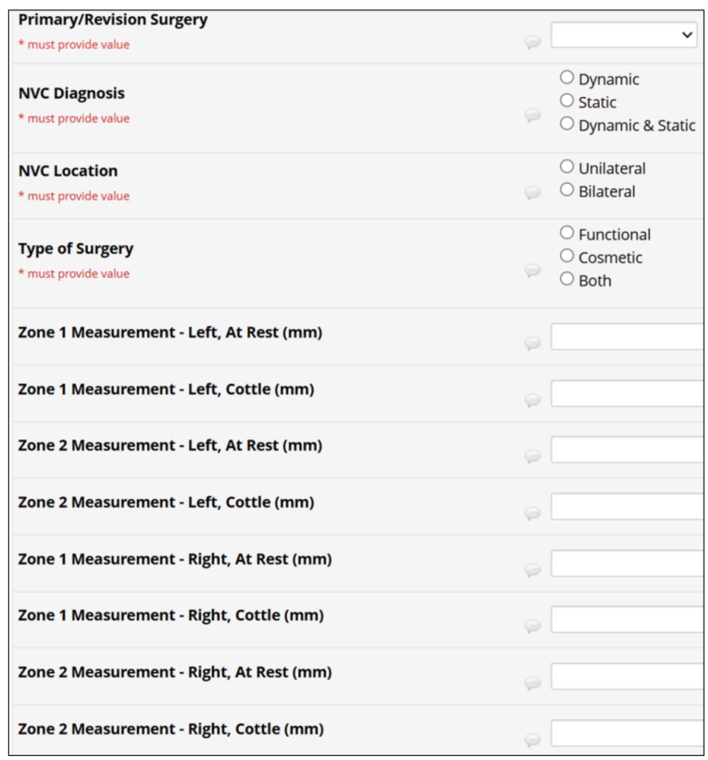
Pressure-sensing technology is widely used in other medical fields but has seen limited application in nasal airway measurement. Although some technologies have been adapted to otolaryngological settings, they were often proven to be inaccurate or too invasive. Intraocular tonometers, for example, measure eye pressure accurately but have not been effectively adapted for nasal applications.[16] Several existing nasal-specific measurement tools, such as the Nasal Peak Inspiratory Flow (NPIF) meter, also provide quantifiable airflow data, but their application is limited in evaluating NVC specifically. NPIF measures peak airflow during inspiration and provides a general assessment of nasal airflow, but it evaluates the entire nasal cavity, reducing specificity for the nasal valve region.[17] This method therefore lacks dynamic measurement capabilities, which are essential to classifying NVC severity.

The advanced tools of acoustic rhinometry and rhinomanometry provide objective assessments of nasal airflow, patency, and resistance by measuring cross-sectional area and airflow dynamics within the nasal cavity.[18] However, these technologies are costly, complex, and require specialized training, limiting their use to specialized clinics and large hospitals. These methods may also be uncomfortable for patients and require a high degree of setup, making them impractical for general clinical and intraoperative use.[18,19]

Despite these technological advancements, no current solution offers a standardized, accessible, and quantitative method specifically designed for real-time assessment of NVC severity. Existing diagnostic approaches either lack specificity for the nasal valve, require expensive equipment, involve substantial training, or fail to capture the dynamic aspects of nasal valve behavior critical for clinical evaluation. As a result, clinicians continue to rely heavily on subjective tests—such as the Cottle or modified Cottle maneuvers, and patient-reported symptom scores like the NOSE and SCHNOS scales—that are inherently inconsistent and have poor reproducibility. To address these gaps, this study focuses on the development and early validation of a portable, low-cost, caliper-based system for objective measurement and evaluation of nasal valve conditions. Specifically, it aims to examine the effectiveness of using nasal valve width as a metric for assessing NVC. The overall caliper-based system aims to provide clinicians with a simple, reproducible, and accessible tool to enhance preoperative evaluation, intraoperative decision-making, and long-term management of NVC.

Results

Nasal valve width was assessed in patients undergoing surgical repair for nasal valve collapse (NVC) using a standardized caliper-based system developed as part of this study. Measurements were taken at two anatomical regions—Zone 1 (internal nasal valve) and Zone 2 (external nasal valve)—at four timepoints: the initial pre-operative clinic visit, intraoperatively before surgical repair, intraoperatively after repair, and at the 1-week post-operative follow-up. This quantitative metric formed the basis for tracking surgical outcomes across patients. General patterns of widening were observed post-intervention, prompting further analysis of how each zone responded to structural correction and how those changes aligned with clinical benchmarks. The following figures illustrate the development of the data-tracking system used in this study and highlight the consistency and variability observed in surgical outcomes.


Primary/Revision Surgery
* must provide value

NVC Diagnosis
* must provide value
Dynamic
Static
Dynamic & Static

NVC Location
* must provide value
Unilateral
Bilateral

Type of Surgery
* must provide value
Functional
Cosmetic
Both

Zone 1 Measurement - Left, At Rest (mm)

Zone 1 Measurement - Left, Cottle (mm)

Zone 2 Measurement - Left, At Rest (mm)

Zone 2 Measurement - Left, Cottle (mm)

Zone 1 Measurement - Right, At Rest (mm)

Zone 1 Measurement - Right, Cottle (mm)

Zone 2 Measurement - Right, At Rest (mm)

Zone 2 Measurement - Right, Cottle (mm)

Fig 2. REDCap database screenshot. Visualization of one section of the REDCap database for the long-term clinical study established during this project.

To support consistent data capture, a custom REDCap database was developed (Figure 2). The interface allows for entry of nasal valve width measurements for both left and right nostrils at each zone across the measured conditions. In addition to biometric data, the database captures essential metadata including NVC classification (dynamic, static, or mixed), whether the case was a primary or revision surgery, and the type of grafting techniques used. These variables were included to support future cross-analysis of outcomes by surgical method and to identify patient-specific patterns of anatomical response.

To first understand the overall impact of surgical intervention on nasal valve patency, intraoperative changes in nasal valve width were analyzed for all patients (n = 11) between the pre-operative (at rest) and post-operative states. These measurements are presented in Figure 3, separated by anatomical zone. In nearly all patients, nasal valve width increased following surgical correction, with the degree of widening varying by zone. In Zone 1, corresponding to the internal nasal valve, most patients experienced modest improvements ranging from 0.5 mm to 1.5 mm. However, a few patients demonstrated more substantial gains, while others showed minimal change or slight narrowing, reflecting greater variability in surgical outcomes within this zone. These more conservative changes are likely reflective of the constrained anatomical boundaries of the internal valve, the limited space for lateral wall displacement, and the impact of comorbidities, such as nasal septal deviation. It is also possible that the presence of mucosal scarring or limited tissue elasticity in certain patients influenced the extent to which the internal valve could be expanded. In contrast, Zone 2—the external nasal valve, including the lateral wall and alar rim—demonstrated a broader and generally more substantial increase in width, with several patients exhibiting gains exceeding 2.0 mm. This is consistent with clinical expectations: external valve collapse is more common and more surgically responsive due to the structural reinforcement possible through techniques such as batten grafts, lateral crural strut grafts, and suture suspension. Notably, the magnitude of response in Zone 2 was more consistently positive across the cohort, supporting the utility of caliper-based measurement for evaluating improvement across a broad range of anatomical presentations.

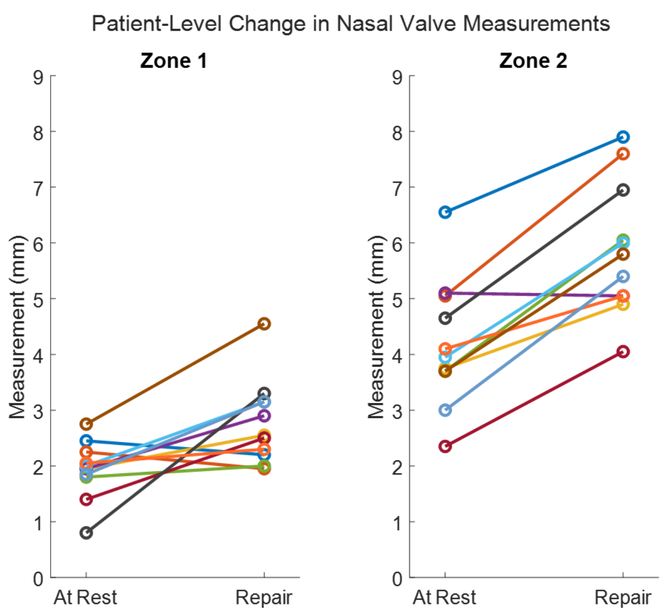


Fig. 3. Patient-level intraoperative nasal valve width measurements by anatomical zone. Each line represents a single patient. Measurements were taken at rest and immediately following surgical repair. Zone 1 (left) shows generally modest width increases, while Zone 2 (right) reveals larger and more variable improvements.

While these intraoperative trends suggest consistent improvements in valve width post-repair, they do not capture how these changes relate to pre-operative diagnostic benchmarks or how they evolve throughout the healing process. To address this, a subset of patients (n = 5) was followed and measured across four timepoints: (1) an at-rest baseline in-clinic, (2) during the modified Cottle maneuver, (3) intraoperatively immediately after surgical repair, and (4) at the 1-week post-operative follow-up. These data are visualized in Figure 4, separated by anatomical zone, and provide a longitudinal view of how structural correction and early healing unfold over time.

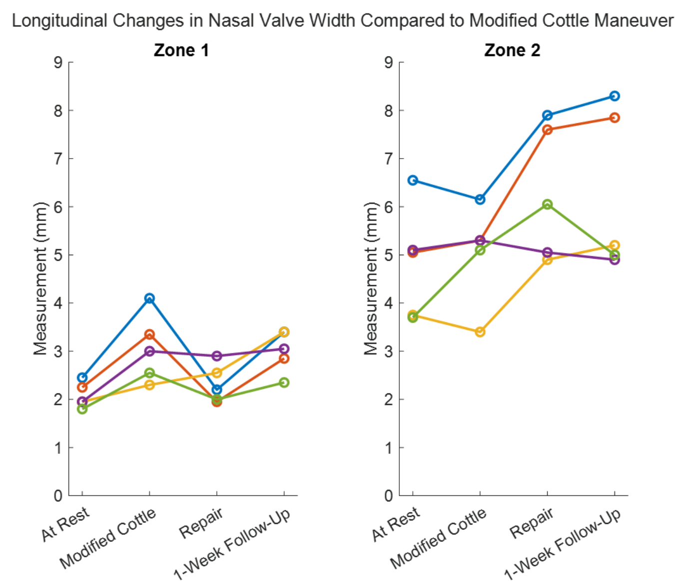


Fig. 4. Longitudinal nasal valve width measurements across four timepoints. Each line represents a single patient. Measurements were taken at rest, during the modified Cottle maneuver, immediately post-repair, and at the 1-week follow-up. Zone 1 (left) shows a lack of alignment between modified Cottle and surgical results, while Zone 2 (right) demonstrates more dramatic and sustained surgical improvements.

Across both zones, nearly all patients experienced measurable increases in valve width post-repair, confirming the consistent anatomical effect of surgery. However, the magnitude, consistency, and clinical implications of these changes differed substantially by zone. In Zone 2—the external nasal valve, comprising the lateral wall and alar rim—all five patients exhibited substantial improvement relative to baseline. In most cases, surgical widths approximated or exceeded those achieved during the modified Cottle maneuver. Notably, these gains were not transient: in three of five patients, widths were maintained or increased further at the 1-week post-operative follow-up. This pattern supports the durability of surgical correction in Zone 2, particularly when batten grafts, lateral crural strut grafts, or suture suspension techniques were employed. The external valve's greater structural flexibility and easier access during surgery likely explain its robust response. The stability of Zone 2 width at follow-up may also provide practical guidance for clinical decision-making, such as when to remove internal nasal splints or assess for signs of early surgical success.

In contrast, Zone 1—the internal nasal valve—demonstrated more conservative and heterogeneous changes. While patients showed some degree of widening, the magnitude was modest (typically 0.5–1.5 mm) and less predictable. Surgical outcomes in Zone 1 often fell short of modified Cottle-induced displacement. This may reflect the inherent structural constraints of the internal nasal valve, where the rigid nasal septum and upper lateral cartilage form a narrow, fixed-angle junction. Additionally, comorbidities such as septal deviation, mucosal inflammation, or prior surgeries may limit the tissue's capacity to shift. In one patient, valve width slightly decreased after repair, possibly due to post-surgical recoil or insufficient lateral support. At the 1-week follow-up, most Zone 1 widths remained stable or increased slightly, likely due to resolution of post-operative edema, soft tissue relaxation after stent removal, or changes in mucosal tension.

Figure 4 also highlights the predictive value of the modified Cottle maneuver, which was assessed in all five patients pre-operatively. In Zone 2, the maneuver generally predicted a baseline for final surgical outcomes. In several cases, the surgical repair exceeded the mechanical lateralization observed during the maneuver, likely due to the added structural rigidity of grafts and suture-based suspension. These findings support the maneuver's utility as not just a diagnostic screening tool, but as a quantitative benchmark for planning surgical goals in the external valve. In contrast, the modified Cottle maneuver's predictive accuracy in Zone 1 was more limited. Despite strong lateralization during the maneuver, surgical width often failed to match this degree of opening. This discrepancy suggests that dynamic mechanical displacement may overestimate the achievable surgical outcome in an area where rigid anatomic boundaries and tissue resistance limit expansion. These findings underscore the importance of interpreting the maneuver with a zone-specific context, as it has proven to be useful for external valve prediction but less so for internal valve correction.

Importantly, several outlier cases emerged that may provide clinical insights. In two patients, the surgical width fell short of the predicted modified Cottle width in both zones, and one showed minimal improvement at the 1-week follow-up. These patients may have had prior nasal surgeries, extensive scar tissue, or reported severe baseline obstruction, raising the possibility that tissue compliance, scarring, or altered anatomy played a role in blunting the expected post-operative response. Such cases emphasize the need for a personalized approach to surgical planning, particularly when standard maneuvers over-predict outcomes or when comorbidities limit tissue mobility, as well as reaffirm the need for a long-term study evaluating the impact of demographic characteristics on NVC repair success. These outliers may also represent an opportunity to refine pre-operative assessment protocols, explore alternative grafting strategies, or escalate follow-up intensity in patients at higher risk for suboptimal outcomes.

This longitudinal analysis across four time points provides a more nuanced understanding of how nasal valve dimensions respond to structural correction and how healing progresses during the first post-operative week. The ability of Zone 2 to widen and retain valve size supports the viability of caliper-based tracking as a short-term metric of surgical success. The contrast between zones highlights the need for zone-specific interpretation of diagnostic tools like the modified Cottle maneuver. Finally, the detection of early deviation from expected trends through caliper-based tracking could prove essential in tailoring post-operative management and identifying patients who may benefit from additional intervention. Longer-term follow-ups at 1, 3, 6, and 12 months will be critical to determining whether these early patterns persist, regress, or evolve with ongoing tissue remodeling.

Figure 5 shows a surgeon-based evaluation of the Castroviejo caliper's clinical usability, conducted through a heuristic review. The tool scored highest in sterilization (5/5), size range (5/5), training time (5/5), and portability (5/5) affirming its viability for both clinical and intraoperative use. These high scores suggest that the tool is both dependable and practical within sterile environments, offering quick and consistent measurements without extensive setup. However, patient comfort scored lower (2/5), as did speed of measurement (2/5) and ergonomic form (1/5). This feedback highlights the difficulty of accurately positioning a rigid analog device within the nasal cavity—particularly when the patient is sedated or under surgical drapes—and the challenge of using the Castroviejo caliper one-handed while simultaneously performing the modified Cottle maneuver or surgical repair. These insights directly informed the ideation of the next-generation measurement device.

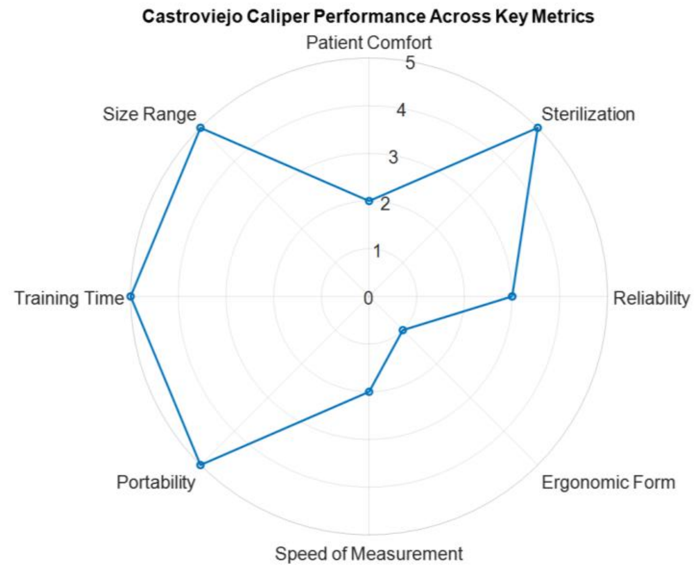


Fig. 5. Heuristic evaluation of the Castroviejo caliper across clinical usability metrics. Surgeon-assigned ratings (0-5 scale) reflect performance across eight key domains, including portability, sterilization, ergonomic form, and speed of measurement.

Figures 6 and 7 provide a visual contrast of the current Castroviejo caliper and a prototype of the modified caliper under development. Figure 6 shows the standard Castroviejo caliper, which, although effective in measurement, lacks features that enhance ergonomic control, precise readout, or streamlined surgical integration. In contrast, Figure 7 displays the conceptual model of a new prototype designed to improve usability in clinical and surgical environments. The proposed design includes an extended, contoured grip for improved

Fig. 6. The Castroviejo caliper. A precision surgical instrument commonly used for measuring small anatomical distances in facial plastics, featuring fine-tipped jaws and a graduated scale for manual readings.

maneuverability, an integrated display for real-time readout and data logging, and surfaces optimized for ease of sterilization and one-handed operation. These design improvements aim to address limitations identified in clinician feedback, improve the reproducibility of measurements, and support integration into existing workflows without compromising sterility or precision.

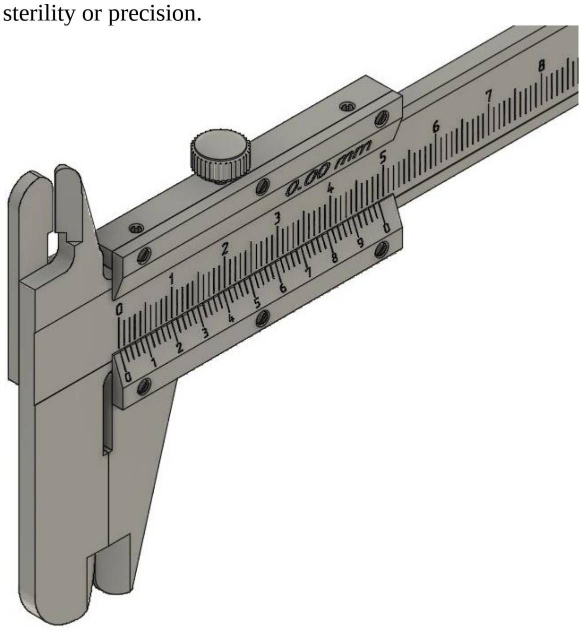


Fig. 7. Modified caliper ideation for nasal valve measurement. A baseline ideation of a custom-designed caliper featuring a linear track for improved accuracy and physician comfort, extended arms to better reach into the nose, and rounded tips for improved patient comfort.

These results demonstrate the viability of nasal valve width as a quantifiable and clinically meaningful variable for assessing NVC and its surgical treatment. The data not only supports the use of nasal valve width as a surrogate for nasal airway patency but also validates the modified Cottle maneuver as a predictive tool for post-operative outcomes, particularly in Zone 2 (external valve). Additionally, the consistent format of data collection through the REDCap system highlights the potential for this approach to be standardized across institutions and scaled for use in larger studies. With ergonomic improvements already in development, this measurement approach has the potential to become a core component of evidence-based NVC diagnosis and treatment planning. These findings established the foundation for a long-term evaluation of clinical feasibility, usability, and broader implications of caliper-based nasal valve measurement, as discussed below.

Discussion

This study provides foundational evidence for the feasibility and clinical value of a caliper-based system to objectively measure nasal valve width in the diagnosis and surgical management of nasal valve collapse (NVC). Quantitative tracking of valve dimensions—particularly in the external nasal valve (Zone 2)—revealed consistent post-operative widening, suggesting that valve width may serve as a dependable anatomical proxy for improved airflow and obstruction relief. These findings support the broader hypothesis that nasal valve width can be used not only as a surgical outcome measure, but also as a planning and intraoperative verification tool.

Using a standardized protocol, nasal valve width was measured with a Castroviejo caliper across two key anatomical zones—Zone 1 (internal valve) and Zone 2 (external valve)—and at four clinically relevant timepoints: baseline at rest, during the modified Cottle maneuver, immediately following surgical repair, and at the 1-week post-operative follow-up. This longitudinal framework enabled assessment of both the magnitude and durability of surgical correction. To support structured, scalable data capture, a custom REDCap database was implemented to log biometric and procedural data across various timepoints. This infrastructure lays the groundwork for future cross-patient comparisons, predictive modeling, and clinical outcome tracking.

One of the most clinically significant findings was the alignment between post-operative valve width and values achieved during the modified Cottle maneuver, particularly in Zone 2. In most patients, surgical outcomes met or exceeded modified Cottle-induced lateralization, suggesting that the maneuver functions not only as a diagnostic screen for dynamic collapse, but as a quantifiable benchmark for target surgical outcomes. This predictive relationship has direct implications for surgical planning: preoperative assessments may now serve as measurable guides during intraoperative correction, aiding surgeons in achieving anatomically optimized results. In contrast, Zone 1 showed a weaker alignment with modified Cottle estimations. Several patients failed to reach the level of displacement observed preoperatively, highlighting the anatomic rigidity and surgical limitations of the internal valve region.

Figures 3 and 4 reinforce the anatomical differences in responsiveness between the two zones. Figure 3 illustrates the immediate effect of surgical repair on valve width, with Zone 2 demonstrating larger and more uniform gains. Figure 4 extends the analysis to early recovery, incorporating all four timepoints to reveal trends in healing. In Zone 2, most patients retained or slightly improved valve width at the 1-week follow-up, indicating early structural stabilization. These trends are particularly meaningful because they suggest that short-term post-operative measurements may serve as early indicators of longer-term success. Zone 1, by contrast, exhibited more variability. While some patients showed delayed gains—potentially due to resolution of edema or tissue relaxation after stent removal—others demonstrated minimal improvement or even mild regression, underscoring the limited surgical maneuverability and greater healing-phase variability in this region.

The identification of outlier cases—those whose surgical outcomes did not align with pre-operative predictions or who showed minimal follow-up gains—provides valuable insights. These cases may show the impact of complicating factors such as prior nasal surgery, scar tissue, mucosal rigidity, or anatomical deviation. Such findings point to the importance of personalized assessment and surgical planning, and the need for a more comprehensive, long-term clinical study that evaluates the impact of demographic differences on NVC repair success and recovery. They also suggest that predictive use of the modified Cottle maneuver should be applied with caution in anatomically complex or previously operated-on patients. Caliper-based tracking may help identify suboptimal responders early, prompting timely adjustments in post-operative care or consideration of alternative interventions.

In addition to anatomical insights, this study evaluated the clinical usability of the measurement system. As shown in Figure 5, the Castroviejo caliper (see Figure 6) received high ratings for sterilization, portability, size range, and training time, affirming its practicality in both clinical and intraoperative settings. However, notable limitations were identified in ergonomics, measurement speed, and patient comfort, especially during intraoperative use under drapes or sedation. These limitations informed the development of a next-generation measurement device (Figures 7), which incorporates an extended handle, optimized grip, and plans for a digital readout to enhance intraoperative precision and allow real-time integration into digital data systems like REDCap.

These design improvements aim to increase reproducibility, reduce intra-operator variability, and streamline clinical workflows.

Beyond the operating room, this system may have broader implications for access to care and diagnostic equity. NVC remains underdiagnosed in primary care settings and amongst underserved populations, in part due to the absence of simple, objective assessment tools. A low-cost, portable measurement system could empower non-specialists to screen for nasal obstruction and make timely referrals for surgical evaluation. In resource-limited settings, this could help bridge gaps in access and reduce the burden of untreated nasal airway obstruction.

The standardized REDCap database also unlocks opportunities for translational research. By correlating nasal valve width changes with other clinical variables—such as patient-reported outcome measures (e.g., NOSE, SCHNOS scores), grafting techniques, comorbidities, and general demographic data—future studies could identify predictors of NVC repair success and personalize surgical approaches. Long-term follow-ups will be especially important in evaluating the durability of anatomical gains and understanding how valve width correlates with functional outcomes over time.

Despite these promising findings, this study has limitations. The sample size was small (n = 11), and although trends were consistent, broader validation is needed in more diverse populations. Patient-reported outcomes were not yet integrated into this analysis, making it difficult to correlate anatomical improvements with perceived airflow or symptom relief. Additionally, the current system captures only structural changes; the absence of airflow measurement limits the functional interpretation of anatomical gains. Future iterations may incorporate airflow or resistance metrics to provide a more complete picture of nasal valve function.

In conclusion, this pilot study establishes feasibility of nasal valve width as a quantifiable, clinically relevant parameter for assessing NVC and guiding surgical repair. The use of a Castroviejo caliper—combined with structured, longitudinal data collection—demonstrates feasibility in both clinical and operative environments. The alignment of modified Cottle maneuver performance and surgical outcomes supports its use as a predictive tool and intraoperative benchmark, particularly in Zone 2. Ongoing development of a next-generation caliper, paired with REDCap integration and broader clinical deployment, has the potential to improve surgical precision, standardize outcome measurement, reduce revision rates, and expand diagnostic access in the management of nasal valve collapse, especially in low-resource or underserved settings.

Materials and Methods

This observational pilot study was conducted in the otolaryngology clinic under the supervision of a facial plastic and reconstructive surgeon. The primary aim was to identify a clinically relevant, quantifiable measurement technique to support the diagnosis of nasal valve collapse (NVC), with a particular focus on changes in nasal cavity width during the modified Cottle maneuver, which is the current standard of care for NVC evaluation. The study involved clinical observations, the development of measurement techniques, prototype design, and the implementation of a data management system.

Patients included in this study were adults, aged 18 years or older, who had been clinically diagnosed with NVC or were scheduled to undergo surgical intervention for NVC. Initially, biweekly lists of eligible patients were provided by the supervising surgeon. To streamline data collection and support ongoing entry, the research team developed a REDCap (Research Electronic Data Capture) database that allowed the surgeon to directly upload patient names and medical record numbers (MRNs) for long-term patient tracking and follow-up. Institutional Review Board (IRB) approval was obtained for both the database (IRB #302344) and the accompanying chart review study (IRB #HSR240110). Patients with unrelated nasal trauma, severe comorbidities impairing nasal evaluation, or those who declined participation were all excluded. All identifying information was de-identified during analysis, and data collection was conducted in accordance with institutional privacy and data protection guidelines.

Structured nasal valve width data were collected using a Castroviejo caliper to evaluate treatment outcomes in patients diagnosed with NVC and scheduled for surgical repair. Measurements were taken at two anatomical locations: Zone 1, corresponding to the internal nasal valve, and Zone 2, representing the external nasal valve (Figure 1). For each zone, data were recorded under four conditions: at rest, during the modified Cottle maneuver, immediately following surgical correction, and at the 1-week post-operative follow-up visit. This protocol allowed for consistent within-subject comparisons of nasal valve width across multiple anatomical states and perioperative timepoints.

During clinical evaluations, nasal width was measured using a Castroviejo caliper, a precision surgical instrument commonly used in facial plastic procedures (Figure 6). The caliper was used to measure the distance between the nasal septum and the lateral nasal wall. These measurements were taken both before and during lateral displacement of the nasal wall, a maneuver performed using a cotton nasal swab as part of the modified Cottle maneuver, in both the lower and upper regions of the nasal valve canal. The modified Cottle maneuver was only measured if the patient reported subjective improvement with lateral wall support during inhalation. In these cases, the caliper was used to simulate the degree of lateral wall displacement created by the maneuver, and width was recorded. If no improvement was reported, no measurement was taken of the modified Cottle maneuver. This approach reflects clinical diagnostic practices and is limited by the caliper's design, which currently does not support simultaneous manipulation and measurement. Patients were asked to inhale during the procedure, and any reported symptom relief was noted. These measurements, expressed in millimeters, were recorded and entered into the REDCap database, along with the patient's diagnosis, surgery status, and relevant clinical notes. The same measurements were later repeated in the operating room to assess whether the surgeon was able to replicate the lateral nasal wall displacement observed in the clinic. These comparisons aimed to determine the reliability of width measurements as an objective clinical variable for NVC assessment.

All data collected during the study were securely stored in the REDCap database. The database features a color-coded tracking system to monitor completion of patient records and ensure data integrity. As of this writing, the team is still in the process of enrolling patients and collecting long-term data. Therefore, no statistical analysis has been conducted on real patient data at this stage. However, the anticipated analytical approach includes descriptive statistics to evaluate the mean and variance of nasal width changes during the modified Cottle maneuver, as well as comparison between clinical and intraoperative measurements. Planned tools for analysis include Python, Excel, and R for statistical evaluation and data visualization.

Several alternative measurement approaches were explored during the study design process but ultimately rejected due to limitations in feasibility, relevance, or consistency. Variations in cartilage thickness and hardness were initially considered but were determined to be too variable between patients to serve as reliable diagnostic indicators. Intraluminal pressure measurement methods, including techniques involving nasal occlusion and visual assessment of nostril inflation and collapse, were also evaluated. However, these methods required specialized equipment, clinician expertise, and extensive training, which limited their practical integration into routine clinical care. Although retrospective studies using CT imaging to assess the nasal valve area showed strong correlation with NVC diagnosis, CT imaging is not standard practice for NVC evaluation and would add financial and logistical burdens for patients.[17] Additionally, efforts to quantify nostril movement using video recordings were dismissed due to their inability to assess static NVC cases.

Based on clinical feedback, nasal valve width was selected as the primary physiological variable because it aligns with the modified Cottle maneuver—the current standard of care for NVC evaluation—and can be quickly measured using tools like the Castroviejo caliper. Although cross-sectional area was also considered—using a proposed circular dilation tool to mimic the modified Cottle maneuver—width measurements were ultimately deemed more practical for standard clinical use and easier to integrate into the existing workflow. Feedback from the supervising surgeon emphasized the need for a simple, reproducible method of capturing the nasal wall displacement observed in the clinic.

To address concerns regarding the ergonomics of the Castroviejo caliper, the research team began developing prototype measurement tools. A physical Castroviejo caliper was obtained to serve as a reference during this process. Preliminary designs were created using computer-aided design (CAD) software, drawing inspiration from digital and linear calipers. These designs aimed to improve user grip, ease of measurement, and compatibility with nasal anatomy. Sketches and CAD models of these prototypes are currently under review and will inform the next phase of device development.

Although preliminary in nature, the study has already received qualitative feedback from the supervising surgeon indicating that the incorporation of measurable, objective data into the diagnostic process has improved patient confidence in NVC repair. Patients perceived the use of physical measurements as an indicator of a more thorough and evidence-based approach to care. As the project progresses, continued refinement of measurement techniques and device prototypes will support future data collection and potentially inform larger-scale validation studies in the diagnosis of NVC.

This project focused on the development and early validation of a non-invasive, cost-effective, and portable set of metrics for the real-time, quantitative evaluation of NVC. Focusing specifically on the nasal valve region, the system aims to offer a simpler and potentially more accurate method for classifying NVC severity by eliminating reliance on complex imaging, subjective assessments, and specialized airflow modeling. Inspired by the principles of tonometry but adapted for nasal valve tissue, the system is designed to capture dynamic features of nasal valve behavior, such as lateral wall collapse. Through ongoing data collection and evaluation, the study seeks to determine whether the data generated can provide precise, reproducible, and clinically meaningful insights to support diagnostic and therapeutic decision-making. The system is being engineered for flexible use in both clinical and operating room environments, with the additional advantage of being useful when patients are sedated. If successfully validated, this technology has the potential to redefine standards for NVC assessment by providing an objective, accessible, and reproducible method that improves diagnostic accuracy and expands consistent care across various healthcare settings. By offering a pathway toward a reproducible and quantitative classification of NVC severity without reliance on expensive imaging, complex airflow simulations, or subjective interpretation, this project addresses a critical unmet clinical need. It has the potential to significantly improve diagnostic accuracy, inform better treatment planning, and ultimately enhance outcomes for patients suffering from nasal valve collapse.

End Matter

Author Contributions and Notes

G.O. and J.D. designed research, S.O. collected data, G.O. and J.D. analyzed data; and G.O. and J.D. wrote the paper under guidance from S.O and P.C.

The authors declare no conflict of interest.

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