

ORIGINAL RESEARCH–ALLERGY

Comparison of optical rhinometry to acoustic rhinometry using nasal provocation testing with *Dermatophagoides farinae*

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ABSTRACT

OBJECTIVE: To evaluate optical rhinometry (ORM) as an objective evaluation of nasal patency using nasal provocation testing with *Dermatophagoides farinae* (*Df*) as compared with acoustic rhinometry.

STUDY DESIGN: Prospective pilot.

SETTING: Academic rhinologic practice.

SUBJECTS AND METHODS: Five adult healthy controls and five adult subjects with allergic rhinitis (AR) underwent nasal provocation testing with increasing concentrations of *Df* while undergoing ORM. The minimum concentration of *Df* causing a positive reading was recorded. Nasal cross-sectional area was measured before and after testing using acoustic rhinometry. Nasal patency was assessed subjectively after each challenge with the visual analogue scale.

RESULTS: The median amount of *Df* causing a positive response on ORM was less in AR patients as compared to healthy controls, at 5000 AU/mL and greater than 10,000 AU/mL, respectively. There was a statistically significant correlation between the change in optical density in ORM and subjective nasal congestion after increasing *Df* challenges ($r = 0.63$; $P = 0.0007$). Similarly, there was a statistically significant correlation between change in optical density by ORM and both minimum cross-sectional areas as measured by acoustic rhinometry ($r = -0.60$, $P = 0.03$; and $r = -0.64$, $P = 0.02$, respectively).

CONCLUSION: This is the first study to show a correlation between optical rhinometry and acoustic rhinometry during nasal provocation testing with *Df*. In addition, the data support a correlation of optical rhinometry to subjective symptoms of nasal congestion. These preliminary data suggest that optical rhinometry is able to assess changes in nasal patency during challenges with *Df*.

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Allergic rhinitis (AR) is an IgE-mediated response to inhaled antigens in the nose causing the release of immediate and delayed mediators, which then lead to mucosal gland stimulation and increased vascular permeability. Patients complain of symptoms such as nasal obstruction, rhinorrhea, sneezing, and watery eyes; symptoms can last hours to days.

In the United States, patients who are suspected by history and physical examination to have AR may undergo objective testing by way of either skin or in vitro blood testing (modified radioallergen sorbent test). Skin testing has been questioned regarding its accuracy in detecting inhalant allergies. Sensitivity and specificity of epicutaneous testing in predicting nasal response to *Alternaria* was 42 percent and 44 percent, with only a modest increase to 58 percent when followed by the addition of intradermal testing. Other antigens such as timothy grass are better, with 87 percent sensitivity and 86 percent specificity.^{1,2} Currently, there is no “gold standard” objective testing method for inhalant allergies.³

Recently, nasal provocation testing (NPT) has been used in the attempt to characterize the response to an allergen challenge. The antigen is introduced into the nasal cavity and nasal mucosal swelling is monitored. NPT is used widely throughout Europe as a clinical tool to evaluate inhalant allergies; however, it has been limited to research purposes in the United States.

The most common objective methods to monitor nasal patency are rhinomanometry and acoustic rhinometry (AcR). Both rhinomanometry and AcR have been validated and are standardized for clinical use in Europe, but are mainly used in scientific research in the United States.

Optical rhinometry (ORM) is a new technique introduced in Germany in 2004 under the trademark Rhinolux (Rhios GmbH, Groerkmannsdorf, Germany).⁴ The device works via optical spectroscopy, which measures the absorption of visible and near-infrared light in tissue. In the same way that pulse oximetry measures hemoglobin absorption of near-infrared light and thus oxygen blood saturation, the

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optical rhinometer measures blood volume within the nasal cavity. An emitter and detector are placed at the nasal dorsum and swelling is measured as the extinction of light, or optical density (OD), as a function of time. Nasal provocation studies using histamine and allergens have shown correlation with subjective findings and objective measurements with anterior rhinomanometry.^{4,7} Threshold for the detection of a significant positive response to antigens was determined to be 0.2 OD.⁴ Advantages of ORM include improved patient comfort, technical ease of use, ability to obtain real-time data, and ability to obtain measurements in patients with nasal polyposis, choanal atresia, and septal perforations in patients who cannot undergo testing with the acoustic rhinometer or rhinomanometry. Previous work by Luong et al found a strong correlation between ORM and subjective symptoms on nasal congestion in both healthy controls and allergic subjects when challenged with histamine.⁸ The purpose of this study is to compare ORM as an objective evaluation of nasal patency using NPT with *Dermatophagoides farinae* (*Df*) and to compare ORM with AcR.

Materials and Methods

Patients

Eleven subjects (7 male and 4 female), six with AR and five healthy controls (HCs), were enrolled in this study after Institutional Review Board approval from the University of Texas Health Science Center at Houston. Participants were aged 22 to 54 years. The median age was 29. One AR subject was excluded from the study after his flat nasal bridge made measurement with ORM not possible. The HCs had no history of allergy symptoms such as sneezing, rhinorrhea, and/or itchy eyes and no history of using antihistamines or nasal steroid sprays. AR subjects had symptoms of allergic rhinitis consisting of sneezing, rhinorrhea, and/or itchy eyes and skin test positive for *Df*.

The following patients were excluded from the study: pregnant patients; those with asthma or lung disease, a history of immunotherapy or immunodeficiency, chronic rhinosinusitis, sinonasal polyps, or history of sinus surgery within eight weeks; patients taking beta-blockers; patients with dermatographism, latex sensitivity, or previous systemic reaction to skin testing; and patients who had an episode of rhinitis in the past month or who were currently symptomatic.

Patients were asked to discontinue the following medications: antihistamines were discontinued three days prior; topical, nasal, and systemic corticosteroids one week prior; tricyclic antidepressants one week prior, and H2 blockers and leukotriene receptor antagonists one day prior.

Study Design

Each subject underwent NPT with three increasing concentrations (1000 AU/mL, 5000 AU/mL, and 10,000 AU/mL) of *Df* antigen (Hollister-Stier Laboratories, Uttar Pradesh, India). The subjects were monitored by ORM during the entire course of the NPT. Prior to the first challenge, measurements with the

acoustic rhinometer (AcR) were taken of each nasal cavity and a baseline visual analogue scale (VAS) rating for subjective nasal congestion was recorded. Starting with a 1000 AU/mL *Df* challenge to the right nasal cavity, continuous measurements with the optical rhinometer were obtained for at least 10 minutes at each dose of *Df*. If a change in OD of less than 0.2 was noted by ORM, then the next-higher *Df* dose was administered until there was at least a 0.2 change in OD or the maximum 10,000 AU/mL was given. The value of 0.2 OD is the published value of a positive response for the optical rhinometer.⁴ Measurement with optical rhinometer was continued for 20 minutes at this final *Df* amount. After this 20-minute recording, measurements from the AcR from each nasal cavity were taken. VAS assessments were obtained from the subject after each *Df* challenge.

Nasal Provocation Testing

Each subject was first fitted with the spectacles-like frame of the optical rhinometer. Then, five measurements from each nostril were taken with the AcR. The average value from these five measurements was reported. A two-minute baseline ORM recording was performed. Subjects were then challenged with increasing concentrations of *Df* antigen (prepared at the appropriate concentration with sterile saline just prior to administration) as described above. The *Df* antigen was administered to the right nasal cavity at a fixed volume of 150 μ L via a mucosal atomizer device directed at the right inferior turbinate. After the 20-minute recording by ORM at the final *Df* challenge amount, five measurements from each nostril were taken with the AcR. The average value from these five measurements was reported as the final cross-sectional area (CSA).

Statistical Techniques

The Spearman nonparametric correlation was used to compare change in optical density (Δ OD) and changes in subjective ratings of nasal congestion based on the VAS after each *Df* challenge. Mean CSA readings from the AcR before and after final antigen challenge were compared to Δ OD before and after the final antigen challenge. The critical alpha level was set at $P = 0.05$ for all tests, and all P values quoted are two-tailed unless otherwise indicated.

Results

Less Dust Mite Needed in AR versus Non-AR Subjects to Incite Positive Response in Nasal Provocation Testing

The median minimum concentration of *Df* required to incite a positive response in AR subjects was 5000 AU/mL. As expected, a majority of the HCs did not respond to even the highest amount of *Df*. Only one HC subject had a positive ORM response, which was to the highest applied concentration of *Df* (10,000 AU/mL).

Optical Rhinometry Correlates with Subjective VAS for Nasal Congestion after Provocation with Dust Mite Antigen

Figure 1 illustrates the relationship between the changes in OD and VAS with increasing challenging concentrations of *Df* and the correlation between ORM and subjective rating

of nasal congestion. Figure 1A and B shows that both mean change in OD and VAS increase with higher amounts of *Df* used in the NPT. This trend is clearly evident in the AR subjects, and to a lesser extent in the HCs. Figure 1C depicts the correlation between the change in OD as measured by ORM and change in subjective rating of nasal congestion by VAS, $r = 0.63$ ($P = 0.0007$).

Optical Rhinometry Correlates with Acoustic Rhinometry

Figure 2 shows the correlation between change in OD and change in mCSA1 and mCSA2 on the right nasal cavity, $r = -0.60$ and -0.64 , respectively. The right side represents the side that was challenged by NPT. The mCSA1 represents the minimum cross-sectional area between 0 and 22 mm from the nasal vestibule, and mCSA2 is the minimum cross-sectional area between 22 and 54 mm. For comparison, there was a poor correlation between change in OD and change in mCSA1 and mCSA2 on the left. The r values were 0.024 and -0.073 , respectively.

Discussion

This follow-up study evaluates ORM for assessing nasal patency during NPT. The first study showed a strong correlation between ORM and subjective ratings of nasal congestion using histamine and oxymetazoline challenges.

In this study, ORM was sensitive enough to detect changes in nasal patency after *Df* challenge in AR subjects. Only one AR subject did not have a change in OD greater than or equal to 0.2 after challenges with all three *Df* concentrations. Rather, the maximum change in OD was 0.17 in this subject. On the other hand, only one HC had a change in OD greater than 0.2 (ΔOD was 0.35) and characterized as a positive response by ORM. This occurred at the highest *Df* concentration tested. These findings support that ORM is sensitive enough to detect changes in nasal patency by *Df* antigen in AR subjects.

The current study also supports the conclusion of the initial study, since strong correlation between ORM and changes in subjective ratings of nasal congestion after challenge with *Df* (Fig 1) were noted. In addition to this correlation, ORM also correlates well with acoustic rhinometry (Fig 2).

Acoustic rhinometry is an accepted and validated technique for assessing nasal patency during NPT. However, its limitations, including sensitivity to malpositioning and need to occlude the nasal cavity during measurements, make it a less than optimal monitoring device. ORM addresses some of the current limitations of the available monitoring devices and provides some clear advantages, such as continuous monitoring during the entire NPT, ease of use, and patient comfort. Given the strong correlation between AcR and ORM, these preliminary studies suggest that ORM may represent an alternative technique for assessing nasal patency during NPT with *Df* antigen.

Some limitations of ORM were encountered. For one, there was notable variability in the readings during facial

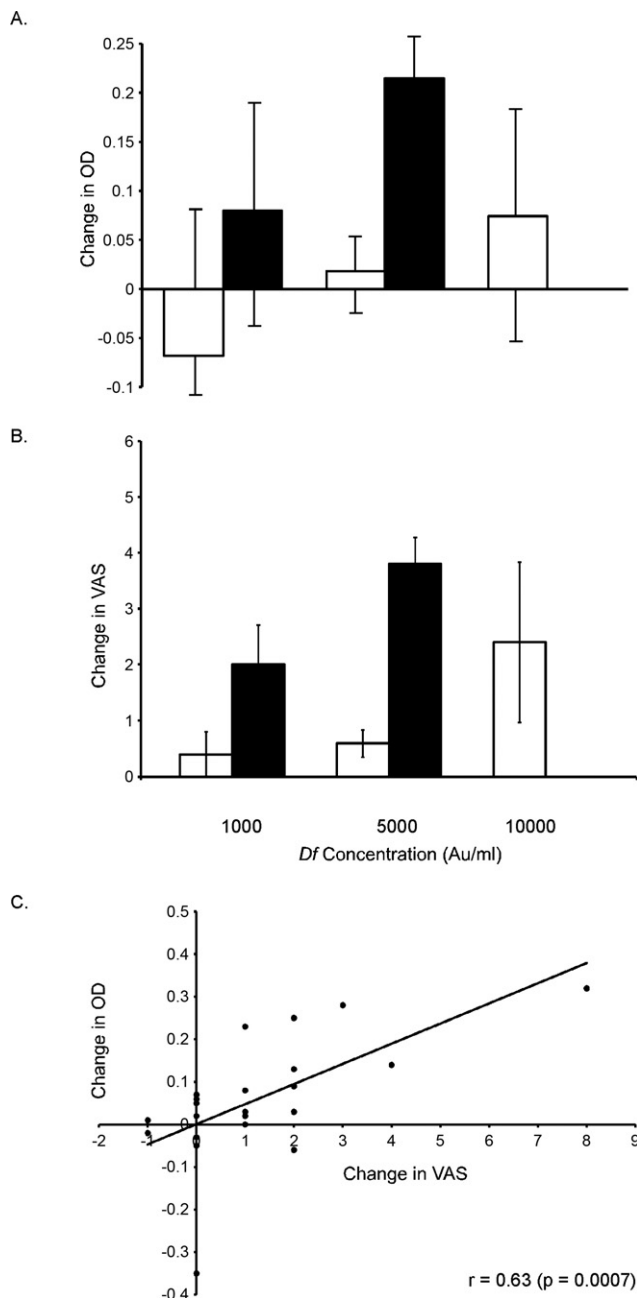


Figure 1 Change in optical density (OD) by optical rhinometry correlates with change in subjective rating of nasal congestion by visual analogue scale (VAS). (A) Mean change in OD in healthy control (HC; white bar) and allergic rhinitis (AR; black bar) subjects at increasing concentrations of *Dermatophagoides farinae* (*Df*). (B) Mean change in VAS for HC (white bar) and AR (black bar) subjects at increasing concentrations of *Df*. (C) Correlation of change in OD with change in VAS for nasal congestion.

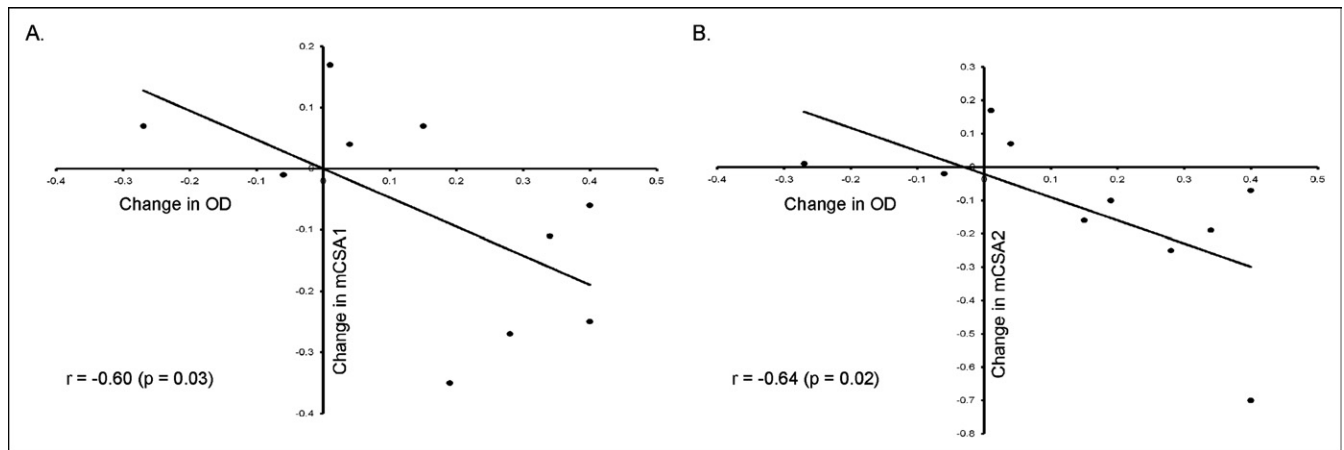


Figure 2 Optical rhinometry (ORM) correlates with acoustic rhinometry (AR). (A) Correlation of change in optical density (OD) by ORM with change in minimum cross-sectional area 1 (mCSA1) on the same challenged nasal cavity. (B) Correlation of change in OD by ORM with change in mCSA2 on the same challenged nasal cavity.

movements such as sneezing or expressive talking. Also, subjects with wide nasal bridges were difficult to measure by ORM. By design of the optical rhinometer, the photo emitter and detector need to be aligned across the nasal bridge. This configuration is difficult to sustain in a subject with a flat nasal bridge. Finally, since the light emitter and detector lie across the nasal bridge, the measurements are not lateralized. Despite these few limitations, ORM seems to represent a good alternative device for assessing nasal patency.

Based on these pilot results, further studies on ORM are warranted. Current ongoing studies are assessing ORM for NPT with other common antigens.

Conclusion

Optical rhinometry can detect changes in nasal congestion in AR subjects challenged with *Df* antigen. In addition to correlating with subjective ratings of nasal congestion, ORM correlates strongly with acoustic rhinometry. Optical rhinometry may present an alternative device to acoustic rhinometry for NPT with *Df*.

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Disclosures

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