

Objective Measurements Using the Skin Prick Test in Allergic Rhinitis

Beom-Joon Kim, MD; Seog-Kyun Mun, MD

Objective: To objectively measure the change in size of the wheal or erythema resulting from the skin prick test.

Design: Prospective randomized trial involving patients with allergic rhinitis recruited from March 8, 2009, through August 21, 2009, in Seoul, South Korea.

Setting: Otorhinolaryngology clinic of a university hospital.

Patients: Of 69 patients suspected of having allergic rhinitis, 46 with positive skin prick test results were selected.

Main Outcome Measures: Skin prick test and Minolta CR-400 Chromameter.

Results: Comparing the 2 values, as the size of the wheal or erythema increased, there was also an increase in the L*, a*, and b* values ($P = .049$ for each).

Conclusions: Use of the Minolta CR-400 Chromameter provides an objective measure of the change in the size of the wheal or erythema. This method may be used in the clinical setting to improve the interpretation of skin prick testing results.

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ALLERGIC RHINITIS IS A COMMON clinical disorder affecting 10% to 25% of the world's population; it is reported to have as much as 40% morbidity, and its frequency is increasing.¹ Allergic rhinitis is an IgE-mediated inflammatory reaction of the nose caused by exposure to a specific antigen. Although patients with this condition may show local symptoms, systemic disorders such as asthma may also occur, along with other allergic diseases.²

The most commonly used skin prick test for the diagnosis of allergic rhinitis is performed by placing a drop of solution containing the suspected antigen extract on the skin and performing a series of needle pricks to allow the solution to enter the skin.³ The antigen then activates mast cells by interacting with IgE antibodies on the surface of those cells, which leads to the release of chemical substances such as histamine from granules and results in the development of a wheal and erythema reaction.³ The skin prick test, which is easily performed in the clinical setting, is a highly efficient method for identifying the causative agent.³ However, because the investigator subjectively obtains the results by using a ruler, variations in the results are common among different examiners. In

this study, a Minolta CR-400 Chromameter (Minolta Holdings Ltd, Tokyo, Japan) (**Figure**) was used to determine whether objective measurements of the change in the size of the wheal or erythema could be obtained from the skin prick test.

METHODS

PATIENTS

Between March 8, 2009, and August 21, 2009, at the otorhinolaryngology clinic at Chung-Ang University, Seoul, South Korea, 46 patients with positive skin prick test results were selected from 69 patients suspected of having allergic rhinitis. Diagnosis of allergic rhinitis was based on the patient's medical history, edematous nasal mucosa, watery rhinorrhea, and a wheal or erythema greater than or equal to 3 mm with no reaction to a negative control substance on the skin prick test.³ Patients using agents that might mask the skin reaction; patients with a decrease in the reactivity of the skin, such as infants or those older than 60 years; and patients with dermatographism were excluded.

THE SKIN PRICK TEST AND MEASUREMENT

The skin prick test involved applying 29 antigens (Torii and Co Ltd, Tokyo, Japan) on the

Author Affiliations:
Departments of Dermatology (Dr Kim) and Otorhinolaryngology–Head and Neck Surgery (Dr Mun), College of Medicine, Chung-Ang University, Yongsan Hospital, Seoul, South Korea.

patient's forearm. Histamine was used as a positive control substance and normal saline as a negative control. The maximum length and its perpendicular length were measured in millimeters, and their mean values were recorded for the wheal or erythema that developed 15 to 20 minutes after the skin prick test was administered.

METHOD USING THE MINOLTA CR-400 CHROMAMETER

The Minolta CR-400 Chromameter was used to evaluate the wheal or erythema that resulted from the skin prick test by analyzing the light source reflected from the flat glass applanation surface. Calibration was performed by using the white plate provided by the manufacturer. Tristimulus color analysis of the reflected light was carried out at 450, 560, and 600 nm. This measured value was represented by the $L^*a^*b^*$ system, developed by the Commission Internationale de l'Éclairage⁴ to objectively describe all colors visible to the naked human eye. The L^* value represents brightness, (a spectrum from black to white), a^* represents a spectrum from red to green, and b^* represents a spectrum from blue to yellow.

STATISTICAL ANALYSIS

Values obtained from the skin prick test and chromameter were compared using mean (SD) values. In addition, Pearson correlation coefficient was used to verify the reliability of the chromameter, and SPSS version 13.0 (SPSS Inc, Chicago, Illinois) was used for the statistical analysis. $P < .05$ was considered statistically significant.

RESULTS

The patients with allergic rhinitis were between 9 and 59 years old, with a mean age of 30.6. There were 29 men and 17 women in the group studied.

The results of measurement of the size of the wheal or erythema after the skin prick test showed that 111 U of antigens in 46 patients showed a positive result. There were 55 U and 30 U with positive results at approximately 3 mm and 4 mm, respectively. Most units observed were in these 2 groups. For the rest, 9 u showed positive results at 5 mm, 10 U at 6 mm, and 7 U at 7 mm. The mean (SD) of the L^* value obtained by using the Minolta CR-400 Chromameter for the 3-mm-sized wheal or erythema was 60.0 (1.6). The mean (SD) of the L^* value measured 62.1 (1.6) for 4 mm, 64.7 (1.1) for 5 mm, 68.1 (0.7) for 6 mm, and 70.1 (0.8) for 7 mm. The mean a^* value measured 12.9 (0.6) for 3 mm, 13.7 (1.4) for 4 mm, 15.2 (0.4) for 5 mm, 16.4 (0.8) for 6 mm, and 18.5 (0.6) for 7 mm. The mean of the b^* value measured 17.4 (0.2) for 3 mm, 17.9 (0.4) for 4 mm, 18.6 (0.6) for 5 mm, 19.8 (0.9) for 6 mm, and 21.3 (0.4) for 7 mm (**Table**).

Comparing the 2 values as the size of the wheal or erythema increased, there was also an increase in the L^* , a^* , and b^* values. Pearson correlation coefficients were high: 0.992 for L^* , 0.972 for a^* , and 0.960 for b^* .

COMMENT

To appropriately treat allergic rhinitis, one must identify the causative agent. However, antigens can vary with



Figure. Minolta CR-400 Chromameter (Minolta Holdings Ltd, Tokyo, Japan).

Table. Comparison of Skin Prick Test and L^* , a^* , and b^* Values^a

Size, mm (No. of patients)	Mean (Min-Max)		
	L^*	a^*	b^*
3 (n=55)	60.0 (59.7-60.1)	12.9 (12.6-13.2)	17.4 (17.0-17.7)
4 (n=30)	62.1 (62.0-62.2)	13.7 (13.5-13.9)	17.9 (17.7-18.1)
5 (n=9)	64.7 (64.3-66.1)	15.2 (15.0-15.7)	18.6 (18.4-19.0)
6 (n=10)	68.1 (67.6-68.8)	16.4 (16.3-16.5)	19.8 (19.6-20.1)
7 (n=7)	70.1 (69.7-71.0)	18.5 (17.5-18.9)	21.3 (21.1-21.4)

Abbreviations: Max, maximum value; min, minimum value.

^aAs the size of the wheal or erythema increased, there was also an increase in the L^* , a^* , and b^* values. Pearson correlation coefficients were high: 0.992 for L^* , 0.972 for a^* , and 0.960 for b^* .

time and place and must be evaluated on a continuous basis.^{2,5} In addition, accurate analysis of the causative antigen is needed especially in patients sensitized to multiple antigens because treatment takes longer for those with more severe symptoms compared with those sensitized to a single agent.⁶

The methods used to identify the causative agent include the skin prick test, provocation test, and level of IgE-specific antibodies.³ Among these methods, the skin prick test is the most common technique used in the clinical setting: it is easy to perform, accurate, and very low risk.^{3,7} However, interpretation of the results such as skin redness can be difficult in Asian or black patients compared with those in white patients. Furthermore, because the results are measured using a ruler, the investigator's measurements can vary.

Tristimulus colorimeters are widely used in the textile, paint, and food industries as well as in skin-related research clinics.^{8,9} Minolta produces a handheld CR-400 Chromameter, in which a pulsed xenon arc lamp sends light through an 8-mm aperture to illuminate the skin surface.¹⁰ Use of the CR-400 Chromameter has shown excellent reproducibility for intrauser, interuser, and interinstrument results.⁸⁻¹⁰ Not only is this handheld, portable instrument safe and easy to use but it also provides objective, reproducible data with regard to color and pigmentation. Another advantage is that no additional software or training is needed to operate the instrument.

In this study, L*, a*, and b* values were obtained and compared with the results of the skin prick test. As the size of the wheal or erythema increased, there was a statistically significant increase in the L*, a*, and b* values ($P = .049$ for each). This result demonstrates that the antigen-induced change was not only the same size as the wheal and erythema but also the same color of the skin. The L* value increased with more sensitivity than the other values, which demonstrated it was more sensitive than the a* and b* values, which were affected by skin color. In addition, the results of the CR-400 Chromameter increased in proportion to the wheal or erythema reaction regardless of causative antigens. This finding may improve the accuracy of the assessment of the results because there is no bias with regard to the causative antigens.

As seen in the Table, L*, a*, and b* values increase in a limited range according to the size of the wheal or erythema. In addition, each different range does not overlap. Therefore, as the number of patients increases, a higher sensitivity and specificity may be achieved because each different L*, a*, and b* value may be assigned as a different range.

In this study, measurements were made with a gap of 2 cm to minimize the effect of different antigens; these measurements can be difficult to perform on a forearm where there is limited space. Still, especially in children and young women, the forearm is a preferable measurement location compared with the back. However, because the chromameter identifies the antigen by analyzing only the color of the reaction, many different types of antigens may be detected because a wide gap is not needed. Hence, this technique may be effectively used to identify various antigens. When compared with the naked eye, the chromameter can detect greater skin redness changes even in Asian and black patients. The results of this study show that the objective results obtained via use of a chromameter replace the subjective results derived from using a ruler in skin prick testing.

In conclusion, there was an increase in the L*, a*, and b* values measured by the Minolta CR-400 Chromame-

ter as the size of the wheal or erythema increased. Therefore, the Minolta CR-400 Chromameter may be efficacious because it is easy to use in the clinical setting, may objectively measure the change in wheal or erythema, and, to our knowledge, always provides consistent results.

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Correspondence: Seog-Kyun Mun, MD, Department of Otorhinolaryngology–Head and Neck Surgery, Chung-Ang University, Yongsan Hospital, Hangangno 3-ga, Yongsan-gu, Seoul 140-757, South Korea (entdoctor@cau.ac.kr).

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