RED-GREEN-BLUE COLOR ANALYSIS OF NASAL MUCOSA OF MIDDLE MEATUS IN THE DIAGNOSIS OF CHRONIC RHINOSINUSITIS WITHOUT POLYPOSIS (CRSSNP)

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ABSTRACT

INTRODUCTION
Chronic Rhinosinusitis (CRS) can be defined broadly as a chronic inflammatory condition of the nose and paranasal sinus mucosa. There is need of a simple; easy to perform objective test that can make diagnosis of CRSSNP even in OPD settings. This prompted us to investigate use of smart phones as an objective method in cases of CRSSNP.

OBJECTIVE
This study was done to analyse the color changes of middle meatus area by doing RGB analysis with Smartphone for objective diagnosis of CRSSNP. It was also seen whether severity of CRSSNP could be measured objectively by comparing RGB analysis to SNOT-22 score

METHODS
Prospective, Observational, Analytical and hospital-based study of 75 patients presenting with symptoms of CRSSNP in the OPD setting

RESULT
A total of 75 and 50 patients were included in case and control groups respectively. On further analysis, there was statistically significant difference in the color changes in the form of RGB values in CRSSNP and control group only at uncinate process (middle part) with R value (p=0.007), R value at middle turbinate (anterior end) (p <0.001) and B value at middle turbinate (anterior end) (p <0.001).

CONCLUSION
This study concluded that R values at middle part of uncinate process and anterior end of middle turbinate along with B value at anterior end of middle turbinate may provide the diagnosis of CRSSNP objectively using the smart phone.

KEYWORDS-Chronic rhinosinusitis, chronic rhinosinusitis without nasal polyposis, sinonasal outcome test, red-green-blue.

INTRODUCTION
Chronic Rhinosinusitis is one of the most common clinical conditions for which a patient visits an Otorhinolaryngologist. It carries a significant physical and economic burden in terms of the quality of life and the cost of treatment. CRS is characterized by two or more symptoms, one of which should be either- nasal blockage /obstruction/congestion or nasal discharge (anterior/ posterior nasal drip), +/- facial pain/pressure, +/- reduction or loss of smell. Endoscopic signs include nasal polyp, and /or mucopurulent discharge primarily from middle meatus and/ or edema / mucosal obstruction
primarily in middle meatus. Objective evidence of inflammation is visualized on either computed tomography scan (CT) or endoscopy.

CT of the paranasal sinuses has become the gold standard for CRS evaluation and is an integral component of diagnosis. 2 Eyelids objective data on mucosal inflammation and polyps. On the other hand, nasal endoscopy is simple, fast, and relatively cheap assessment, which can be done in an OPD setting with minimum equipment. It is a relatively quick procedure in which the entire nasal cavity can be assessed. The results can even be shown to the patient for a higher degree of satisfaction.

In recent years, smart phones have been used in various areas in the medical field for its application as an endoscopic device. Using a smart phone as a capturing device has its inherent advantages. It allows for a better teaching tool for the students and patients who can be shown the findings of endoscopy and educated about the disease and its impact.

All colours in nature are formed by combinations of the three primary colours - red, green and blue. The correlation between inflammation and the RGB colours of various tissues and mucosa has been investigated previously. Each colour has an objective numeric value which can be measured using a software. Hence, the degree of pathology of any tissue can be interpreted according to these values.

Photographic red–green–blue (RGB) measurements provide an objective value to assess the colour of mucosa. Doing so with the help of smart phones could aid the diagnosis of CRSsNP by evaluating the colour of nasal mucosa. It is deemed as a direct, non-invasive, objective photographic measurement, which can be used as an objective parameter of CRSsNP. In this study, nasal endoscopy and RGB analysis of nasal mucosa were done at specific points in middle meatus on both sides during third pass. That data was then compared to each point and colour in both patient and control groups. It was then ascertained whether smartphone devices can be used as an objective method of diagnosing CRSsNP.

**OBJECTIVE**

This study was done with the objective to evaluate whether Red-Green-Blue colour analysis of nasal mucosa in middle meatus can be used as an objective method for diagnosing patients with CRSs NP. This method can be used as a reliable diagnostic tool in OPD settings in the future, which may be a replacement of the CT scan of nose and PNS, which is currently the gold standard for diagnosing CRSsNP.

**METHODS**

The study was a prospective, observational, analytical and hospital-based study, done from January 2021 to June 2022. It was conducted in Department of Otorhinolaryngology-Head and Neck Surgery, Lady Hardinge Medical College & Associated hospitals, New Delhi, India. The study population consisted of patients of either sex, age >18 years, presenting to ENT OPD. The patients were divided in two groups- the cases (CRSsNP) and the control group. The sample size in our study was 75 patients in CRSsNP group and 50 patients in control group. It was calculated by considering mean and standard deviation RGB values from a previous similar study conducted. Inclusion criteria for the case group included patients who presented to ENT OPD with symptoms of nasal blockage/ obstruction /congestion or nasal discharge, +/−facial pain/pressure, +/−loss of smell, then diagnosed as CRSsNP via nasal endoscopy. The control group included 50 normal subjects. These were patients in which nasal examination and
endoscopy was done as a part of routine examination.

The exclusion criteria for the study consisted of patients < 18 years, cases of CRSsNP with symptom < 12 weeks, patients of CRSwNP, sinonasal malignancy, history of previous sinonasal surgery.

Detailed history was taken and patients presenting with inclusion criteria were enrolled. The patients were then explained the nasal endoscopic procedure, following which written and informed consent was taken. Nasal Endoscopy was performed in ENT OPD, during OPD hours with the patients seated on the chair. No decongestion was done as it would interfere with the colour changes of the nasal mucosa. This would alter the RGB values of the nasal mucosa. Hence, all the endoscopies were performed without any decongestion to maintain the RGB values as close to their true value as possible.

The endoscope used for the study was a 4 mm, 0-degree endoscope (Storz). The endoscope was mounted on an adaptor connected to a smart phone (Samsung J 2). This adaptor was available online and was purchased by the examiner.

Posterior triangle is bounded anteriorly by - posterior border of sternocleidomastoid,

A portable LED light source was attached to endoscope. Using a 0 degree endoscope, DNE was performed. While performing the third pass, endoscopic pictures were taken at the following four points in the middle meatus on both sides - (1) superior part Uncinate process,(2) middle part of Uncinate process,(3) anterior face of Bulla Ethmoidalis, (4) anterior end of Middle Turbinate. Then, RGB analysis was done by using an App 'Color Picker', a mobile android application, which measures the intensity of color objectively in numbers. This app was freely available on the internet. Numerical values of each color at each point was then recorded on a proforma for statistical analysis.

After nasal endoscopy, the patients were given a SNOT-22 scoring test, which the patients used to score the severity of their symptoms. The score was between 0-110. Hence, a lesser score implied a better quality of life and vice-versa. The test was used as a patient reported outcome measure (PROM) to correlate the symptoms experienced by the patient with their life quality and hindrance to their day to day activities.

RESULTS
Among the participants, the age ranged from 18-61 yrs in the case group, while it was 18-60 years in control group. The mean age in case group was 32.81 yrs, whereas in control group was 35.58 yrs. There was no significant difference of age between the two groups. In the case group, percentage of male and female were 41.3% and 58.7%. Whereas, in the control group it was 52% and 48%. It was observed that the most common symptom of CRSsNP was nasal blockage(92%), followed by nasal discharge (67%).

On further analysis, there was statistically significant difference in RGB values in CRSsNP and control group only at specific points. These points were R value at uncinate process (middle

FIGURE 1- The photo of the smartphone adaptor mount used for the study
part) (p=0.007), R value at middle turbinate (anterior end) (p <0.001) and B value at middle turbinate (anterior end) (p <0.001). On the basis of this study, Hence we can conclude that R values at middle of uncinate and anterior end of middle turbinate along with B value at anterior end of middle turbinate may provide the diagnosis of CRSsNP objectively using the smartphone.

**FIGURE 2**- Showing the RGB color values at different points on right side.

**FIGURE 3**- Showing the RGB color values at different points on right side.

Further, the values from the SNOT-22 questionnaire were compared statistically with all the parameters - age, gender, chief complaints as well as the RGB values at the individual points of the nasal endoscopy. At any point, there was no correlation found in RGB analysis during nasal endoscopy. Hence, SNOT-22 turned out to be a poor predictor for predicting the severity of CRSsNP.

**FIGURE 4**- Showing the cumulative value of R,G and B color at all points.

**DISCUSSION**

In our study, nasal endoscopy was performed on a total of 125 patients -75 cases of CRSsNP and 50 control cases. This study was done keeping in mind, to analyse the color changes of middle meatus area using RGB analysis with smartphone for objective diagnosis of CRSsNP. Its secondary objective was to see whether severity of CRSsNP could be measured objectively by comparing RGB analysis to SNOT-22 score.

CRS affects a significant population worldwide, imposing a huge toll on the human economy as well as on quality of life. CRS remains a common cause of morbidity, social embarrassment, impaired performance at school or workplace, and in addition to physical discomfort. It also causes a substantial economic burden to the patient in terms of missed workdays due to the physician or hospital visits. Thus, it is particularly important to define a cost-effective and easily available diagnostic tool for it.

The clinical features of CRSsNP are such that, it is not uncommon in clinical practice to encounter similar symptomatology in other diseases. Thus, attempts to diagnose it with symptomatology alone are futile. Although the diagnosis of CRS is made on clinical findings, the utilization of nasal endoscopy and CT scan helps to decide the appropriate management. To evaluate the
objective components of CRS diagnosis, DNE (diagnostic nasal endoscopy) and the computed tomography (CT) scan play important roles. Currently, nasal endoscopy and CT scan have been used for the diagnosis of chronic rhinosinusitis. The available literature that compares the two modalities on the diagnosing of CRS offers variable opinions. According to some studies CT scan offers superior diagnostic ability whereas, others prefer DNE of diagnosing CRS. However, nasal endoscopy is inexpensive and can be easily incorporated as a part of routine examination. Even then, there is need of an objective test that can be used in OPD settings to diagnose CRSsNP with minimum resources and cost.

Chronic rhinosinusitis without nasal polyposis (CRSsNP) has been attributed to mechanical obstruction of the ostiomeatal complex. The pathological changes of the disease are in the middle meatus. Thus, any change in color of middle meatus or surrounding areas might give the clue to diagnosis. This forms the basis of our study to look for the RGB (Red Blue Green) color changes in the middle meatus for diagnosing CRSsNP.

In the 21st century, there has been an unanticipated major transformation in the field of communication modalities, which has led to widespread use of mobile communication devices including smartphones. Given the increasing digital quality of the smartphone cameras, their improved screen resolution and integration of a smartphone for the purpose of endoscopy appears inevitable. This prompted us to investigate use of ubiquitous smart phones as camera device. In the current era of modern medicine, smartphones have been used as an endoscopic device in every speciality.

The smartphone-endoscope device used in these studies were found easy to set up and offered the ability to manipulate the image by using the smartphone camera functions in real time. The availability of a reliable, secure, portable and high quality method for recording nasal examinations would greatly facilitate patient evaluation and triage, especially in cases of CRSsNP. The application of smartphone technology to patient care represents an opportunity to reduce costs, improve communication and ease accurate documentation. Our study used smartphone for performing nasal endoscopy to diagnose CRSsNP. In the literature, there was no study found that used a smartphone for diagnosing CRSsNP.

The correlation between inflammation and the RGB colours of various tissues and mucosa has been investigated previously. The objective results of RGB measurements have been used to definitively diagnose laryngopharyngeal reflux, otitis media with effusion as well as in GI endoscopy.

The use of patient related outcome measures is increasing day by day. It includes tests like SNOT-22, where the patient review becomes a basis of further disease management. A greater score indicates a poorer quality of life while, a lesser score indicates less disease burden as well as improvement of life quality with the treatment. In our study, SNOT-22 proforma was given to all the cases. It was found that, there was no statistically significant correlation between the SNOT-22 score and patient's symptoms. Also, no correlation was found at any point of RGB analysis during nasal endoscopy. Hence, SNOT-22 turned out to be a non-significant diagnostic as well as prognostic tool in CRS.

However, the study has its limitations. There was no availability of white balance while using a portable light source. This may have caused a variability in the color changes. Also,
decongestion was not done prior to the procedure. So all points on the middle meatus were not visible in all the patients during endoscopy. Also, the presence of pus in the middle meatus would have affected the color changes.

CONCLUSION
This study concluded that R values at middle part of uncinate process and anterior end of middle turbinate along with B value at anterior end of middle turbinate may provide the diagnosis of CRSsNP objectively using the smartphone.

DECLARATION
Ethics approval and consent to participate: The study was approved by Institutional Ethics committee.

Conflict of Interests- The authors declares that there are no conflicts of interest.

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