# The role of Narrow Band Imaging (NBI) in the diagnosis of sinonasal diseases*

Chiara Bruno#, Guglielmo Maria Fiori#, Luca Giovanni Locatello#, Angelo Cannavicci, Oreste Gallo, Giandomenico Maggiore

Department of Otorhinolaryngology, Careggi University Hospital, Florence, Italy

**Rhinology 59: 1,** 40 - 48, 2021
https://doi.org/10.4193/Rhin20.032

***Received for publication:**
February 2, 2020
**Accepted:** April 17, 2020

# contributed equally

## Abstract

**Background**: Narrow band imaging (NBI) endoscopy is an optical method that helps to characterise tissue vasculature. Its application in sinonasal pathology remains scarce and a systematic study of its application to rhinology is lacking. The aim of this study is to analyse and describe the normal sinonasal mucosa under NBI light and to characterise the microvascular features of various sinonasal pathologies. We also want to suggest a classification of the patterns, peculiar to this district, and to evaluate whether they can be indicative of a specific physiological or pathological condition.

**Methods**: Digital videos and images under white light and NBI of 103 patients (82 evaluated) with 29 sinonasal pathologies and 55 controls (33 evaluated). were independently analysed by three otolaryngologists and the final pattern was then arranged for each image, reaching an agreement between the individual evaluations.

**Results**: Once the appearance of normal sinonasal (SN) mucosa was established (SN1), four patterns for the pathological mucosa were described and a working classification was proposed (SN2, SN3, SN4, SN5). We calculated specificity (80.6% vs 90.6%), sensitivity (20% vs 38.5%), PPV (46.1% vs 50%), NPV (54.7% vs 85.7%) and accuracy (53% vs 80.3%) of the ability of SN4 and SN5 pattern to discriminate between benign and malignant nasal neoformations.

**Conclusions**: This is the first study to propose a systematic NBI description and a classification of the vasculature of healthy and pathological mucosa in the sinonasal tract. Our preliminary results show that this technique can help in the workup of several rhinologic conditions and especially in distinguishing benign from malignant tumors.

**Key words**: Diagnostic techniques respiratory system, nasal mucosa, nasal polyps, paranasal sinus diseases, paranasal sinus neoplasms

## Introduction

Fiberoptic endoscopy under white light (WL) is the cornerstone of the clinical examination of the whole upper aerodigestive tract, including the sinonasal district[1]. Lately, new optical technologies such as narrow-band imaging (NBI) or contact endoscopy have been developed in order to further improve our diagnostic accuracy[2,3]. NBI, in particular, is a technique based on specific filters that allow visualization of the microvascular texture of the mucosa thanks to blue and green light wavelengths which are reflected by epithelial tissues but absorbed by hemoglobin[4]. Patterns of normal and aberrant vascularisation were actually described and the effectiveness of NBI in the identification of premalignant and malignant lesions was demonstrated in different areas of the head and neck region (larynx and oral cavity, in particular)[5,6]. Moreover, the association between the vascular patterns and specific pathologic conditions was established for several subsites and the reported sensitivity of NBI varies from 70% to 100% while specificity is between 61% and 92.3%[6-10]. As far as the sinonasal district is concerned, very few studies have been published so far on the use of this

technique for diagnostic purposes and, strikingly, a general and systematic description of normal and pathological nasal mucosa under NBI is still lacking. Furthermore, reproducible vascular patterns in this region have never been clearly described so far, thus making the implementation of this technique very difficult in the rhinological practice[11,12]. In the "squamous" part of the upper aerodigestive tract, a macroscopically defined leukoplakia corresponds to several microscopic lesions; likewise, sinonasal polypoid masses represent a wide spectrum of different histopathological tumours[13]. In addition, inflammatory and neoplastic tissues do often coexist and an erroneous or a delayed diagnosis is frequent, even in referral centers for sinonasal surgery, because of insufficient or incorrect sampling[14]. In this respect, an enhanced visualization of the nasal lesions to suggest the diagnosis or, at least, to guide the biopsy, would be of tremendous help.

The aim of this study is to describe the normal sinonasal mucosa under NBI light and to characterise the microvascular features of various sinonasal pathologies. We also want to suggest a classification of patterns peculiar to this district, evaluating whether they can be indicative of a specific physiological or pathological condition.

## Materials and methods

### Population and selection criteria

A total of 158 patients were enrolled in the present study at the Department of Otorhinolaryngology, Careggi University Hospital, in Florence, Italy from November 2018 to August 2019. During routine in-office ENT examination, we have captured WL and NBI videos of endoscopic examinations of 103 patients with sinonasal complaints and of 55 patients visited for a non-nasal ENT condition requiring fiberoptic examination (globus sensation, laryngeal disorders, etc.). The latter did not complain of any nasal symptom or they had no history of previous sinonasal surgery and they were considered as negative controls. The following characteristics were recorded for each patient: sex, age, smoking status (classified as never, former and current), and work-related exposure with particular attention to wood dust and metals. Exclusion criteria were as follows: significant presence of blood upon the mucosa, an history of intranasal cocaine use, the need to apply a topical vasoconstrictor in order to explore the nasal fossae, the presence of adherent crusts whose removal caused mucosal hemorrhages and anatomical impossibility (e.g., septal spurs) to perpendicularly frame the site of interest. Low quality (blurred) pictures because of motion artefacts or inadequate stabilization were also discarded. For allergic rhinitis, hypersensitivity was always confirmed by skin prick test and/or allergen-specific IgE detection[1]. Atrophic rhinitis was defined according to the criteria of Ly and coworkers and all cases were secondary to external radiation therapy for sinonasal or nasopharyngeal malignancy and without any evidence of recurrence[15]. In case of the unexpected finding of a new sinonasal mass, subsequent imaging and biopsy were always performed to confirm the diagnosis[1].

### Endoscopic examination and data acquisition

Examination of the nasal cavity was performed by a flexible endoscope (ENF-VQ) with Narrow Band Imaging technology connected to a video processor (VISERA Elite OTV-S190) equipped with a xenon light source (VISERA Elite CLV-S190); the video monitor used was the OEV261H 26" LCD HD (all from Olympus Medical System Corporation, Tokyo, Japan). Instead, the Medicap system (Medicap USB300, MediCapture Inc., Plymouth Meeting, PA, USA) was used for recording and archiving images and videos of the procedures on a hard disk drive. White balance was always performed before each endoscopy. When required, secretions were carefully aspirated under endoscopic guidance, without damaging the mucosa, to improve the visualization. If requested by the patients, lidocaine spray was applied to anesthetize the surface of the nasal cavity before endoscopic examination. The exploration was conducted in a standardised way exploring both nasal cavities and the nasal meati with WL and NBI and framing each area of interest with the tip of the endoscope placed perpendicularly and as close as possible to the point of interest. All the stored videos were revised by the authors and the most representative images under WL and NBI were captured from each file. Three otolaryngologists experienced in nasal endoscopy analysed the videos and the images independently and they were all blinded to the clinical or histopathological diagnoses.

### Study protocol

For the first part of our study, we dedicated to the analysis of the vascular anatomy of the sinonasal mucosa in apparently normal conditions. We systematically evaluated the following landmarks within each nasal cavity: head of the inferior turbinate, body of the inferior turbinate, head of the middle turbinate, body of the middle turbinate, and septal mucosa. The most recurring vascular anatomical features were noted so to define what the "healthy" mucosa is supposed to look like.

In the second part of our work, we turned to the subjects with sinonasal complaints. We tried to define the patterns with the best correspondence to each NBI image and we took as a hint those already published and validated for other head and neck subsites[8-10]. Subsequently, pathological areas and masses were reviewed, and again a description of the observed vascularisation patterns was suggested by each author. If an examiner could not find any correspondence between the image and the patterns presented in the literature, it was given the possibility to propose a new one. For each case, the final pattern was then determined by the agreement between all examiners. After their description, all patterns were sketched by one of the authors

Table 1. Demographic and clinical characteristics of the study population.

| Items | Overall population (115) | Normal (33) | Pathological (82) | p-value |
|---|---|---|---|---|
| Sex: | | | | |
| Male | 80 (69.6%) | 17 (51.5%) | 63 (76.8%) | |
| Female | 35 (30.4%) | 16 (48.5%) | 19 (23.2%) | 0.025 |
| Age (years) | | | | |
| Range | 18-88 | 19-79 | 18-88 | |
| Median | 52.6 | 35.5 | 59.5 | <0.001 |
| Smoking Status | | | | |
| Never | 77 (67.0%) | 23 (69.7%) | 54 (65.8%) | |
| Former | 14 (12.2%) | 3 (9.1%) | 11 (13.4%) | |
| Current | 24 (20.8%) | 7 (21.2%) | 17 (20.8%) | 0.812 |
| Work-Related Exposure | | | | |
| None | 106 (92.2%) | 33 (100%) | 73 (89%) | |
| Yes | 9 (7.8%) | 0 (0%) | 9 (11%) | 0.578 |

Table 2. Prevalence of different sinonasal conditions in our cohort (n=82).

| Sinonasal Pathologies | n (%) |
|---|---|
| CRSsNP | 4 (4.9%) |
| CRSwNP | 4 (4.9%) |
| Atrophic Rhinitis | 3 (3.7%) |
| Allergic Rhinitis | 4 (4.9%) |
| CRSwNP in Cystic Fibrosis | 4 (4.9%) |
| Granulomatosis with polyangiitis | 1 (1.1%) |
| Eosinophilic granulomatosis with polyangiitis | 16 (19.5%) |
| Sinonasal Papilloma | 22 (26.9%) |
| ITAC | 5 (6.1%) |
| Squamous cell carcinoma | 3 (3.7%) |
| Mucosal melanoma | 4 (4.9%) |
| Plasmacytoma | 1 (1.1%) |
| Schwannoma | 1 (1.1%) |
| Septal perforation | 2 (2.5%) |
| Post-ESS synechiae | 3 (3.7%) |
| Granulation after ESS | 5 (6.1%) |

CRSsNP: Chronic Rhinosinusitis without Nasal Polyps; CRSwNP: Chronic Rhinosinusitis with Nasal Polyps; ESS: Endoscopic Sinus Surgery; ITAC: Intestinal-type adenocarcinoma.

(GMF) using GIMP (The GIMP Development Team, version 2.10.84, available at gimp.org). Such drawings were used to give a clearer representation of each pattern and to improve reproducibility.

In the third and final part of our study, clinical and pathological diagnosis were matched to each pattern and a standard descriptive statistics was performed. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy were also determined. All procedures performed in the present study were in accordance with the Ethical Standards of the Institutional and National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. IRB approval was requested and informed consent was always obtained from each patient.

### Statistical analysis

Statistical analysis of the population was conducted using GraphPad Prism, version 7.00 for Windows (GraphPad Software, La Jolla, CA, USA).

## Results

A cohort of 115 patients (82 with sinonasal pathology and 33 without sinonasal complaints) was extracted after application of the exclusion criteria. Their clinico-epidemiological and pathological features are presented in Table 1. Therefore, 27.3% of patients were not included in the pattern analysis and the main reasons were excessive bleeding during the examination (31.3%), anatomical constraints (47.9%) and diffuse crusting (9.8%).

In the first part of our study, from the recordings of the "healthy" subjects, a total of 124 pictures were extracted after excluding those with suboptimal quality. From their analysis, we noticed that the vascularisation of the healthy sinonasal district presented the following characteristics. First, the head of both the middle and inferior turbinate almost always demonstrated a dotted pattern composed of small and close dark dots (97% of cases). Only 1 case (3%) was characterised by dots of larger diameter and more spaced from each other (SN2 pattern, described below). On the other hand, the bodies of the inferior and the middle turbinates presented, in 100% of cases, a vasculature composed of a simple network of loosely arborescent vessels, oriented in a parallel manner and in a posterior-anterior direction. Otherwise, the septal mucosa, the most difficult subsite to assess because of the orientation of the viewing probe, appeared to be characterised by small and thin dark-blue vessels which are crowded and densely branched, yet in a regular fashion in all the cases. The texture of submucosal vessels of greater caliber, dark-green colored, was also appreciable. Expectedly, we also noticed that the vascularisation seemed to be more prominent in the most anterior septal part.

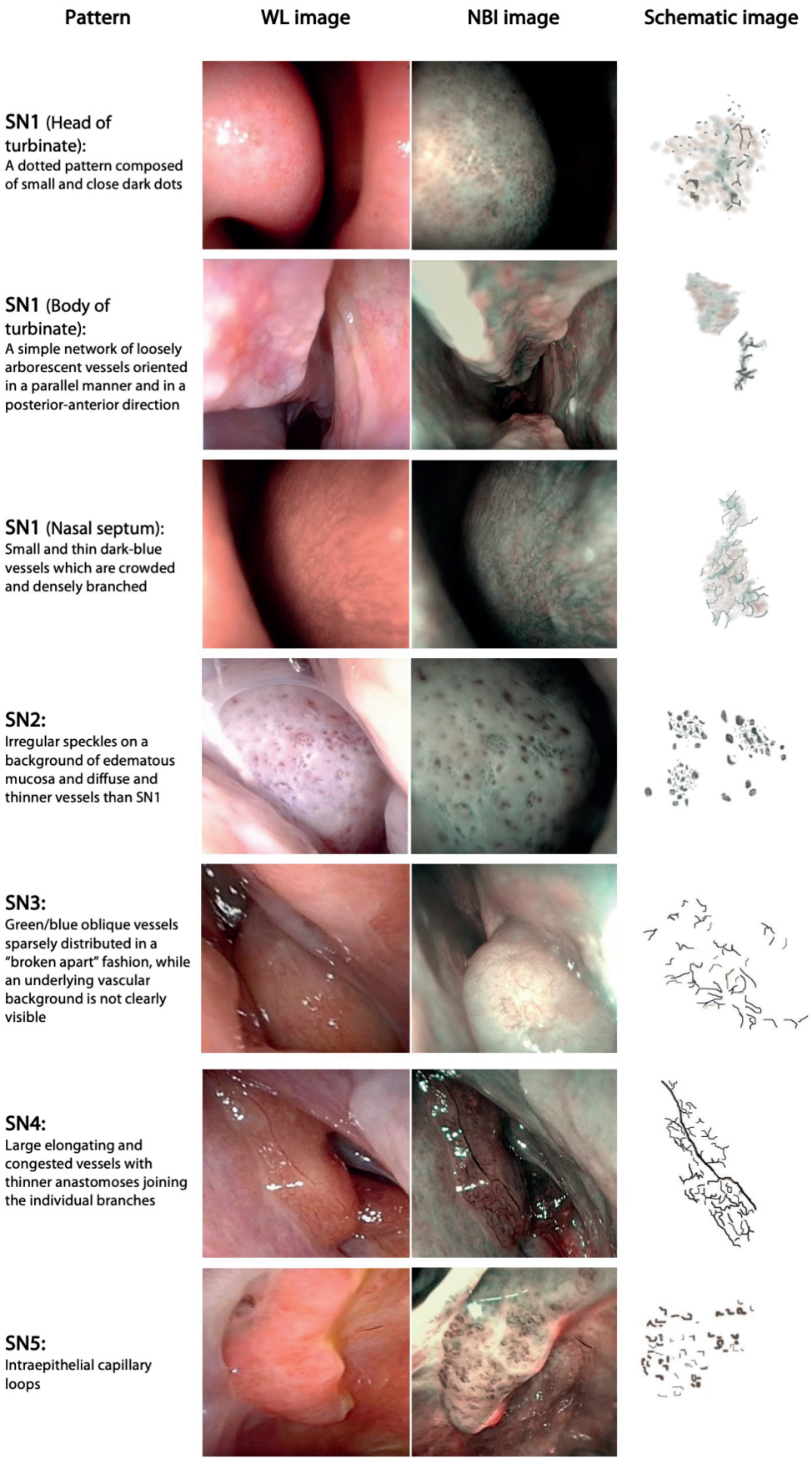


Figure 1. NBI classification of vascular patterns of the sinonasal mucosa.

Table 3. Percentages of cases according to vascular pattern.

| Pattern | Total | Pathologies | Nr. | % |
|---|---|---|---|---|
| **SN1** | 32 | Normal mucosa | 32 | 100% |
| **SN2** | 9 | Allergic Rhinitis | 2 | 22% |
| | | Atrophic Rhinitis | 3 | 33% |
| | | CRSsNP | 3 | 33% |
| | | Normal mucosa | 1 | 12% |
| **SN3** | 25 | Sinonasal Papilloma | 9 | 36% |
| | | Eosinophilic granulomatosis with polyangiitis (formerly, Churg-Strauss syndrome) | 4 | 16% |
| | | CRSwNP in Cystic Fibrosis | 3 | 12% |
| | | CRSwNP | 3 | 12% |
| | | Allergic Rhinitis | 2 | 8% |
| | | Synechiae | 2 | 8% |
| | | Squamous cell carcinoma | 2 | 8% |
| **SN4** | 34 | Sinonasal Papilloma | 9 | 26.5% |
| | | Eosinophilic granulomatosis with polyangiitis (formerly, Churg-Strauss syndrome) | 12 | 35.3% |
| | | Schwannoma | 1 | 2.9% |
| | | ITAC | 4 | 11.8% |
| | | Septal perforation | 2 | 5.9% |
| | | CRSsNP | 1 | 2.9% |
| | | Granulomatosis with polyangiitis (formerly, Wegener's granulomatosis) | 1 | 2.9% |
| | | CRSwNP in Cystic Fibrosis | 1 | 2.9% |
| | | Plasmacytoma | 1 | 2.9% |
| | | Mucosal Melanoma | 1 | 2.9% |
| | | Synechiae | 1 | 2.9% |
| **SN5** | 10 | Granulation | 5 | 50% |
| | | Mucosal Melanoma | 3 | 30% |
| | | ITAC | 1 | 10% |
| | | Squamous cell carcinoma | 1 | 10% |
| **NBI-null** | 5 | Sinonasal Papilloma | 4 | 80% |
| | | CRSwNP | 1 | 20% |

CRSsNP, Chronic Rhinosinusitis without Nasal Polyps; CRSwNP, Chronic Rhinosinusitis with Nasal Polyps; ESS, Endoscopic Sinus Surgery; ITAC, Intestinal-type adenocarcinoma.

Once normality was defined, we moved to the second part of our research and we reviewed all the images of patients affected by any sort of sinonasal pathology. A brief summary of the various conditions is outlined in Table 2. The sinonasal (SN) patterns we identified were classified as follows (Figure 1):

- SN1: it is the "normal" mucosa as previously outlined and it depends on the nasal cavity subsite (head of the middle and inferior turbinate, body of the inferior and middle turbinate, septal mucosa);
- SN2: here irregular speckles on a background of edematous mucosa and diffuse and thinner vessels than SN1 can be identified;
- SN3: in this pattern, green/blue oblique vessels are sparsely distributed in a "broken apart" fashion while an underlying vascular background is not clearly visible;
- SN4: it is represented by large elongating vessels which are more uneven than the normal mucosa. They appear congested and can be clearly seen as thin brownish lines while thinner anastomoses joining the individual branches are often present;
- SN5: here intraepithelial capillary loops are clearly visible with a relatively smooth arrangement.

In the final part of the study, we matched all the "pathologic" images to the aforementioned patterns. Notably, not all the images we collected showed a frank superficial vascularisation to the NBI light, so 7.04% of them were classified as NBI-null. Such cases appear to have no superficial or deeper vascular texture. This null pattern was found in 3 cases of sinonasal papillomas and in a case of a polyp in a patient affected by chronic rhinosinusitis with nasal polyposis (CRSwNP). Table 3 summarizes the distribution of the cases according to the corresponding pattern whereas Table 4 represents the several patterns found for each disease. SN2 pattern could be found in chronic rhinosinusitis without nasal polyps (CRSsNP), in allergic rhinitis cases and in atrophic rhinitis. Considering only the neoplasms (benign and malignant), we then calculated sensitivity, specificity, PPV, NPV and accuracy of their most represented patterns. SN3 pattern was able to identify sinonasal papilloma with a sensitivity of

Table 4. Proportion of patterns according to different pathological conditions.

| Pathologies | Total | Pattern | Nr. | % |
|---|---|---|---|---|
| Normal mucosa | 33 | SN1<br>SN2 | 32<br>1 | 97%<br>3% |
| CRSsNP | 4 | SN2<br>SN4 | 3<br>1 | 75%<br>25% |
| CRSwNP | 4 | SN3<br>NBI-null | 3<br>1 | 75%<br>25% |
| Allergic Rhinitis | 4 | SN2<br>SN3 | 2<br>2 | 50%<br>50% |
| Atrophic Rhinitis | 3 | SN2 | 3 | 100% |
| CRSwNP in Cystic Fibrosis | 4 | SN3<br>SN4 | 3<br>1 | 75%<br>25% |
| Granulomatosis with polyangiitis (formerly, Wegener's granulomatosis) | 1 | SN4 | 1 | 100% |
| Eosinophilic granulomatosis with polyangiitis (formerly, Churg-Strauss syndrome) | 16 | SN3<br>SN4 | 4<br>12 | 25%<br>75% |
| Sinonasal Papilloma | 22 | SN3<br>SN4<br>NBI-null | 9<br>9<br>4 | 41%<br>41%<br>18% |
| ITAC | 5 | SN4<br>SN5 | 4<br>1 | 80%<br>20% |
| Squamous cell carcinoma | 3 | SN3<br>SN5 | 2<br>1 | 66.7%<br>33.3% |
| Mucosal melanoma | 4 | SN4<br>SN5 | 1<br>3 | 25%<br>75% |
| Plasmacytoma | 1 | SN4 | 1 | 100% |
| Schwannoma | 1 | SN4 | 1 | 100% |
| Septal perforation | 2 | SN4 | 2 | 100% |
| Scars | 3 | SN3<br>SN4 | 2<br>1 | 66.7%<br>33.3% |
| Granulation | 5 | SN5 | 5 | 100% |

CRSsNP, Chronic Rhinosinusitis without Nasal Polyps; CRSwNP, Chronic Rhinosinusitis with Nasal Polyps; ESS, Endoscopic Sinus Surgery; ITAC, Intestinal-type adenocarcinoma.

43%, a specificity of 71%, a PPV and a NPV of 41% and 73%, respectively, and an accuracy of 62%. We must underscore that 75% of the sinonasal papillomas were actually recurrences and not primary cases. SN4 pattern was typically associated to eosinophilic granulomatosis with polyangiitis (previously known as Churg-Strauss syndrome) with a sensitivity of 75%, specificity of 64%, PPV of 40%, a NPV of 89% and an accuracy of 67%. Finally, we investigated the ability of SN4 versus SN5 pattern to detect a malignancy in the subpopulation of patients with nasal masses. We found a sensitivity of 38.5% and a specificity of 90.6%, with a PPV of 50%, a NPV of 85.7% and an accuracy of 80.3% for SN5 pattern; while, for SN4, sensitivity was 20%, specificity 80.6%, PPV and NPV were 46.1% and 54.7%, and the accuracy was 53%.

## Discussion

The present study aims to provide a working classification of NBI patterns in the sinonasal region. In this context, the definition of "normality" was the first unavoidable step to take. Our SN1 ("anatomical") pattern is the reflection of the microvascular anatomy of the turbinates that was extensively studied in the last decades[16-18]. The dotted appearance of the turbinates' head is probably to be referred to the tiny terminal branches of the posterior and anterior lateral nasal arteries whereas the dense and arborescent appearance of septal SN1 pattern reflects nothing but a detailed view of the Kiesselbach's plexus[17].

Due to the anatomical heterogeneity of the head and neck district, standardised and distinct NBI classifications were proposed, even though the nasal cavity and paranasal sinuses have been so far neglected[8-10]. Our results show that the vascular network of schneiderian mucosa is unique. As compared to other regions, the nasopharynx seems to have the most resemblant NBI features and this can be explained by the common embryological origin from the ectodermal layer[19].

When it comes to a specific disease, some considerations can

be made. In atrophic rhinitis cases, we found an atypical scarce vascular network which should correspond both to the process of endarteritis obliterans and to the squamous metaplasia of the nasal mucosa that were elegantly investigated by histopathology some years ago[20,21]. Although it was reported that the polyps in eosinophilic granulomatosis with polyangiitis syndrome appear to be histologically similar to the other nasal polyps[22], in our series they showed a greater superficial vascularisation and a different pattern: it would be interesting to perform targeted biopsies under NBI guidance of these areas to see if signs of vasculitis can also be found in the polypoid mucosa. Sinonasal papilloma is a benign epithelial lesion with a high propensity to recur and, under NBI light, it appeared more frequently with broken vessels pattern (SN3)[23]. This peculiar feature can be linked to the altered expression of vascular endothelial growth factor that was demonstrated some years ago[24]. In addition, the hyperkeratosis that is occasionally found in this tumour (10% of the specimens in the large Hyams' series)[25] would, in our opinion, also explain the NBI-null cases that we registered[26]. The only one schwannoma in our cohort appeared with a SN4 pattern and, despite its usual histology does not show a prominent vascular network, it is frequently featured by small intralesional haemorrhages[27]. In our study, SN3 pattern was present both in cases of common CRSwNP and in patients affected by cystic fibrosis. Histopathologically, nasal polyps in the latter condition do not seem to be a distinct subtype compared to CRSwNP, apart from a more neutrophilic inflammatory infiltrate[28].
Granulation tissue appeared to be represented by the SN5 pattern in our series. The utility of NBI in the distinction between reactive and neoplastic tissue has been recently reported for laryngeal granuloma[29]. The authors used a dichotomous classification ("suspicious" with perpendicular vascular changes versus "normal" longitudinal vascular pattern) in their series and they concluded that NBI can be very helpful in the differential diagnosis[29]. Our data do not show linear longitudinal vessels for nasal granulation, that present instead a more intricate vascularisation and future studies could solve the issue.
In all of the NBI classifications for other subsites, malignancy is characterised by visible and abnormal intraepithelial papillary capillary loops (IPCL)[7]. From the histological point of view, only in the most anterior part of the nasal fossa, loops of capillaries arising from the subepithelial plexus enter the papillae of the mucosa; instead, in the other parts, such papillae are not present and the capillary bed is limited to a flattened plexus which lies immediately beneath the basement membrane[30]. Therefore, the IPCLS visible in the SN5 pattern, which is very similar to the Va pattern of the Ni's laryngeal classification[9], are probably the result of neoangiogenesis which is a fundamental process both for wound healing and neoplastic growth[31].
NBI has the potential to add value to both in-office and intraoperative diagnostic workup of almost every sinonasal pathology, yet the very few studies on the subject were mainly limited to specific conditions[11,12,32,33]. For instance in the evaluation of patients affected by hereditary hemorrhagic telangiectasia, the NBI technique permitted to better characterise the typical vascular abnormalities but no classification was attempted in this peculiar cohort[11]. On the contrary, an interesting study of some years ago has analysed the nasal vascular alterations in granulomatosis with polyangiitis (GPA, formerly known as Wegener's)[32]. The authors did actually identify three "abnormal" NBI patterns in GPA cases that were defined as "vascular island", "web" and "hypertrophic vessel" and, remarkably, the latter is very similar to that of our case of GPA (SN4)[32]. Although it was shown that the three patterns were quite distinct from the negative controls, normality was not clearly defined nor the subsites of nasal cavity were taken into account. The authors' description of nasal polyps in patients with CRSwNP was very similar to our SN3 pattern and they nonetheless described the "low-density pitting" of the turbinates which corresponds to our SN1[32]. Three other reports need to be mentioned here[12,33,34]. Petersen et al. used NBI in a patient affected by follicular lymphoma with nasal involvement at imaging and where biopsy-confirmed lesion was barely visible under WL[12]. The second work described a case of a patient with a hemangiopericytoma-like tumor that was removed under NBI light[33]. Both studies concluded that NBI can be useful to reveal suspicious areas but no clear-cut definition of abnormality was given. The last paper analysed, under NBI, a series of 33 middle turbinate heads and the authors found this technique to be useful in the diagnosis of subtle edematous mucosal changes by a digital software-assisted measurement of the image brightness(34). More simply, in our experience allergic rhinosinusitis showed some slightly different vascular patterns (SN2 and SN3) which is the counterpart of the subtle and still debated remodeling of the upper airways in allergic rhinitis[35,36].
Nearly 7% of the sinonasal lesions in our series were not evaluable by NBI. This was in agreement with the current literature even though on a different basis. We noticed that this NBI-null pattern was mainly due to a large edematous component of the respiratory mucosa while, in laryngeal pattern study, the similar proportion (5.8%) of unclassifiable cases was justified by the hyperkeratotic appearance of the squamous epithelium[9]. Again, 6.6% of the patients in the series of oral cavity patterns had no NBI findings on the thick leukoplakias or leukoerythroplakias[10]. Curiously, in the classification of nasopharyngeal patterns, only lymphomas were considered not to be evaluable by NBI but this was not true for our case[8].
Our study, to the best of our knowledge, is the first to propose a systematic evaluation of normal and pathological vascular patterns in sinonasal district. The present work was a perspective study on the general application of narrow band imaging to the rhinological diagnosis in everyday practice. Therefore, we decided to include every kind of inflammatory, benign or malignant

condition in order to give a full picture of the potential application and pitfalls of this technique. Our work has however some limitations: the first description of any pattern is always open to subjective interpretation, therefore external validation to assess interobserver reproducibility is needed. Secondly, peculiar to this district are mucosal crusts, that impede the visualization of NBI pattern while their removal only worsens the picture because of diffuse bleeding: this is a critical point to consider in certain subgroups (patients recently undergoing radiation therapy, concomitant acute rhinosinusitis, etc.). Moreover, the need to use vasoconstrictors in nasal cavities can alter the NBI vision. Nonetheless, our proposed classification has shown potential clinical utility especially regarding the diagnostic accuracy of SN5 pattern in differentiating benign from malignant tumors. Future studies are needed to confirm our promising findings so to strengthen the evidence in this regard.

## Conclusion

The present work suggests that NBI can be a valid diagnostic tool even for the analysis of nasal cavity and paranasal sinuses. Our patterns should be viewed as a framework that can help clinicians to standardise the use of this technique and could be useful to distinguish different sinonasal disorders. Every new classification comes with the need for adequate training and it will also be necessary to externally address the learning curve for our categorisation. Nonetheless, we hope that our effort will help to better define the complex heterogeneity of sinonasal diseases.

## Acknowledgements

None

## Authorship contribution

CB: Conceptualization, data curation, project administration, resources, supervision, and writing - review and editing. GMF: Data curation, formal analysis, investigation, methodology, validation, visualization, and writing - original draft. LGL: Conceptualization, data curation, project administration, resources, supervision, and writing - review and editing. AC: Conceptualization, data curation, project administration, resources, supervision, and writing - review and editing. OG: Conceptualization, Data curation, supervision and editing. GM: Conceptualization, Data curation, supervision and editing.

## Conflict of interest

All authors declare they have nothing to disclose.

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Chiara Bruno, MD
Department of Otorhinolaryngology
Careggi University Hospital Largo Brambilla,
3 - 50134 Florence
Italy

Tel: +39 0557947989
E-mail: bruno.chiara91@gmail.com

ORCID iD: 0000-0002-2506-4452.