



Review Article

Narrow Band Imaging- A New Imaging Technology in Early Detection of Head and Neck Cancer

Prem Kumar^{*@}, Shraddha Bahirwani^{***}, Swati Garg^{*}, Mallayya Pujari^{**}, Monica Tuteja^{**}, Jigna V Raja^{**}

^{*}Postgraduate Student, ^{***}Professor and HOD, ^{**}Senior Lecturer
Dr. Syamala Reddy Dental College Hospital & Research Centre
Affiliated to Rajiv Gandhi University of Health Sciences
Bangalore, Karnataka, India

[@]Correspondence Email: drprem01@gmail.com

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ABSTRACT

Narrow band imaging (NBI) is a novel method of imaging that increases the diagnostic potential of conventional endoscopy. It highlights abnormalities in the superficial vasculature of mucosal lesions so that precancerous or cancerous lesions can be identified more easily. Initially developed for the gastrointestinal tract, and widely used in other branches of medicine, it is now being used for the assessment of patients with malignancy in the head and neck. We review current published papers relating to NBI and discuss its benefits for early detection of cancer of the head and neck.

Keywords: Narrow band imaging, Oral, Squamous cell carcinoma

INTRODUCTION

Oral cancer is a significant global health problem with more than 10 million new cases and 6 million deaths each year worldwide. ^[1] Developing countries contribute to more than half of all cancer cases and are currently witnessing an escalating cancer epidemic. ^[2] In India, oral cancer is the third most common cancer and constitutes 16.5% of all cancers with relatively high incidence

rates of 21.5 and 12.8 per 100 000 men and women, respectively, in the age group 35 to 64 years. ^[3] It remains a lethal disease for over 50% of cases diagnosed annually, largely reflected by the fact that most cases are in advanced stages at the time of detection. ^[4] The ability to observe disease onset and progression through non-invasive and cost effective screening methods at the population level may help to implement the prevention and treatment strategies at an early stage. High-quality studies to assess

the efficacy and effectiveness of reliable non-invasive techniques for early detection of oral cancer are necessary to recommend the inclusion of these methods in a nationwide population-based screening programme.

Narrow band imaging (NBI) is a novel method of imaging which has the potential to improve the diagnostic capability of standard white light endoscopy. It was initially developed for use in the gastrointestinal tract, but is now commonly used to image other areas including the respiratory tree, urinary tract, and upper aerodigestive tract. More recently there has been a rapid development in its use for screening and examining patients for mucosal squamous cell carcinoma (SCC) in the head and neck. NBI increases tissue contrast by specifically identifying superficial capillaries and neo-angiogenesis in abnormal mucosa. It requires no special dyes and allows for easy inspection of the superficial vascular bed. A combination of the mucosal abnormalities detectable by NBI may result in an accurate endoscopic tool that will help to target biopsy examination to areas with suspicious superficial vascular morphology, or enable excision biopsies to be more accurate. [5]

NBI

NBI (Olympus Medical Systems, Tokyo, Japan) was developed primarily to emphasize the mucosal microvasculature and to identify vascular alterations indicative of pathologic conditions. [6] The technology consists of placing narrow band pass filters in front of a conventional white-light source to obtain tissue illumination at

selected, narrow wavelength bands. These bands produce the greatest contrast between vascular structures and the surrounding mucosa. Initial NBI development consisted of a 3-band NBI prototype system for the RGB sequential endoscope given the ease of integrating 3 NBI filters into the rotating filter wheel of the RGB sequential system. The narrow band filters were selected on the basis of studies that determined a set of filters that achieved the preferred appearance for mucosal vascular patterns (Table 1). [6] The selected NBI filters restricted tissue illumination to the blue spectral range given the shallow depth of penetration of short-wavelength blue light into tissue (ie, limited to mucosa), relative to deeper penetrating, longer-wavelength light (e.g., red light). Moreover, blue illumination at one of the chosen narrow band wavelengths (i.e., 415 nm) corresponds to the main peak on the absorption spectrum of hemoglobin. Structures with high hemoglobin content (i.e., blood vessels) absorb the 415-nm light and thus appear darker and provide stark contrast to the brighter surrounding mucosa that reflects the light. In contrast to the initial 3-band NBI prototype, currently available NBI systems use 2 narrow band filters that provide tissue illumination in the blue (415 nm) and green (540 nm) spectrum of light. The deeper penetrating 540-nm light corresponds to a secondary hemoglobin absorption peak. Capillaries in the superficial mucosal layer are emphasized by the 415-nm light and are displayed in brown, whereas deeper mucosal and submucosal vessels are made visible by the 540-nm light and are displayed in cyan (Fig. 1).

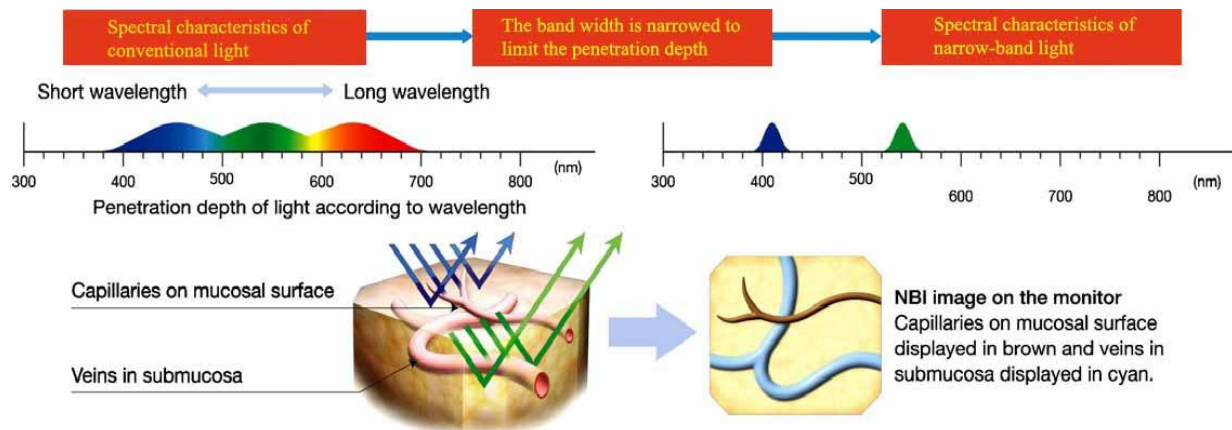


Fig.1. Diagram of narrow band filtration of light highlighting improved contrast of superficial and submucosal vessels.

NBI systems

Except for modifications within the light source, instrument components of NBI-equipped endoscopes are otherwise identical to those of conventional RGB sequential or color CCD video endoscopes. NBI can also be coupled with electronic or optical (zoom) magnification for enhanced visualization of mucosal details. The initial prototype 3-band NBI system configured for the RGB sequential illumination video endoscope contains 2 separate light sources, one for standard white-light imaging and one for NBI. Although the same video processor is used for both light sources, switching between white-light imaging and NBI requires disconnecting the endoscope from one light source and connecting it to the other. The NBI light source contains an optical filter with narrow band transmission at 415, 445, and 500 nm that replaces the broadband RGB filter found in the rotating

filter wheel of a conventional light source. After tissue illumination, the reflected blue images are processed and converted into a composite pseudo color NBI image on the monitor (Table 1). Commercially available NBI systems include either 2-band NBI RGB sequential endoscopes (Evis Lucera 260 Spectrum) or color CCD endoscopes (Evis Exera II 180, Olympus Medical Systems, Tokyo, Japan). The same narrow band filter is used in both video endoscope systems, with center wavelengths at 415 and 540 nm. Both systems have white-light illumination and narrow band illumination integrated into a single light source. Switching from white light mode to NBI mode occurs by mechanical insertion of the narrow band filter in front of the xenon arc lamp. The final composite NBI image is displayed by feeding the 415-nm image in the blue and green channels and the 540-nm image in the red channel of the monitor (Table 1).

TABLE 1. Narrow band filters and display of 2-band versus 3-band NBI systems		
NBI systems	NBI filters (center wavelength)(bandwidth)	Video channels used for image display
2-Band RGB sequential and color CCD NBI	415 nm (30 nm)	Blue and green
	540 nm (20 nm)	Red
3-Band RGB sequential NBI	415 nm (30 nm)	Blue
	445 nm (30 nm)	Green
	500 nm (30 nm)	Red

NBI APPLICATIONS

NBI uses a blue light directed at the oral mucosa and observed through an eyepiece that filters the light. Tissues with different physical, vascular, and cellular characteristics reflect or absorb the blue light, resulting in an image as viewed through the scope with different visual characteristics. The blue light augments the fluorescence properties of some tissue components, generating a green-white appearance. On the other hand, the optical characteristics of some tissues result in a loss of fluorescence (LOF), causing a dark pattern when the tissues are observed through the scope.

Inflamed and highly vascularized tissues absorb the light and appear dark compared to the same tissue without inflammation. Oral dysplasia and oral cancer also absorb the light and appear darker than the corresponding tissue without cancer or dysplasia. Dysplastic tissues with significant keratinization (leukoplakia) can exhibit increased fluorescence (whiteness) with LOF (darkness) around the periphery of the lesion. Obviously, because inflammatory lesions absorb the light and appear dark, traumatic, viral, and aphthous lesions demonstrate an LOF, as do migratory glossitis and lymphoid tissue (Fig. 2–9).^[7]



Fig. 2. Clinical photograph of the lateral tongue



Fig. 3. Photograph of the same area as in Figure 2, demonstrating LOF that represents dysplasia



Fig. 4. Clinical photograph of the ventral tongue, showing normal to slightly atypical mucosa.

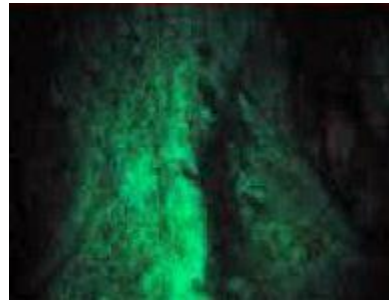


Fig. 5. Photograph of the same area as in Figure 4, demonstrating LOF that represents dysplasia.



Fig. 6. Clinical photograph of herpes simplex of the palate.



Fig. 7. Photograph of the same area as in Figure 6, demonstrating LOF that represents acute inflammation.



Fig. 8. Clinical photograph of the anterior tonsil pillar, illustrating the lymphoid tissues.



Fig. 9. Photograph of the same area as in Figure 8, demonstrating LOF that represents chronic inflammatory change.

Appearance of normal mucosa under NBI

In the oral cavity, normal mucosa that is identified under NBI with clear branching vessels in the sub epithelial layer is visualized as cyan or green in colour as a result of 540nm of light penetrating through to the sub mucosa and being reflected (Fig.

10). The sub epithelial vessels are well structured with a clear pattern in their course. The 415nm centred light does not penetrate any further than the epithelial layer and is in the peak absorption band of haemoglobin, [8] which means that blood vessels in the most superficial tissues are brown in colour.

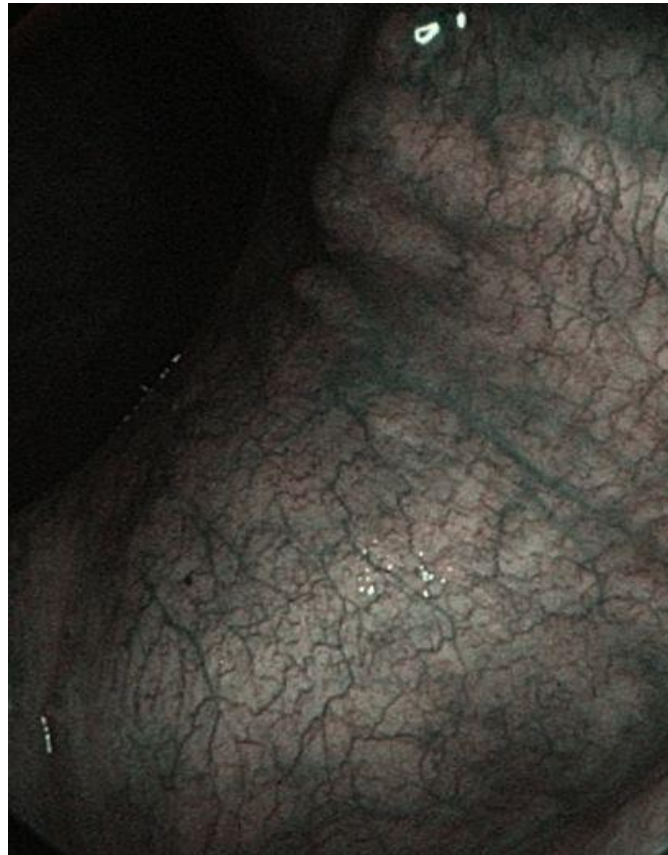


Fig 10: Narrow band image of normal capillary bed in the floor of mouth.

Appearance of abnormal mucosa under NBI

It is a characteristic of tissue found in the upper aero digestive tract that has undergone severe dysplasia to show substantial neo-angiogenesis [9] associated with accumulation of nuclear p53 and over expression of thymidine phosphorylase. [10] Furthermore, our own work has found significantly raised expression of vascular

endothelial growth factor (a powerful angiogenic factor) in severe dysplasia of the oral cavity. [11] Neo-angiogenesis is a prerequisite for the development of invasive SCC. Recent pathological studies have confirmed that microvascular irregularities are also an important pathological factor in carcinogenesis and early invasiveness of SCC of the oropharynx. [12] The abnormal vasculature that occurs within the sub epithelial layer is seen as brownish dots with

extension, dilatation, weaving, and differing shapes. [6] The usual branching arrangement that is seen in normal capillary beds is lost. In addition to microvascular abnormalities, other characteristics of early cancerous

lesions are changes in the microsurface such as irregularities in the margin. These changes are consistent with severe dysplasia or SCC and can readily be seen with NBI and magnifying endoscopy (Fig. 11). [13]

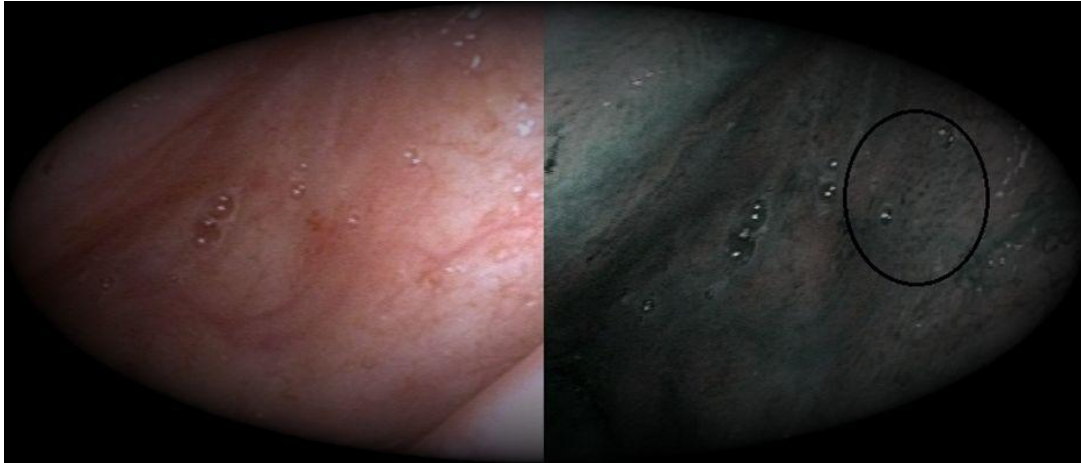


Fig. 11. Intraoperative views of the oral cavity. White light (WL1) (left) compared with narrow band imaging (NBI) (right)

Comparison between NBI and Iodine staining

NBI scale

According to the method of Zhang et al, [14] the NBI scale was determined based on the border and surface of lesions as follows: (1) grade I, the border was clear, the brown region was obvious, and the surface was unequal; (2) grade II, the border was clear and the brown region was light; (3) grade III, the border was unclear and the brown region was fairly light; and (4) negative, no obvious brown region was observed.

Iodine staining scale

According to the method of Wang et al, [15] the iodine staining scale was recorded based on the staining status and border of the tissue after iodine staining as follow: (1) negative, normal staining with a brown color; (2) grade I, the region not stained was obvious, the border was clear, and the lesion

was eminent or depressed; (3) grade II, the region not stained was light brown, but the border was clear; and (4) grade III, the region not stained was light and the border was obscure.

A study in literature shows that the lesion detection rate with NBI was lower than with the iodine staining ($P < 0.01$), but there was no significant difference for the detection of high grade intraepithelial neoplasia between NBI and iodine staining ($P > 0.05$). The main difference was that NBI was inferior to iodine staining for the detection of low grade intraepithelial neoplasia ($P < 0.01$) because NBI was not sensitive for the detection of mild dysplasia. In this study, mild and moderate dysplasia were classified as low grade intraepithelial neoplasia; intraepithelial neoplasia and severe dysplasia were classified as high grade intraepithelial neoplasia. The majority of high grade intraepithelial neoplasia was NBI grade I while the majority of low grade intraepithelial neoplasia was NBI grade II,

III or negative ($P < 0.01$). Most high grade intraepithelial neoplasia was iodine staining grade I while the majority of low grade intraepithelial neoplasia was iodine staining grade III or III ($P < 0.05$). This showed that the NBI scale and iodine staining scale were correlated with the pathologic diagnosis. ^[16]

CONCLUSION

Narrow band imaging has the potential to improve diagnostic accuracy and the intraoperative planning of resection margins for lesions of the oral cavity. There is evidence that it allows for the detection of dysplastic areas not clearly evident with white light examination alone, thus reducing the chance of inadequate resection. Although already commercially available, the classification of mucosal and vascular patterns with narrow band imaging in the head and neck has not yet been standardised or validated. Further studies are needed before it can be considered routinely in clinical practice.

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