

Proposal for a consensus terminology in endoscopy: how should different endoscopic imaging techniques be grouped and defined?¹

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Introduction

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 In Japan, gastrointestinal endoscopy began with the introduction of the gastroscope, which prompted active clinical use of endoscopes in subsequent years [1]. After the gastroscope had been introduced into practice, various fiberscopes began to be used clinically. In 1984, electronic video endoscopes were also developed. Unlike fiberscopes in which light signals are directly observed, electronic video endoscopes convert electronic signals into images via semiconductor elements and allow various forms of electronic image processing and analysis.

Recently, it was demonstrated that narrow band imaging (NBI) is useful for early diagnosis of cancers of the oropharynx, hypopharynx, esophagus, stomach, and large intestine. This finding invited many responses not only from Japanese investigators but also colleagues in many other countries, and NBI has been attracting considerable attention in academic societies, research organizations, etc. In Japan, the term “special light (observation)” was and is now frequently used to describe this method. A succession of analogous techniques were later made public. The term “special light (observation)” came to have various and sometimes ambiguous meanings in this field, causing some confusion among investigators. In view of this problem and the necessity of establishing internationally applicable terminology related to endoscopy, the present authors hereby propose a new classification for endoscopic techniques, that is tailored to the methods and technologies and provides precise definitions of individual terms.

¹ This proposal was discussed at a symposium on novel endoscopic imaging technologies at the Japan Digestive Disease Week (JDDW) 2007 in Kobe, and was submitted to Endoscopy by the authors with authorization from the Executive Board of the Japan Gastroenterological Endoscopy Society.

Methodological classification of endoscopic imaging

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 As shown in **Fig. 1**, endoscopy techniques are divided into categories: (i) conventional (white light); (ii) image-enhancement; (iii) magnifying; (iv) microscopic; and (v) tomographic.

Image-enhanced endoscopy is subdivided into digital, optical-digital, and chromoendoscopy methods; magnification into optical and digital; microscopy into optical and confocal methods; and tomographic endoscopy is subdivided into endoscopic ultrasonography and optical coherence tomography (OCT) (**Fig. 2 and 3**).

“Special light observation,” a term which has recently begun to be used at meetings of academic societies, research organizations, etc., refers to the optical-digital approach among the various image-enhancement endoscopy methods currently available [2,3].

Conventional endoscopy (white light endoscopy)

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 White light, which covers the visible range of wavelengths almost completely, is used for illumination to yield images which reproduce the object in a way most closely resembling the macroscopic view. This technique can be subdivided into diverse methods depending on the type of light source, color, temperature, etc. Detailed discussion is beyond the scope of this report.

Image-enhanced endoscopy

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 Image-enhanced endoscopy is a method that is designed to emphasize the small blood vessels and minute patterns on the mucosa surface. This is done by employing a light source with different optical characteristics from ordinary white light,

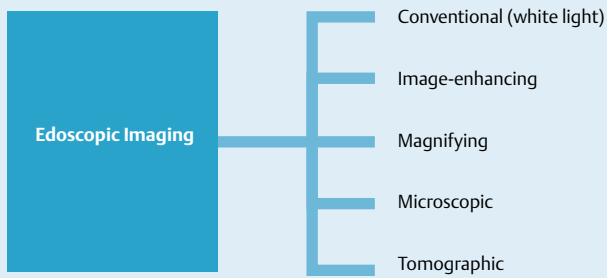


Fig. 1 Major categories of endoscopic imaging, according to approach.

by signal processing and the use of an image-processing algorithm, by using dye, or by a combination of these methods. A characteristic of the living body is that the information obtained can vary depending on the absorption or scattering characteristics of the wavelength used for observation. With this feature at the forefront, attempts have been made to develop new endoscopy systems capable of yielding more natural images or that make use of varying wavelengths depending on the observation target. Attempts to obtain specific diagnostic information by changing

the spectrum of the illumination were already being made during the era of gastroscopes, and some ultraviolet gastroscopes were developed in those days. Many investigators attempted to collect information from the deeper layers of the mucosa using infrared light, and to analyze differences in characteristics of the images obtained depending on the wavelength used within the visible light spectrum. Around 1960 attempts were begun to apply fluorescence within endoscopy, including studies on fluorescence gastroscopy where ultraviolet light was used for excitation [1,4]. The attempt has been carried further in the age of the videoscope, with various digital means of signal processing, and beyond that with a combination of optical and digital methods.

Digital image enhancement

This method involves image enhancement through signal processing and the use of an image-processing algorithm. Various algorithms have been proposed depending on the objectives and means of imaging, including one that enhances the contours or fine patterns in the constructed images, one emphasizing image contrast, one for color conversion, and so on. The Fuji Intelligent Color Enhancement (FICE) system [5,6], real-time image mapping (RIM), adaptive structure enhancement, and index of hemoglobin (IHb) color enhancement belong to this category.

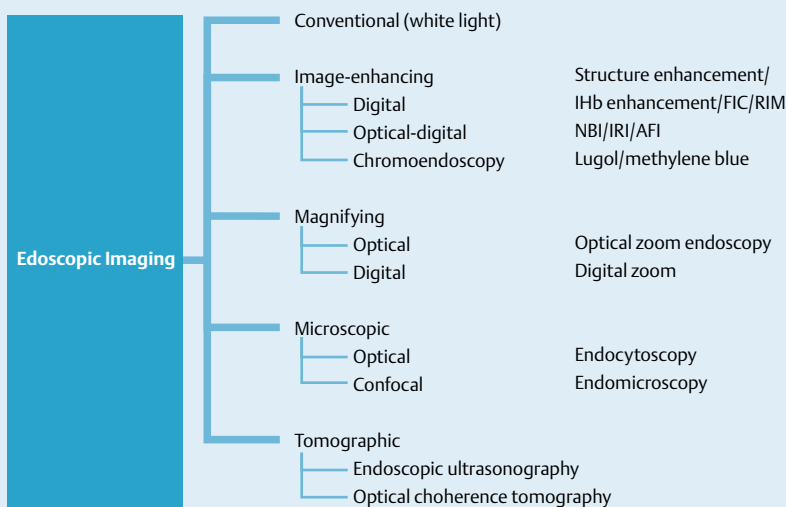


Fig. 2 Intermediate categories of endoscopic imaging, according to method, with examples. IHb, index of hemoglobin; FICE, Fuji Intelligent Color Enhancement; RIM, real time-image mapping; NBI, narrow band imaging; IRI, infra-red imaging; AFI, autofluorescence imaging.

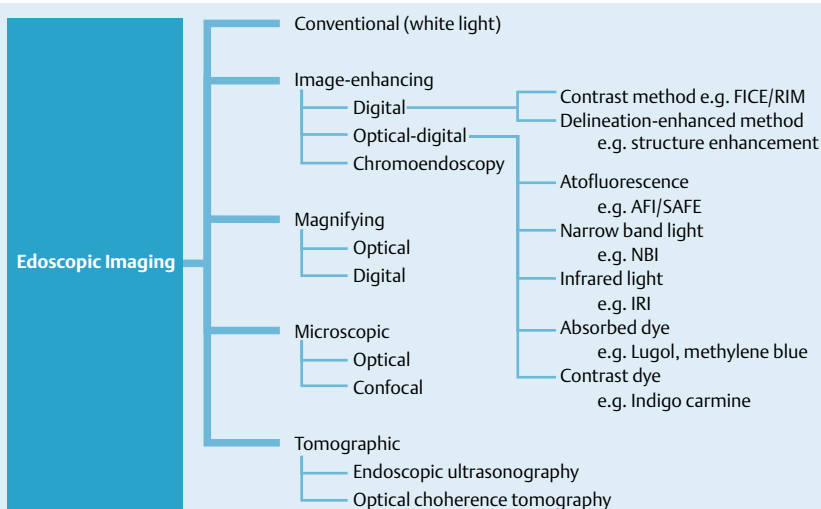


Fig. 3 Categories of endoscopic imaging in more detail. SAFE, simultaneous autofluorescence endoscopy.

With the FICE system, an image at a freely selected wavelength is obtained from a conventional image by means of computerized processing. This method has been applied to endoscopy, and because it involves conversion of the images from charge-coupled device (CCD) cameras, images using the selected wavelengths can be obtained in real time.

Optical-digital method

Like the optical technique, the optical-digital method involves adaptation of the optical characteristics of the illuminating light, or using a light source with different characteristics from ordinary white light. At the same time, the signal is processed to yield enhanced images. This method usually encompasses narrow band imaging (NBI), autofluorescence imaging (AFI), and infrared imaging (IRI).

With NBI, the central wavelengths are optimized at 415 and 540 nm, corresponding to the light wavelength most intensely absorbed by blood and that showing intense reflection and scattering at the mucosa. With a narrow spectrum, this method is intended to emphasize the small blood vessels and minute patterns on the mucosal surface [7–13].

If blue excitation light reaches the subepithelial layer, autofluorescence is generated. Autofluorescence methods attempt to facilitate the detection and diagnosis of tumorous lesions by showing them as areas that are different in fluorescence intensity or color from the adjacent intact tissue. With the AFI system, it is possible to switch easily from ordinary observation with a videoscope to fluorescence observation and vice versa, using only one endoscope [14–16]. An electronic video endoscopy system for simultaneous autofluorescence observation (SAFE-3000; Hoya), is also available clinically [17,18].

Infrared imaging (IRI) is designed to visualize deep tissues of the living body, using near-infrared light. IRI employs two different wavebands of infrared as a light source. The difference in light absorption in the human body is emphasized digitally. This method has provided diagnostic data from blood vessels in deep layers of the mucosa where it is difficult to collect information with visible light [19,20].

Chromoendoscopy

This category includes contrast methods dye (e.g. using indigo carmine) and absorption methods (e.g. using methylene blue and Lugol stain) [21–24]. Further discussion is needed to determine whether these techniques can be viewed as methods of image-enhanced endoscopy in the present classification.

Magnifying endoscopy



Magnifying endoscopy emphasizes the small blood vessels and minute patterns on the mucosa surface by enlarging the endoscopic image using an optical lens or digital processing.

Optical method

A zoom lens is connected to the endoscope tip. By controlling this lens, images magnified up to 100-fold are produced with a CCD on a 14-inch monitor, which allows observation of fine patterns and capillaries on the mucosa [25–29].

Digital method

Digital signal processing is used to enlarge or shrink, by several factors, part of the endoscopic images obtained from the CCD.

Because the magnified image is obtained through signal processing, this method tends to decrease image quality, and therefore, various remedies such as interpolation between pixels are employed. This approach is generally used to supplement other diagnostic methods.

Microscopic endoscopy



Microscopic endoscopy is intended to obtain images close to those obtained at cytological microscopy, by enlargement of 500- to 1000-fold.

Optical method

The combination of a CCD and a microscopy optical system is used to yield magnified images that allow observation of cell nuclei and tissue architecture. Endocytoscopy is representative of this method, allowing presentation of images magnified up to 450- or 1100-fold on a 14-inch display. Because nuclei can be stained with dyes such as methylene blue, nuclear atypia may be evaluated optically, with images similar to those obtained with conventional cytology [30–32].

Confocal method

This method is designed to yield tomographic images of the mucosal surface or to achieve detailed observation at the cellular level by means of a confocal optical system that selectively conveys and images information from the focus area of the living tissue. Usually, imaging is performed by 2- or 3-dimensional laser scanning; thus the confocal method is distinguished from an optical method. Confocal endomicroscopy is representative of this category and has been extensively applied clinically, primarily in Europe [33–37]. The magnification and resolution are quite high with this method, allowing digital images of cells, magnified 1000-fold, to be presented in real-time on a computer display. Intravenous administration or local direct spraying of fluorescent dye is needed.

The confocal category also includes probe-based confocal microscopy technology.

Tomographic endoscopy



Tomographic endoscopy obtains tomographic images by matrix computing of percolation or scattering data from inside the object of interest, using various means such as light illumination or radiowaves emitted in multiple directions.

Endoscopic ultrasonography

Endoscopic ultrasonography requires an endoscope fitted with an ultrasound probe at the tip [38–42]. However, small-diameter ultrasound probes that can be inserted through an ordinary forceps channel are also frequently used.

Optical coherence tomography (OCT)

OCT uses near-infrared light as a light source and can yield tomographic images with a resolution ranging from several to magnitudes of tens, in a noninvasive manner [43]. This resolution is more than one-rank higher than that of conventional two-dimensional ultrasonography. In the field of ophthalmology, this method has been used clinically to detect retinal diseases.

Conclusion

We have proposed a new classification of endoscopy imaging and presented definitions of the relevant terms. Although the term “special light” has often been used in recent years, its intended meaning (“light in a specific waveband with characteristic behavior in living tissue”) is not sufficiently precise and its general validity has thus been eroded with recent successive developments in new endoscopy techniques. We also see the necessity of establishing a uniform classification and terminology for related endoscopy techniques. It is desirable that uniform and correct terminology should be promulgated throughout the academic and clinical spheres, worldwide, to facilitate further advances in endoscopic diagnosis and treatment.

Competing interests: None

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