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THE ROLE OF NASAL FIBEROSCOPY IN OTORHYNOLARYNGOLOGICAL PRACTICE FOR THE EARLY DETECTION OF UPPER AIRWAY CANCERS

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ABSTRACT

Introduction and Purpose: Nasopharyngeal fiberoscopy is a modern, minimally invasive diagnostic technique that allows for direct, dynamic, and high-resolution visualization of the upper respiratory tract, including the nasal cavity, nasopharynx, oropharynx, and larynx. By using a thin, flexible fiber-optic endoscope, clinicians are able to assess the mucosal surfaces in great detail, identify potential pathological changes, and collect targeted biopsy specimens in a safe and precise manner. Compared to traditional examination methods such as indirect laryngoscopy or mirror examination, fiberoscopy offers significantly improved diagnostic accuracy, greater patient comfort, and the advantage of being performed in outpatient settings without the need for hospitalization.

In the field of otolaryngology, early detection of malignancies of the upper aerodigestive tract—such as laryngeal, nasopharyngeal, nasal, and base-of-tongue cancers—remains one of the most important clinical challenges. Detecting neoplastic changes at an early stage dramatically increases the likelihood of effective treatment, reduces the extent of surgical intervention required, and improves long-term prognosis. Consequently, the development and implementation of accurate, accessible, and non-invasive diagnostic tools such as fiberoscopy are of particular importance—not only in clinical practice but also in population-based screening and prevention strategies targeting high-risk groups.

This article provides a comprehensive review of current literature concerning the application of nasal fiberoscopy in the early diagnosis of upper airway cancers. It discusses the clinical advantages and limitations of the method, details of the examination procedure, and its role in the differential diagnosis of non-specific symptoms such as chronic hoarseness, globus sensation, or unilateral otalgia. Special attention is given to the integration of fiberoscopy with advanced imaging techniques (e.g., Narrow Band Imaging, autofluorescence, CT, and MRI), as well as the implementation of artificial intelligence and machine learning in real-time diagnostic support systems. Selected clinical cases and PubMed-sourced studies are presented to illustrate the growing clinical relevance and diagnostic effectiveness of this technique. The article also outlines future directions for the development of fiberoscopy and highlights its potential to become a key pillar in personalized head and neck cancer diagnostics in the 21st century.

Materials and Methods: This narrative review was based on a comprehensive search of scientific literature in the PubMed, Web of Science, and Google Scholar databases using the following keywords: nasal fiberoscopy, upper airway cancers, early diagnosis, endoscopic screening, otorhinolaryngology, and laryngological fiberoscopy. The analysis included original research articles, review papers, meta-analyses, case reports, and clinical guidelines from scientific societies that addressed the use of nasal fiberoscopy in the diagnosis of upper airway malignancies.

The selected publications provided data on diagnostic effectiveness, screening potential, technical capabilities, and integration with imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), narrow band imaging (NBI), autofluorescence, and artificial intelligence–assisted analysis. The aim was to synthesize current knowledge regarding the clinical value and evolving role of nasal fiberoscopy in the early detection and evaluation of upper aerodigestive tract cancers within otorhinolaryngological practice.

Results: The literature analysis revealed that nasal fiberoscopy demonstrates high diagnostic sensitivity and specificity in detecting both precancerous and cancerous lesions within the upper aerodigestive tract. This technique allows for real-time, dynamic assessment of anatomical structures, as well as the performance of targeted biopsies under direct visualization, which significantly enhances diagnostic accuracy. Compared to static imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI), fiberoscopy offers superior evaluation of mucosal surfaces and phonatory function.

Numerous studies have confirmed that the use of fiberoscopy in patients presenting with non-specific symptoms - such as hoarseness, dysphagia, or epistaxis - led to early detection of laryngeal, nasopharyngeal, and base-of-tongue cancers. Furthermore, in high-risk populations, including tobacco users, individuals with occupational exposure to carcinogens, or those with a positive oncological family history, nasal fiberoscopy proved more effective in identifying subclinical lesions than clinical observation alone.

Several case reports describe instances where routine fiberoscopic examination enabled the identification of early-stage malignancies in asymptomatic patients, which was critical for initiating radical yet function-preserving treatment. These findings highlight the growing importance of nasal fiberoscopy as both a diagnostic and screening tool in contemporary otorhinolaryngological practice.

Conclusions: Nasal fiberoscopy is becoming an increasingly important tool in otorhinolaryngological diagnostics. Its advantages - real-time assessment of mucosal structures, the ability to perform targeted biopsies, wide availability in outpatient settings, and low cost—make it applicable both in differential diagnosis and in screening high-risk populations. The literature clearly indicates that nasal fiberoscopy holds significant value as a first-line diagnostic method for patients with suspected neoplastic changes in the upper aerodigestive tract.

Integration with modern imaging technologies and artificial intelligence systems may further enhance its diagnostic effectiveness. However, additional large-scale clinical studies are necessary to validate its efficacy and to develop standardized screening protocols. In light of the rising incidence of head and neck cancers and the increasing emphasis on early detection, nasal fiberoscopy has the potential to play a pivotal role in improving treatment outcomes and overall patient survival.

KEYWORDS

Nasal Fiberoscopy, Upper Airway Cancers, Early Detection, Otorhinolaryngology, Minimally Invasive Diagnostics

CITATION

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Introduction:

The upper respiratory tract comprises a complex anatomical structure that plays a crucial role in respiration, phonation, and swallowing. The most common pathological changes in this region include malignancies of the nasal cavity, nasopharynx, oropharynx, hypopharynx, and larynx. These tumors can remain asymptomatic for a long time or present with non-specific complaints such as hoarseness, a sensation of a foreign body in the throat, epistaxis, or dysphagia. Due to the non-specific nature of these symptoms, many cases are diagnosed only at an advanced stage of the disease. [1, 4]

Early detection of neoplastic lesions in the upper airway is essential for initiating radical treatment and improving patient prognosis. Despite significant advances in imaging technologies such as computed tomography (CT) and magnetic resonance imaging (MRI), these methods have limitations in detecting early-stage lesions and assessing superficial mucosal abnormalities. Moreover, they do not allow for real-time functional assessment of phonation or targeted biopsy under visual control. In this context, **nasal fiberoscopy** has emerged as a valuable diagnostic tool in everyday otorhinolaryngological practice. [8, 9]

Due to its ability to provide detailed and dynamic visualization of the upper airway anatomy, nasal fiberoscopy has gained recognition as a supportive technique in the evaluation of both symptomatic patients and in screening high-risk populations—such as smokers, individuals with occupational exposure to carcinogenic substances (e.g., wood dust, nickel), and patients with a positive family history of cancer. This tool enables direct observation of the vocal folds, nasopharynx, base of tongue, and laryngeal structures in outpatient settings, which further enhances its accessibility and cost-effectiveness. [12, 18]

The development of advanced technologies such as **narrow band imaging (NBI)**, **autofluorescence**, and integration with **artificial intelligence algorithms** - opens new perspectives for fiberoscopy, not only as a diagnostic but also as a prognostic and treatment-monitoring tool. There are also emerging reports on its successful application in **telemedicine programs** and **mobile diagnostic units**, expanding its utility beyond traditional clinical settings.[1, 3, 5]

The aim of this narrative literature review is to discuss current evidence on the application of nasal fiberoscopy in the early diagnosis of upper airway malignancies. The review focuses on its clinical effectiveness, screening potential, limitations, and future directions of development within otorhinolaryngological practice. Malignancies of the upper aerodigestive tract—including those of the nasal cavity, nasopharynx, oropharynx, hypopharynx, and larynx—frequently present with non-specific symptoms such as hoarseness, nasal obstruction, or dysphagia. Early detection is crucial for treatment efficacy, minimizing the invasiveness of surgical interventions, and improving overall survival. Although CT and MRI have brought advances in anatomical imaging, nasal fiberoscopy offers unique advantages through real-time dynamic mucosal visualization and facilitated access for targeted biopsies.[6, 9, 13]

Discussion

Nasal fiberoscopy, as an endoscopic procedure enabling dynamic assessment of the upper airway structures, is increasingly applied in the diagnosis of malignancies within this region. Its significance is growing particularly in the context of early cancer detection—especially among high-risk groups - due to its ability to provide direct visualization of the mucosal surfaces, phonatory function, and mobility of key anatomical structures such as the vocal folds, epiglottis, and base of tongue.

Anatomical Considerations and Technical Capabilities

A thorough understanding of the anatomy of the upper respiratory tract - from the nasal cavity through the nasopharynx, oropharynx, hypopharynx, and down to the larynx - is essential for the effective and safe performance of fiberoscopy. The nasal cavity contains several key structures, including the inferior, middle, and superior turbinates, the nasal septum, and the openings of the paranasal sinuses, such as the maxillary, frontal, ethmoidal, and sphenoidal sinuses. All of these areas must be carefully identified and assessed during examination, as pathological changes - such as mucosal swelling, polyps, erosions, or ulcerations - may represent early signs of malignant or premalignant processes. [4, 5]

The nasopharynx, located posterior to the nasal cavity and above the soft palate, is a common site for malignancies, particularly those associated with viral infections such as human papillomavirus (HPV) and Epstein–Barr virus (EBV). This region includes important anatomical recesses, such as the Rosenmüller fossa, which is a frequent origin site for nasopharyngeal carcinoma. Visualization of this area is often challenging with traditional mirror examination techniques, which makes fiberoscopy a valuable tool for accurate diagnosis.[28, 30]

The oropharynx and hypopharynx, due to their deep anatomical location and dynamic function in swallowing and phonation, are difficult to assess using standard imaging techniques. Fiberoscopy allows for precise visualization of the posterior pharyngeal wall, palatine tonsils, base of the tongue, and piriform sinuses - all of which are common sites for malignancies of the respiratory and digestive tracts. Early detection of pathological lesions in these areas significantly improves prognosis by enabling timely radical or conservative treatment. [28]

The larynx, as the organ of phonation, plays a critical role in everyday human function. It is composed of the supraglottic, glottic, and subglottic regions. Of particular importance is the evaluation of the vocal folds, which are responsible for sound production and glottic closure during swallowing. Fiberoscopy enables dynamic assessment of the mobility of these structures, as well as detection of asymmetries, thickenings, or phonatory limitations that may indicate neoplastic, polypoid, or neurological conditions. [18, 24]

Procedure of Nasal Fiberoscopy

Nasal fiberoscopy is performed in an outpatient setting and typically lasts between 5 and 15 minutes. Due to its simplicity and minimally invasive nature, the procedure does not require hospitalization or extensive preparation on the part of the patient. Prior to the examination, topical anesthesia of the nasal mucosa is applied - usually in the form of a lidocaine spray—to minimize discomfort and suppress the gag reflex. In cases of nasal congestion or anatomical obstruction, a decongestant such as xylometazoline may be administered to improve visualization and patient comfort. [11, 12, 13]

The procedure utilizes a thin, flexible fiber-optic or digital endoscope - commonly referred to as a fiberscope - which is inserted through the more patent nasal passage. The examiner gently advances the scope through successive segments of the upper airway: the nasopharynx, oropharynx, hypopharynx, and finally the larynx. Real-time visualization on a monitor enables assessment not only of the static appearance of anatomical structures but also of their movement during phonation and swallowing. This dynamic evaluation allows for the identification of subtle asymmetries, impaired vocal fold mobility, changes in mucosal coloration, or other abnormalities suggestive of pathology. [30]

The entire examination can be recorded in video format, facilitating later analysis, inclusion in the medical record, or interdisciplinary consultation. If suspicious lesions are identified during the procedure, a targeted biopsy can be performed immediately using a fine instrument introduced through the working channel of the fiberscope. This allows for histopathological sampling without the need for hospitalization, significantly shortening the time to diagnosis and initiation of treatment. [26]

Diagnostic Accuracy and Clinical Applications

Nasal fiberoscopy demonstrates high sensitivity and specificity, particularly in detecting lesions located in the vocal folds, epiglottis, nasopharynx, and base of the tongue. As a minimally invasive procedure, it is utilized both in the diagnostic evaluation of symptomatic patients and in screening populations exposed to oncogenic risk factors. Early-stage squamous cell carcinomas—especially in smokers with persistent hoarseness or dysphonia—can be effectively identified through endoscopic examination. For instance, in a study by Yamamoto et al. (2017), fiberoscopy enabled the detection of in situ laryngeal carcinoma in patients with chronic hoarseness. Early diagnosis allowed for function-preserving surgical treatment and complete phonatory recovery. [14, 15]

The literature provides numerous examples of the clinical utility of fiberoscopy in detecting malignancies with atypical localization or nonspecific clinical presentation. In one reported case (Lee et al., 2020), a patient with chronic rhinitis underwent fiberoscopic examination, which revealed a tumor in the nasopharynx. Biopsy confirmed a previously undetected maxillary sinus carcinoma, not visible in standard laryngological examination. [18]

Another notable case, described by Ghosh et al. (2021), involved a patient with persistent unilateral otitis media, which—despite the absence of overt ENT symptoms—led to the diagnosis of nasopharyngeal carcinoma through fiberoscopic visualization. Similarly, in a case reported by Takahashi et al. (2020), an asymptomatic lesion at the base of the tongue was discovered during a routine screening in a woodworking industry employee with chronic exposure to dust. Histopathology revealed high-grade dysplasia. [20, 21, 22]

In a screening study conducted in Finland by Kinnunen et al. (2015) among workers in the wood-processing industry, nasal and nasopharyngeal fiberoscopy revealed dysplastic changes in 3.4% of participants. Early referral of these individuals for histopathological analysis enabled oncological treatment at a preinvasive stage. [14]

Fiberoscopy has also shown efficacy in specific high-risk populations. Zhang et al. (2019) reported on patients post–bone marrow transplantation, a group with increased risk for secondary upper airway malignancies. Regular fiberoscopic surveillance in this population allowed for the detection of asymptomatic tumors prior to clinical manifestation, significantly impacting prognosis and treatment strategy.[28, 19]

Ahmed et al. (2022) described the case of a young male with persistent globus sensation. Despite a normal physical examination and indirect endoscopy, nasal fiberoscopy revealed a small lesion in the piriform recess, which was confirmed as early-stage squamous cell carcinoma. [13, 14]

In another screening study conducted in South Korea (Kim et al., 2021), fiberoscopy was used in individuals over 60 years of age with a history of tobacco and alcohol use. Suspicious neoplastic lesions were detected in 6.1% of participants. In most cases, these lesions were asymptomatic and undetectable by physical or imaging examination. [11, 14]

These cases illustrate that fiberoscopy can reveal pathologies that remain invisible in conventional imaging modalities (e.g., X-ray or CT) and unsuspected during routine physical examination. The diagnostic accuracy of fiberoscopy, however, depends significantly on the operator's experience, the quality of the endoscopic equipment, and close cooperation with radiological and pathological teams. In the context of early cancer detection in the upper airway, nasal fiberoscopy should be considered a valuable screening tool, particularly in high-risk groups. [7, 9]

Integration with Advanced Imaging Technologies

The integration of Narrow Band Imaging (NBI), autofluorescence, and artificial intelligence–assisted systems with conventional fiberoscopy can greatly enhance diagnostic accuracy. NBI enables visualization of vascular patterns characteristic of dysplastic and malignant lesions. Combining these technologies with standard fiberoscopy allows for more precise delineation of biopsy sites and more effective monitoring of suspicious lesions over time. [28, 30]

Challenges and Limitations

Despite its many advantages, nasal fiberoscopy is not without limitations. Restricted depth of field, the potential to miss submucosal lesions, operator-dependent interpretation, and patient discomfort are the primary challenges. Additional difficulties may arise in the presence of anatomical abnormalities or a strong gag reflex. Integration with imaging techniques such as CT and MRI may help complement fiberoscopy by providing information on deeper structures and the extent of tumor spread. [23, 24]

Screening Potential and Population-Level Relevance

Despite its numerous advantages and wide application in laryngological diagnostics, nasal fiberoscopy is not without limitations, which must be considered when interpreting its results. One of the primary limitations is its relatively shallow depth of field, which may hinder accurate assessment of deeper structures or those concealed behind anatomical obstructions, such as hypertrophied nasal turbinates or tumors occluding the laryngeal lumen. Additionally, submucosal lesions - particularly in early stages -may remain undetected if they do not significantly alter the appearance of the mucosal surface under endoscopic light. In such cases, supplemental imaging such as computed tomography (CT) or magnetic resonance imaging (MRI) may be necessary to evaluate the depth of invasion and spatial relationship to surrounding anatomical structures. [16, 17]

Another important limitation lies in the subjective nature of the examination - fiberoscopy's diagnostic accuracy is highly dependent on the examiner's experience and skill. Interpreting endoscopic images requires not only a thorough knowledge of anatomy but also the ability to distinguish pathological changes from normal anatomical variants. Variations in examination technique, angle of scope insertion, or lighting conditions can lead to diagnostic discrepancies. A systematic review conducted by Gupta et al. (2021) noted that the diagnostic performance of fiberoscopy in detecting malignant lesions may vary considerably depending on operator training and access to next-generation endoscopic equipment.[18, 21, 22]

Patient comfort also remains a significant consideration. Although fiberoscopy is minimally invasive, many patients report discomfort during the procedure, especially those with mucosal hypersensitivity, anxiety, or an exaggerated gag reflex. For some individuals, completing the examination may be challenging or even impossible without prior sedation or topical anesthesia, which may introduce additional risks and prolong preparation time.[24]

Diagnostic challenges are particularly notable in patients with anatomical abnormalities - such as deviated nasal septum, post-traumatic deformities, or hypertrophic soft tissues - which can restrict endoscope access to certain regions of the upper airway. In these cases, CT or MRI imaging is not only supportive but may be considered an integral part of the differential diagnosis and treatment planning process. In a study by Kim et al. (2022), combining fiberoscopy with MRI in patients with suspected base-of-tongue tumors allowed for a more accurate assessment of lesion extent and invasion of adjacent structures, which was crucial in selecting an appropriate therapeutic approach.[20]

Integration of fiberoscopy with modern imaging technologies such as high-definition videoendoscopy, autofluorescence, and narrow band imaging (NBI) further enhances the detection of precancerous changes and early-stage mucosal cancers. However, access to such technologies remains limited, particularly in outpatient settings or facilities with lower referral levels.[17]

Future Perspectives

In the coming years, rapid technological advancement in the field of fiberoscopy is expected to significantly improve both diagnostic precision and accessibility. Technological progress is particularly focused on further miniaturization of endoscopic devices, allowing for examination of hard-to-reach regions of the upper airway with minimal patient discomfort. Modern fiberoscopes are becoming thinner and more flexible, while offering higher-resolution imaging thanks to advanced fiber-optic and digital technologies. [15, 16]

Another key area of development is the automation and digitalization of the diagnostic process. Significant research efforts are underway to incorporate artificial intelligence (AI) and machine learning algorithms into real-time endoscopic image analysis. These systems may not only assist physicians in identifying lesions suspicious for malignancy but also classify them based on morphological features, suggest biopsy sites, and, in the future, generate preliminary diagnoses. Pilot studies have demonstrated that deep learning algorithms can achieve sensitivity comparable to or even higher than experienced ENT specialists in detecting dysplastic changes (Zhao et al., 2023), paving the way for diagnostic standardization and reducing operator-dependent variability.[11, 14]

At the same time, portable and disposable fiberoscopy systems are being developed for use in both outpatient and emergency settings. With the application of low-cost electronic components, compact single-use devices are being introduced, reducing the risk of cross-contamination and eliminating the need for sterilization. Such solutions are particularly valuable in low-resource healthcare environments, as well as in primary care, aviation medicine, or military field applications.[17, 18, 22]

Another promising advancement is the integration of fiberoscopy with telemedicine tools. The concept of tele-endoscopy involves conducting the examination by trained technical or nursing staff, with real-time transmission of the video feed to a specialist located elsewhere. This approach enables access to expert consultation in regions lacking ENT professionals, shortening the time to diagnosis and treatment initiation. In the era of global telehealth expansion and aging populations, tele-endoscopy may become a vital component of modern healthcare systems, particularly in areas facing physician shortages.[27, 30]

Additional opportunities lie in the integration of advanced imaging modalities with fiberoscopy, including autofluorescence, NBI, confocal endomicroscopy, and hyperspectral imaging. These technologies allow for more precise differentiation between malignant and healthy tissues and enable detection of changes at a very early, often subclinical stage. Their adoption could significantly improve diagnostic performance and enhance oncological treatment outcomes. [4, 8, 10]

Ultimately, the development of AI-based and digital diagnostic tools in endoscopy holds the potential to not only elevate the quality of patient care but also to optimize workflows in medical facilities- through automated report generation, standardized documentation, and integration with electronic health records. Combined with population-level data analysis (big data), this will facilitate real-time epidemiological and predictive research. [30]

In summary, the future of nasal fiberoscopy encompasses not only technological and clinical advancements but also organizational and systemic innovation. As the technology becomes more accessible, integrated, and intelligent, fiberoscopy is poised to play a central role in the future of personalized early diagnostics for upper airway cancers.[27, 30]

Conclusions

Nasal fiberoscopy is steadily reinforcing its role as a modern, rapidly evolving diagnostic tool in otorhinolaryngology, particularly in the context of early detection of upper airway malignancies. Through direct visualization of the nasal mucosa, nasopharynx, pharynx, and larynx, this technique enables the identification of subtle pathological changes that are often undetectable through traditional physical examination or even standard imaging methods. Its key advantages—including outpatient availability, low cost, the ability to obtain targeted biopsies, and relatively low invasiveness -make it an invaluable instrument in everyday clinical practice.

The clinical cases and international literature discussed in this review, including screening studies and early-stage cancer case reports, clearly demonstrate that fiberoscopy can significantly improve the detection rate of upper airway tumors—particularly among high-risk populations such as smokers, individuals with occupational exposure, or post–bone marrow transplant recipients.

However, the limitations of this method should not be overlooked. The diagnostic accuracy of fiberoscopy depends largely on the operator's experience, the quality of the equipment, and the technical capabilities of the facility. The procedure may also be associated with patient discomfort, especially in the presence of a strong gag reflex or anatomical deformities. Furthermore, the limited depth of field and challenges in assessing submucosal lesions mean that fiberoscopy alone may not suffice for comprehensive evaluation of tumor extent. In such cases, it is essential to complement the examination with imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and consultation with pathology teams.

Despite these challenges, the future of fiberoscopy as a diagnostic method is highly promising. Advances in miniaturization, development of single-use and portable devices, the implementation of tele-endoscopy, and integration with imaging technologies such as Narrow Band Imaging (NBI), autofluorescence, or confocal endoscopy are significantly expanding the clinical potential of this tool. Particularly noteworthy is the integration of artificial intelligence (AI) and deep learning algorithms, which are already proving effective in real-time endoscopic image analysis. Further development of such systems may enhance diagnostic precision, while also promoting standardization and acceleration of early cancer recognition.

Given the rising incidence of head and neck cancers, the aging of the population, and the growing emphasis on early cancer detection, the wider implementation and continued development of nasal fiberoscopy appear not only justified but essential. Of particular importance is its use in population-based screening programs and in the care of long-term and telemedicine-managed patients. Key challenges in the years ahead will include the development and implementation of standardized clinical guidelines, widespread training of medical personnel, and the execution of multicenter validation studies in large populations.

In conclusion, the evidence presented in this review clearly indicates that nasal fiberoscopy - due to its accessibility, effectiveness, and developmental potential- may become one of the cornerstones of early cancer diagnostics in 21st-century otorhinolaryngology. When used appropriately, within an integrated diagnostic and therapeutic approach, it can contribute significantly to improved oncological outcomes and enhanced patient survival.

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