International Journal of Medical Science and Clinical Research Studies

ISSN(print): 2767-8326, ISSN(online): 2767-8342

Volume 04 Issue 03 March 2024

Page No: 411-415

DOI: https://doi.org/10.47191/ijmscrs/v4-i03-09, Impact Factor: 7.949

Unveiling the Potential of VELScope in Potentially Malignant Oral Lesion Early Detection for Future Dental Diagnosis Technology

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ABSTRACT

Introduction: Oral lesions range from innocuous to possibly dangerous, including oral cancer, which is the world's 16th most common malignancy. Early detection of oral cancer can enhance a patient's life expectancy by a decade, emphasizing the need of diagnostic instruments like VELScope. VELScope is a portable device that employs blue light to examine oral tissue, exposing natural fluorescence and emphasizing aberrant regions that would otherwise be invisible without the use of specialized equipment.

Objectives: This review looks at the possibility of the VELScope for identifying oral lesions, since it has the potential to be a future dental diagnostic tool.

Method: We began with 88 findings and reduced them down to 33 research regarding VELScope technology published in the previous five years. Following screening, we chose ten articles using the same criteria for all research.

Results: VELScope uses fluorescence to identify both obvious and concealed oral lesions, which is especially useful when collagen loss occurs in normal tissues. While using autofluorescence requires knowledge, it assists in analyzing margins in probable pre- malignant oral conditions. VELScope, despite its limitations, has promise for early cancer diagnosis as technology develops.

Conclusion: When utilized for early diagnosis, VELScope helps to reduce oral cancer mortality, reaching an 83% 5-year survival rate. While it has limits, continuous technical improvements have the potential to improve its accuracy, making it a vital tool for accurate early diagnosis and lowering oral cancer mortality.

KEYWORDS: early detection, oral lesion, oral cancer, VELScope

ARTICLE DETAILS

Published On:
07 March 2024

Available on:
https://ijmscr.org/

BACKGROUND

The oral cavity serves as a complex anatomical region, hosting a wide range of tissues and structures, making it susceptible to various pathological conditions [(1)]. Oral lesions are defined as abnormal changes in color, surface aspect, swelling, or loss of surface integrity of the oral mucosa. These lesions can manifest in various forms, ranging from benign to potentially malignant or even malignant. While the majority of oral lesions are benign and resolve without significant intervention, there exists a subset of lesions that present with pathological symptoms, raising concerns about their potential to develop into malignancies, specifically oral cancer [(2)]. It is in this context that early detection and diagnosis of potentially malignant oral lesions become paramount. Timely identification of these lesions can significantly impact patient outcomes by enabling prompt intervention, thereby reducing the risk of disease progression to malignancy.

Oral cancer stands as a formidable and deadly dental and oral disease, often underestimated in its impact on global health. According to the Global Oral Health Status Report authored by the World Health Organization (WHO), it ranks as the 16th most common cancer worldwide. This positioning underscores the severity of the issue and its substantial contribution to the global cancer burden [(3)].

In the year 2020, the International Agency for Research on Cancer (IARC) Global Cancer Observatory (GLOBOCAN) reported a staggering estimated global incidence of oral cancer. The figures revealed a disconcerting reality with approximately 377,713 new cases diagnosed and a heartbreaking 177,757 recorded deaths attributable to this disease [(4)]. These statistics paint a grim picture of the pervasive impact of oral cancer on individuals and communities worldwide.

The term "oral cancer" encompasses a spectrum of malignant neoplasms, with one of the most common types being squamous cell carcinoma. These cancers primarily affect the mucosa of the lips and the oral cavity, including critical areas such as the tongue, gingiva, floor of the mouth, palate, and various other parts of the mouth. The classification and tracking of oral cancer cases typically adhere to the International Classification of Diseases (ICD-10) codes C00-C06, providing a standardized framework for diagnosis and epidemiological research (ICD-10).

Early detection of oral cancer is paramount, with research by Hook in 2021 indicating that it can extend a patient's life expectancy by up to 10 years, boosting survival rates by 18-57% depending on the cancer's stage and location [(5)]. The importance of timely identification is well-established, as the 5-year relative survival rate for early- stage oral cancer patients hovers around 83%, but plummets to approximately 40% when detected at an advanced stage [(6)]. As technology continues to advance, more accurate tools are needed for early oral cancer detection, and one such technology, VELScope (Visually Enhanced Lesion Scope), shows promise in enhancing diagnostics. Operating on the principle of fluorescence visualization,

VELScope aids dental professionals in visualizing and identifying potentially malignant oral lesions, contributing to early detection and more precise assessments of oral health. Despite existing limitations, the integration of VELScope and similar technologies holds potential for improving oral cancer diagnosis, ultimately saving lives and improving the well-being of at-risk individuals [(6)].

VELScope is a tool made for early oral cancer diagnosis, made in the form of a handheld scope that doctors can use for detection to provide illumination to oral tissue with a blue light spectrum that visualizes natural tissue fluorescence. This fluorescence will enhance conventional oral examinations by visualizing abnormal areas that cannot be seen without the help of certain tools or materials. This device is sensitive to abnormal tissue changes when it is shined with the blue light spectrum it will be seen that healthy tissue glows in a different pattern. When there are abnormal changes due to lesions or cancer, this pattern will appear disturbed, which can be seen clearly with VELScope. The fluorescence used in this device is autofluorescence or automatic fluorescence. This autofluorescence substance is non-invasive, and when light is emitted at the appropriate wavelength, it will emit light green autofluorescence light. However, when light is exposed to tissue affected by lesions or cancer, it will appear as a black area caused by the destruction of the autofluorescence substance [(7)].

VELScope is an additional device, meaning it must be used in combination with the conventional intra and extraoral head and neck examinations (COE). One of the advantages of the VELScope is that it is fast and easy to use, does not require any additional equipment for oral examination and can be done in about 2 minutes. The use of VELScope in daily practice can facilitate early discovery of lesions or cancer which can lead to better prognosis for patients [(6)]. This evidence emphasizes the urgency and importance of early detection of oral lesions or oral cancer so that actions can be taken immediately before the condition gets worsen and affect the patient's survival. This literature review will review the potential for using VELScope for the diagnosis of oral lesions, because VELScope technology has great potential which could become a technology to assist diagnosis that is very helpful in the field of dentistry in the future.

METHOD

The initial findings in this study were 88, and after applying filters in our scientific database, we reduced the number of results. We limited our review to studies published within the last five years to ensure the relevance of the results and to mitigate potential issues related to VELScope technology. Over the past five years, only 33 publications are available. To facilitate the review process, we included only manuscripts in full text. After screening these 33 results, three independent reviewers selected a subset of 9 manuscripts. In each evaluated paper, the authors independently assessed the findings. A standardized set of keywords and inclusion/exclusion criteria was applied uniformly across all these results. All documents examined contain information pertaining to the application of VELScope for the detection of cancerous and precancerous lesions in the oral mucosa.

RESULT AND DISCUSSION

VELScope Technology and its Mechanism of Action

The VELScope device detects both visible and invisible oral lesions using the fluorescence principle. This method of diagnosis employs the direct use of fluorescence, in which oral lesions can be seen and detected. Fluorescence is produced by combining a light source generating wavelengths in the 400-460 nm range with a manual visualization device. Autofluorescence, on the other hand, refers to the inherent fluorescence emitted by the primary fluorophores of certain tissues. Collagen, nicotinamide adenine dinucleotide dehydrogenase (NADH), flavin adenine dinucleotide (FAD), metabolic byproducts, and other

structural proteins comprise the tissue's makeup (8). This fluorescence-based method is the fundamental element of VELScope's oral lesion diagnosis capacity.

Since various tissues display varied fluorescence properties, these fluorophores can be useful indications of tissue pathology. Importantly, tumor cells can produce a stronger fluorescence signal, and their fluorescence lifespan can vary based on their levels of (NADH and FAD). This characteristic has the potential to be used in cancer screening and diagnosis. Tumors typically demonstrate neoangiogenesis and hypervascularization, which is frequently accompanied by a relatively high hemoglobin level in the blood. The fluorescence of NADH and FAD molecules in hemoglobin may rise owing to events such as the Warburg effect or cellular alterations associated with tumor growth when the extracellular matrix is disturbed. There is a notable increase in cell density inside the tumor mass as a result of changes in blood supply and structural structure. It is critical to consider the optical properties of the tissue because these properties determine how light scatters, absorbs, and reflects, altering the behavior of light within the tissue. As a result, as shown, fluorescence signals are excited and collected at various depths inside the tissue. In fact, the enlargement of the neoplastic mass changes the integrity and depth of the highly fluorescent submucosa [(8)].

Autofluorescence is automatically green when emitted by normal mucosa, whereas in abnormal areas it will appear darker. Different profile areas undergoing malignant changes where loss of fluorescence visualization is visible can maximize exposure to blue light (400-460 nm) [(9)]. This is mainly due to loss of fluorophore collagen. Malignant tissues exhibit a range of structural alterations, including elevated nuclear grade, increased mitochondrial density, and varying levels of keratin, elastin, and collagen. These differences in composition contribute to distinct spectral features when compared to normal tissues. The Optical methods like microendoscopy and spectroscopy have found extensive application in identifying early-stage and cancerous abnormalities by examining subtle surface alterations linked to mucosal ulceration and the development of lesions.

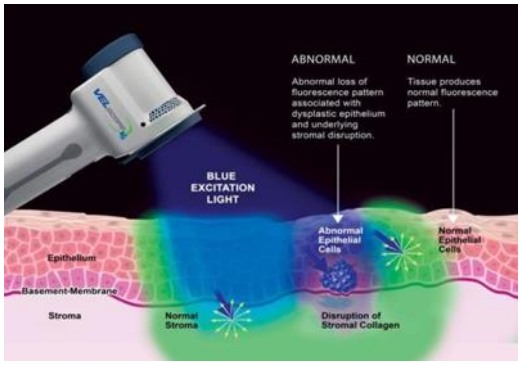

Figure 1. Illustrating the interaction between blue excitation light and healthy and abnormal oral mucosa, leading to the generation of FVR and FVL, respectively, when observed through the VELScope handheld device [(10)]

Comparative Analysis with Traditional White Light Diagnostic Method

Farah et al. observed that autofluorescence gave more accurate margin evaluation in cases of oral premalignant disorders (OPMD) than standard white light [(11)]. The results show that the molecular profile of OPMD changes as one proceeds out from the lesion center, and that autofluorescence- defined margins outperform white light margins when it comes to achieving unique molecular margins while excising OPMD. However, Amirchagmaghi's research indicates that the autofluorescence method cannot differentiate between malignant and benign cases [(12)].

VELScope as A Supporting Examination

The autofluorescence technique, like any other medical tool, requires the experience of a doctor or surgeon to operate efficiently. Despite this, autofluorescence has been found to be a highly sensitive technique for directing surgery. Because biopsy and histology are the gold standards for identifying such injuries, the initial diagnostic step should be performed by a medical practitioner, with a traditional intraoral visit and the autofluorescence light technique approach acting as a valuable in addition tool [(12,13)].

Advantages and Limitation

Early diagnosis of oral cancer by visual examination followed by histological confirmation is crucial for reducing morbidity and fatality rates (5). A variety of devices are used to assist the oral examination. Leuci et al. used VELScope to conduct pilot research on the screening skills of general dentists. Two general dentists, one of whom is trained in a particular course, used clinical examination and VELScope to evaluate 35 patients with oral lesions. The results of histology, clinical examination, and VELScope performed by the two dentists were compared using statistical analysis [(14)].

Unskilled dentists had a sensitivity of 53.3% and a specificity of 65% in identifying potentially malignant oral diseases (OPMDs), with a positive predictive value (PPV) of 53.3% and a negative predictive value (NPV) of 76.5%. These values improved for skilled doctors. Unskilled general dentists (u-GD) had a sensitivity of 53.3%, specificity of 70%, PPV of 57.1%, and NPV of 66.7% when both types of examiners utilized VELScope, whereas skilled general dentists (s-GD) had better values of 86.7%, 90%, 86.7%, and 90%. Without training, VELScope did not significantly improve cancer detection in general dentists. However, when combined with a planned training program, it proved useful as an extra tool for experienced dentist [(14)].

VELScope alone may not be able to detect dysplasia regions, and false positive findings are likely when highly inflamed tissues are present, but its importance in assisting doctors in making more accurate diagnoses regarding the

nature of oral lesions and whether to biopsy problematic areas cannot be overstated. The VELscope has allowed practitioners to select the best biopsy location. It is considerably preferable to sample benign tissue than to fail to diagnose dysplastic or malignant tumors.

The Velscopic examination cannot offer a clear diagnosis of dysplastic tissue changes in oral lesions [(12)]. Despite its high sensitivity, the high frequency of false-positive results limits its utility as an auxiliary. However, because of its high negative predictive value, it can assist to alleviate patient anxiety regarding concerning mucosal lesions in a general practice setting. A VELScope and traditional oral examination combination may also be an effective diagnostic method for the early detection of malignant oral mucosal lesions [(9)].

Future Prospect of Autofluorescence

VELScope, with its capacity to identify early cancer or lesion, has the potential to be the selected instrument to aid support cancer and lesion detection in addition to the standard intra and extraoral head and neck exams. Although it has limits, such as the possibility to provide false positive or false negative findings, we anticipate that as technology advances in the future, these limitations will be overcome. With the alarming number of cases and deaths from oral cancer, VELScope will undoubtedly be required as part of the tests to detect this illness early.

Future research and development will be required to learn more about the potential and use of VELScope, and enhanced enhancements such as increased sensitivity and accuracy will be beneficial to provide more accurate diagnosis in conjunction with conventional tests. This tool will be good for health institutions in terms of more accurate diagnosis, for the public in terms of lessening the concern of late diagnosis and reduced survivability rate with its high mortality, and will undoubtedly be valuable for future study. By identifying VELScope as a tool with significant potential effect, early and accurate diagnosis is achievable, increasing the survival rate of oral cancer and lesion patients by allowing them to take urgent treatment. Autofluorescence-based methods to cancer diagnosis, assessment, and therapy may become widespread in the near future. It is worth mentioning that nanotechnology may be utilised in autofluorescence diagnostic procedures [(8)].

CONCLUSION

VELScope is a tool made for early oral cancer and lesion diagnosis, made in the form of a handheld scope that doctors can use for detection to provide illumination to oral tissue with a blue light spectrum that visualizes natural tissue fluorescence (autofluorescence). Autofluorescence is automatically green when emitted by normal mucosa, whereas in abnormal areas it will appear darker. This is because malignant tissues exhibit a range of structural alterations, including elevated nuclear grade, increased mitochondrial density, and varying levels of keratin, elastin, and collagen. These differences in composition contribute to distinct spectral features when compared to normal tissues.

VELScope has its strength and limitations, with its ability to give screening and early diagnosis, hand-in-hand with other examinations, VELScope gives critical help in the ability to lower the concerning mortality of oral cancer rate with the 5-year relative survival rate percentage as big as 83% when found early. Although it has its limitations and more room for improvement, such as added sensitivity and accuracy in order to lessen the ability for this tool to give false positive and false negative results, along with time a technology develops more and more; these limitations will be able to be solved.

VELScope has the powerful potential to be the tool-of-choice for dentists to be able to give early diagnosis along with conventional exams. This will be beneficial not just for dentists, but also will be immensely helpful for the public, as it will be able to lower the mortality rate of oral cancer and gives the patients more time to take immediate action once diagnosis has been given. Although there has been studies and uses for this tool in many countries, future studies, improvements, and more trial uses must be done more in order for this tool to reach its full potential. We believe that VELScope has the potential to give more accurate early diagnosis in order to lower oral cancer's mortality rate and should be considered as powerful tool in future dental diagnosis technology.

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