Doctoral: A smartphone-based decision support tool for the early detection of oral potentially malignant disorders

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Abstract

Oral potentially malignant disorders can be defined as mucosal lesions and conditions with an increased risk of malignant transformation. Oral potentially malignant disorders are a significant health burden, and they are often diagnosed late due to scant attention to routine dental practice and the low number of specialized oral medicine centres. This report summarizes the DoctOral experience, a research initiative, providing a free smartphone-based decision support tool for the general medical/dental practitioner; the tool is based on the clinical appearance of oral lesions. Captured, oral pictures can be immediately examined via interactive decision trees and constructed on the smartphone. Such decision trees are expressed in standard formats, and they are readily accessible for facilitating the completion of a hypothetical diagnostic path. Since October 2017 the DoctOral mobile app has been downloaded by 10K + users, achieving a score of 4.8 out of 5. DoctOral also supports an unfolding joint initiative, called DoctOralAI: this involves selecting reference images, with which to create an open-source model, and perform a Case-Based Reasoning method, both of which are combined with machine learning. The DoctOral mobile app has revolutionized oral pathology by providing dental students and professionals with an interactive platform for recognizing and diagnosing oral lesions.

Brief communication

Oral mucosal lesions have several clinical patterns; they can be displayed as either isolated oral findings or in association with systemic conditions. Whereas similar clinical appearances could be misleading, it is necessary to accurately distinguish malignant from benign lesions. This is because many lesions are very similar, and clinicians, who are not always experts in oral medicine, could struggle in establishing a clinical diagnosis.

Oral potentially malignant disorders (OPMDs) comprise several mucosal entities with varying degrees of risk of malignant transformation into oral squamous cell carcinoma (OSCC).[1] OSCC is a significant health burden across the globe, and it is often diagnosed late and at advanced stages of the disease (massive infiltration and/or metastasis).[2]

Paradoxically, the oral cavity is easily accessible for examination but it often receives insufficient attention in routine practice; this challenge could be due to the site of the oral lesion (e.g. posterior-ventral surface of the tongue) or to limited clinical expertise. Rectifying this omission could provide a more accurate and prompt diagnosis. To date, a conventional oral examination (COE)

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has been considered as best practice in any diagnostic work-up, with its diagnostic accuracy having been confirmed, especially for the screening of potentially malignant oral lesions, as performed by an oral medicine expert.[3] Unfortunately, the number of oral medicine centres and experts is generally scarce in a country such as Italy, where such centres are usually located within university hospitals.

Dentists are often responsible for the primary prevention of oral soft and hard tissue diseases, including those considered as common (such as gingivitis) and severe (such as oral cancer or drug-related osteonecrosis of the jaw). General practitioners and dentists also play an important role in the secondary prevention of oral diseases but a cursory oral examination during dental and medical recalls may be typical. This has been reported by almost all patients whose oral cancer is diagnosed at a late stage, thereby indicating a possible case of professional liability for a delayed diagnosis ('provider delay').[4] Evidently, the delayed diagnosis does not guarantee an optimistic prognosis, successful treatment and favourable outcomes. OPMD diagnoses can be challenging, in part due to the visual examination, which is considered by some as demanding with low specificity/sensitivity, to be followed by a biopsy and histopathology, where necessary.

Optimal decision-making is becoming a key factor in reaching an accurate diagnosis. Until now, the process of diagnosis has been based on individual knowledge in establishing a differential diagnosis of developing a list of similar conditions. This is an important part of formulating a clinical rationale, but it can be inherently biased; it, therefore necessitates the support of a scientific background and clinical expertise. In recent years and by virtue of the decreasing costs of and innovation in information and communication technology (ICT), remote consultation has been increasingly requested. This facilitates the timely distribution of information to practitioners for improved decision-making, thereby effectively simplifying the triage of patients who require referrals and supporting treatment.[5,6]

These technological innovations are occurring by virtue of several digital platforms (i.e. web and mobile applications). They provide easy access to specialist care and minimize the burden of patients/relatives who would have to travel long distances to attend consultations. In such a context, decision-support systems assisting physicians are playing an ever-increasing role in medical decision-making, particularly where decisions must be made effectively and reliably. Given that simple, conceptual decision-making models, possibly with automated learning, should be considered for performing such tasks, decision trees are be considered as a very suitable candidate model. Having been created in the 1960s, decision tree models are still the most widely used models in clinical practice today.[5]

An example of recent learning initiatives with which to improve the early detection of oral cancer is OralDETECT.[6] It is a one-day program, comprising of pre-tests, lectures, post-tests and review sessions for undergraduate dental students and general/specialist dental practitioners. The results obtained to date have demonstrated that the OralDETECT program could be an efficient and effective method of training in oral medicine. The aim of other initiatives is to develop supporting decision tools.

This report has focused on the use of mobile phones in the field of oral medicine. An example of such an application is a research initiative called DoctOral. It was developed with the aim of tutoring medical/dental professionals and students regarding the clinical recognition of oral lesions. This renders it a valuable tool for healthcare professionals and students who wish to improve their understanding and accuracy of identifying oral conditions. With its user-friendly interface and interactive features, DoctOral assists users to construct their knowledge and confidence in recognizing oral lesions.

The app features a comprehensive database of information and images of oral lesions, which is regularly updated with the latest research and data. The primary goal of DoctOral is to aid healthcare professionals and students stay informed and competent in the recognition of oral lesions. With its accessible and engaging approach to learning, the app is considered by many to be an effective tool for professional development in this field. At any stage in a doctor's career – be it a junior doctor or a practitioner wishing to build on existing skills – DoctOral can assist in achieving professional goals and improving patient outcomes.

Its function is based on two main guided paths: the first is the identification of a given undiagnosed oral lesion; the second differentiates the said oral lesion by morphology/Chroma or aetiology. Each path can be selected in accordance with the answers to multiple-choice questions, thereby leading to one or more diagnostic hypotheses.

The home screen of the application invites the user to start the guided tour by selecting one of the three guided paths (Figure 1). The first two paths involve specifying the classifying criteria (morphological/chromatic or etiological) for initial recognition of a given lesion. Should the user (clinician or student) wish to consider their own clinical case, a photo can be uploaded for comparison with the final hypothesis/es. Based on an initial choice, the user answers different questions relating to diagnostic algorithms. This determines a procedure, including multiple-choice questions, which suggests a suspect or differential diagnosis (Figure 1). On terminating a given pathway, it is possible to consult a summary of pathology/ies with related paradigmatic clinical images for each diagnosis; the latter are useful for comparison with a patient's uploaded clinical picture. Thus, the clinician can select which criteria type is suitable, as relating to (i) the physician's knowledge; (ii) the patient's medical history; and (iii) the physician's diagnostic hypothesis.

Thereafter, the app includes a section specifically designed to provide users with a convenient and efficient means of obtaining a second opinion from an expert in oral medicine. By using this feature, users can easily send an image of the patient and the related medical history to the oral medicine expert, thereby
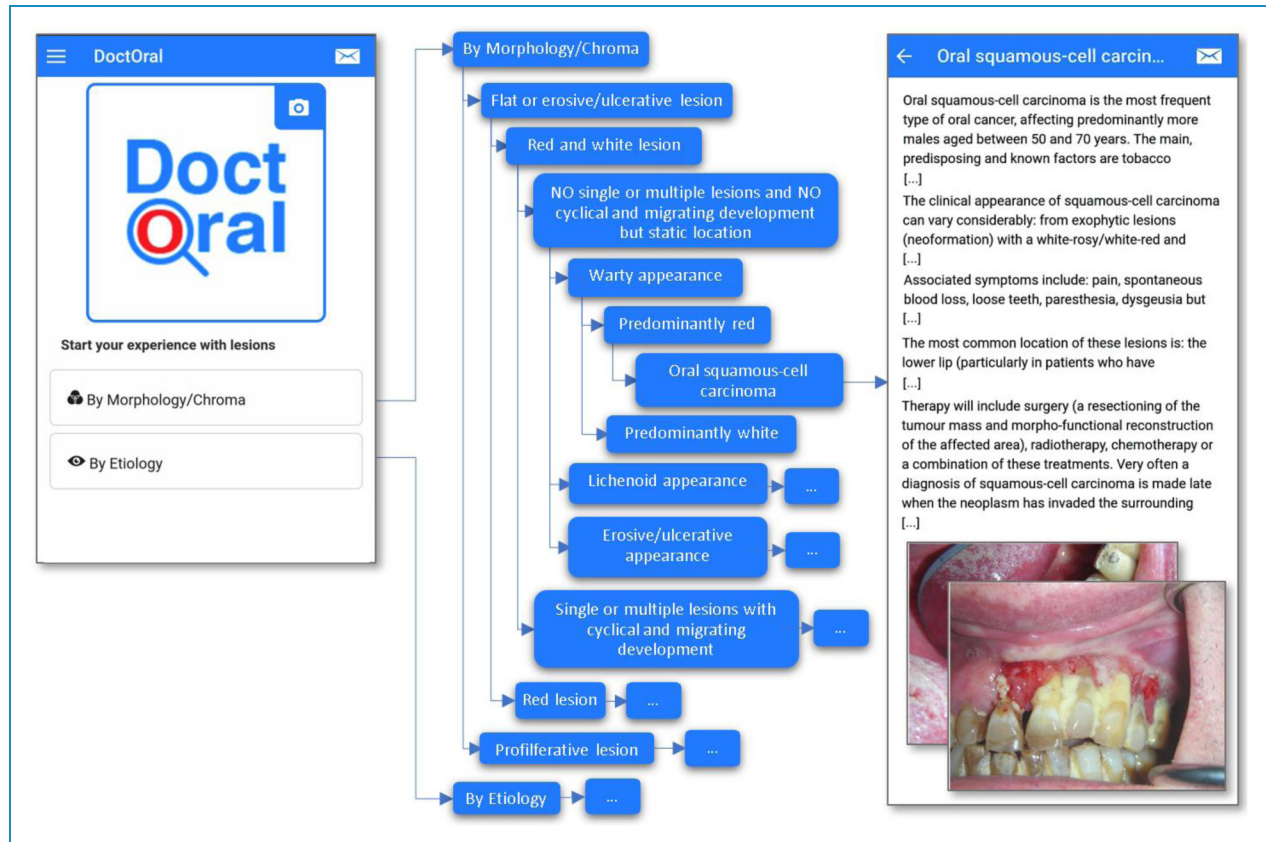
Figure 1. Doctoral app: the home screen (left); a path of a decision tree (middle) and the final hypothesis (right).

providing a comprehensive understanding of the patient's condition. This is especially important when it comes to diagnosing and treating oral lesions, as a prompt and accurate diagnosis can significantly impact the patient's prognosis and recovery. The app streamlines the diagnostic process and assists in avoiding a delayed diagnosis of the lesion. This can lead to faster and more effective treatment, ultimately improving the patient's health outcomes. In addition to improving patient care, the app also provides a more efficient way for healthcare professionals to collaborate and share information. This enhances the overall quality of care and helps to ensure that patients receive the most appropriate treatment for their condition.

A drop-down (or hamburger) menu permits the accessing to additional functions in the app, thereby enabling the user to navigate between: (i) a synopsis of pathologies: the most common pathological conditions, which are located in the oral cavity, are listed and associated with clinical images and a brief description of the pathology; and (ii) elementary lesions: a classification of lesions and semeiotics, which are associated with clinical images and a summary sheet. The decision trees guiding the methodology are expressed in a standardized open format, JSON (JavaScript Object Notation) which is a well-known text-based, language-independent syntax for data interchange.[7] As an international standard, JSON can be easily processed via visual tools to be read and modified by human practitioners. As a consequence, the decision logic is easily

accessible to positively encourage collaboration between research centres.

Further development of DoctOral will support an ongoing joint initiative called DoctOralAI,[8] which will combine the power of Case-Based Reasoning and Machine Learning to provide a value-added service, which is based on Explainable Artificial Intelligence. The idea behind this initiative is to render medical diagnosis easier, faster and more accurate. Reference images or cases will be selected and made public through DoctOralAI, thereby permitting the machine learning system to process the lesion images and generate the most likely diagnostic hypothesis. The use of Case-Based Reasoning ensures that the system can learn from past cases and use that knowledge to provide accurate diagnoses. This approach not only will make it easier to detect the lesion earlier, but it also will assist in providing a rationale for the diagnosis, rendering it a more trustworthy and explainable AI service.

Conclusions

The DoctOral mobile app has been available since October 2017 on both Android and IOS.[9,10] The former has been downloaded by 10,000 + users, achieving a score of 4.8 out of 5. To the best of our knowledge, DoctOral is the only tool which could support clinicians and students in facilitating the recognition of OPMD. Further studies are

necessary to test DoctOral efficiency, in addition to its development by AI.

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References

1. Warnakulasuriya S, Kujan O, Aguirre-Urizar JM, et al. Oral potentially malignant disorders: a consensus report from an international seminar on nomenclature and classification, convened by the WHO collaborating centre for oral cancer. *Oral Dis* 2021; 27: 1862–1880.
2. Oral cancer – the fight must go on against all odds…. *Evid Based Dent* 2022; 23: 4–5.
3. Warnakulasuriya S and Kerr AR. Oral cancer screening: past, present, and future. *J Dent Res* 2021; 100: 1313.
4. Coppola N, Mignogna MD, Rivieccio I, et al. Current knowledge, attitudes, and practice among health care providers in OSCC awareness: systematic review and meta-analysis. *Int J Environ Res Public Health* 2021; 18: 4506.
5. Wasylewicz ATM and Scheepers-Hoeks AMJW. Clinical decision support systems. *Fundam Clin Data Sci* 2018: 153–169.
6. Zain RB, Pateel DGS, Ramanathan A, et al. Effectiveness of 'OralDETECT': a repetitive test-enhanced, corrective feedback method competency assessment tool for early detection of oral cancer. *J Cancer Educ* 2022; 37: 319–327.
7. ECMA-404 - Ecma International, https://www.ecma-international.org/publications-and-standards/standards/ecma-404/ (accessed 30 November 2022).
8. DoctOral–AI, https://mlpi.ing.unipi.it/doctoralai/ (accessed 30 November 2022).
9. DoctOral – App su App Store.
10. DoctOral – App su Google Play, https://play.google.com/store/apps/details?id=com.olgadifede.olgapp&hl=it&gl=US (accessed 14 October 2022).