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Technical Note

Smartphone applications: A contemporary resource for dermatopathology

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Abstract

Introduction: Smartphone applications in medicine are becoming increasingly prevalent. Given that most pathologists and pathology trainees today use smartphones, an obvious modality for pathology education is through smartphone applications. "MyDermPath" is a novel smartphone application that was developed as an interactive reference tool for dermatology and dermatopathology, available for iOS and Android. **Materials and Methods:** "MyDermPath" was developed using Apple Xcode and Google Android SDK. Dermatology images (static and virtual slides) were annotated and configured into an algorithmic format. Each image comprised educational data (diagnosis, clinical information, histopathology, special stains, differential diagnosis, clinical management, linked PubMed references). Added functionality included personal note taking, pop quiz, and image upload capabilities. A website was created (http://mydermpath.com) to mirror the app. **Results:** The application was released in August 2011 and updated in November 2013. More than 1,100 reference diagnoses, with over 2,000 images are available via the application and website. The application has been downloaded approximately 14,000 times. The application is available for use on iOS and Android platforms. **Conclusions:** Smartphone applications have tremendous potential for advancing pathology education. "MyDermPath" represents an interactive reference tool for dermatology and dermatopathologists.

Key words: Application, cell phone, dermatology, dermatopathology, digital pathology, smartphone, whole slide imaging

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INTRODUCTION

Mobile applications (apps) are designed for mobile devices such as smartphones and tablets. Medical apps for smartphones have become increasingly popular. The Food and Drug Administration (FDA) estimates 500 million smartphone users worldwide will use a health care app by 2015[1] and that 1,000 new applications will be released each month.[2] Smartphone applications allow physicians in the medical practice to be mobile, providing them with

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portable resources whenever they are needed. Medical apps include, but are not limited to, education, consultation, and reference tools.[3] Traditional means of dermatopathology education have been with textbooks and/or stored glass slide sets. Glass slide teaching sets are often difficult to use (e.g., haphazardly organized), hard to readily access, cumbersome (e.g., occupy workspace) and difficult to maintain (e.g., faded stains, broken slides). The creation of digital slides provides an interactive reference resource that has the potential to be viewed anywhere at any time. The benefits of developing a smartphone application that includes pathology images (static and whole slide) as a reference resource include widespread accessibility, practical portability, and useful image organization.

To date, there are only a limited number of smartphone pathology applications available as a reference resource. Most medical education apps consist of medical school board-type question and answer platforms. The goal of this technical note is to relay the benefits of creating a pathology reference tool for smartphones.

MATERIALS AND METHODS

Application Development

The goal of developing this application was to create a comprehensive, interactive, and user-friendly dermatopathology resource for pathologists and dermatologists. The app was designed for iOS and Android devices.

The app required interactive drill down lists that were organized using a Microsoft Excel worksheet Microsoft Excel 2007, Microsoft Corporation (Seattle, WA, USA) in a hierarchical fashion, using parent and child columns. The Excel file was converted to a format acceptable by the app; for example, the app shows root nodes as main options on the homescreen. Based on options selected by the user, the app parses the data file and displays all children for this node in the next screen. When the user reaches the final leaf node, it displays the details of that node with the description and image. A search field option in the app was added and optimized by preparing a separate data file on each launch. Each dermatologic diagnosis had a supporting clinical image, histopathology image (both with and without annotations), and digital slides (scanned using Leica Aperio scanners at ×20). The digital slides are hosted on cloud-based servers provided by Leica Aperio and require Internet access on the mobile device to be accessed using Aperio's online viewer software (Leica Biosystems, Aperio). Available images include immunofluorescence, hematoxylin, and eosin, as well as a comprehensive list of special (histochemical) and immunohistochemical stains. All static images are in Joint Photographic Experts Group (JPEG) format. Images and file names were formatted to be uniform in the app. The application data and images were not stored in the app itself. Rather, they are read dynamically from a secure website in order to keep the app at an acceptable size. This is also allowed seamless upgrades when changing data or images, without the need to change the app itself. Any changes would be refreshed on the app with an active Internet connection. The app still has a default data file for users to access when they are offline. Furthermore, embedded within the application is a YouTube video lecture on normal skin histology. The video was first created on Microsoft PowerPoint 2007, Microsoft Corporation (Seattle, WA, USA) and subsequently recorded with MOYEA, a PowerPoint to video converter, with voiceover by one of the application authors.

This entire project took 3 years to complete. However, development was not without complications. One specific issue worth discussing was the creation of an immaculate file naming system. Each diagnosis and related materials (e.g., digital slide, JPEG static image, Excel spreadsheet information, etc.) had to be an exact match. Any character, space, or symbol difference will not link the respective data to the diagnosis page. This crucial, yet simple notion is a major timesaver if implemented correctly at the beginning of the project, and checked regularly. A second problem encountered while developing the application was file sizes and loading times. Initially, all JPEG images were embedded within the application. This created very long loading times. To combat this issue, a File Transfer Protocol client (GoDaddy) was used to host all the images. The hosted images were viewed as thumbnails on the application, which reduced the file size in the application by about 90%. This, unfortunately, has a relative reduction in image quality at first glance, but once the desired image is opened in the application, the full high-quality JPEG is shown.

The app design and development were done in parallel. Development was done using Xcode and Android development platforms. Beta versions were distributed to colleagues for feedback using TestFlight. After incorporating their feedback, the final master version of the app was released.

Website Development

The website (http://mydermpath.com) was developed to offer the same functionality as the application with the added support of user logins. Users can register themselves on the website and access the same content on the app, however, the website allows more of an overview of the diagnostic algorithm. The website was developed using Joomla, a popular open source content management system platform. Joomla is based on Hypertext Preprocessor and MySQL. The website was also expanded to include embedded digital slides (similarly hosted on Aperio servers) and expert tutorials available for on-demand viewing.

RESULTS

The application was accepted by Apple's App Store on August 2011 and was originally listed for $19.99 per download. It is now available as a free download. The American Academy of Dermatology supported the application with a grant from the Sulzberger Foundation, which made it possible to release it as a free download. To date, it has since had approximately 14,000 total downloads (iTunes 12,000 and Android 2,000). The website gets 20–50 hits/day. Most downloads are generated by trainees in dermatology and pathology.

Layout

The application was designed to be user-friendly with all accessible pages available on the homescreen [Figure 1]. The homescreen includes various buttons such as search by the algorithm, search by diagnosis, special stains, immunohistochemistry, direct immunofluorescence, glossary, quiz, and a normal skin histology tutorial video. Each button links to a page respective to its name. For instance, the "search" by algorithm links the user to a screen to select where the major changes in the skin biopsy are located (i.e., stratum corneum, epidermis, dermal-epidermal junction, epidermis, etc.) [Figure 2], then continues into a hierarchical tree until a final diagnosis is reached. The "search by diagnosis" button contains a list of all alphabetically organized diagnoses in the application.

Accessibility

The application was intended for logical, efficient browsing. A search bar was accordingly placed on each page for the user to identify quickly and select a diagnosis of interest. Searchable lists are arranged alphabetically. For example, searching for "melanoma" will result in melanoma, melanoma *in situ*, lentiginous melanoma, and acral melanoma; instead of only resulting the former two [Figure 3]. The hierarchy of data begins at the homescreen.

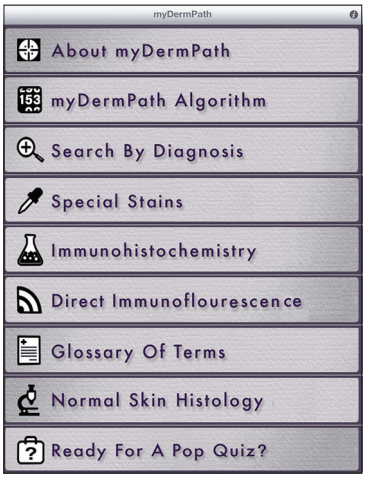

Figure 1: Homescreen Layout showing accessible user buttons at the homescreen

Comprehensiveness

MyDermPath was intended to be a comprehensive dermatopathology platform for pathologists and dermatologists. Each diagnosis has an end page with tabbed scrollable text boxes including microscopic description, clinical information, differential diagnosis, and clinical management [Figure 4]. A thumbnail view of the microscopic slide present on the diagnosis page opens into a full-screen, high-quality image [Figure 5]. A reference button loads relevant research articles. "My Notes" feature allows the user to type and save notes directly attached to a diagnosis page. "My Image" allows the user to save an image taken by the phone's camera to the diagnosis page. "Digital slide" links to a server that hosts whole slide images. "Annotation" will display a photomicrograph of the diagnosis that indicates key microscopic descriptions.

Educational Assessment

A quiz feature was created for added user value [Figure 6]. This enables the user to evaluate their ability to render diagnoses from photomicrographs.

DISCUSSION

Smartphone applications have transformed the presentation and availability of resource materials for medical professions. In medical specialty such as pathology and dermatology, where visual pattern recognition is of vital importance, image-based apps are of great benefit. Applications are being increasingly

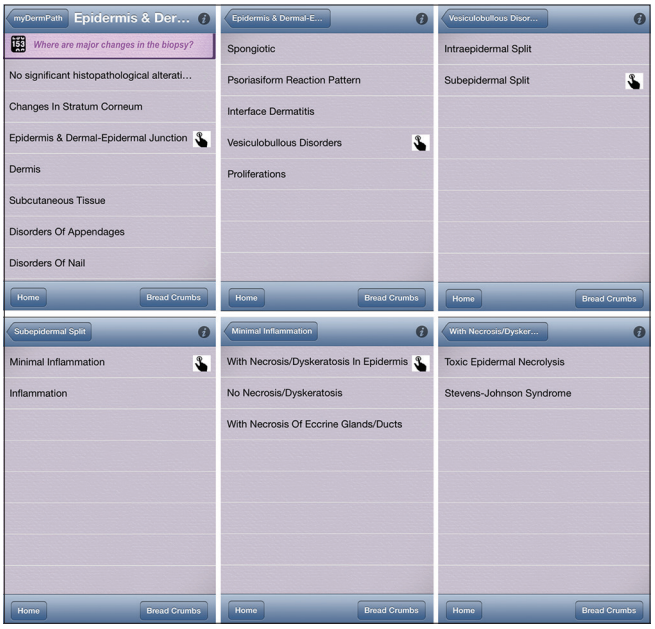

Figure 2: Hierarchical algorithm search algorithm parent and child tree search capabilities are shown in sequence, where the touch symbol represents the user defined input in sequence. The user ultimately choses a diagnosis and will be routed to a diagnosis end page

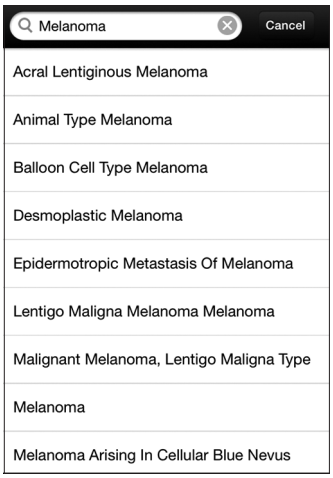

Figure 3: Search by diagnosis searching for the term "melanoma" will identify all diagnoses with that term present without regard to location of the searched word in the diagnosis

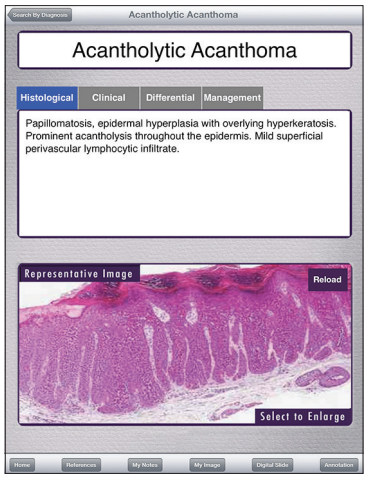

Figure 4: Diagnosis end page. Acantholytic acanthoma each diagnosis has a screen page with histopathological description, clinical information, differential diagnosis, and clinical management tabs atop a scrollable text box. A representative thumbnail of a microscopic image is present near the bottom of the page. An action bar is at the bottom-most section of the page and gives users access to the functions listed

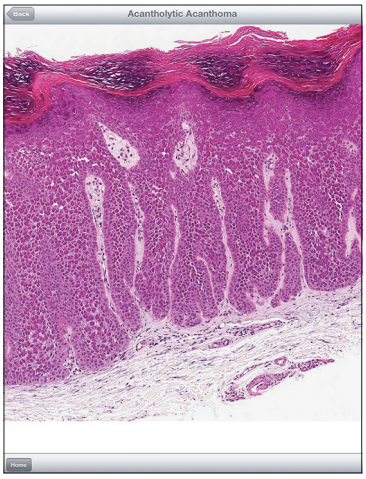

Figure 5: Diagnosis photomicrograph after opening the thumbnail image, a large, higher quality image is loaded onto the screen. Each image can be zoomed inward and outward with the "pinch-in" and "pinch-out" gestures

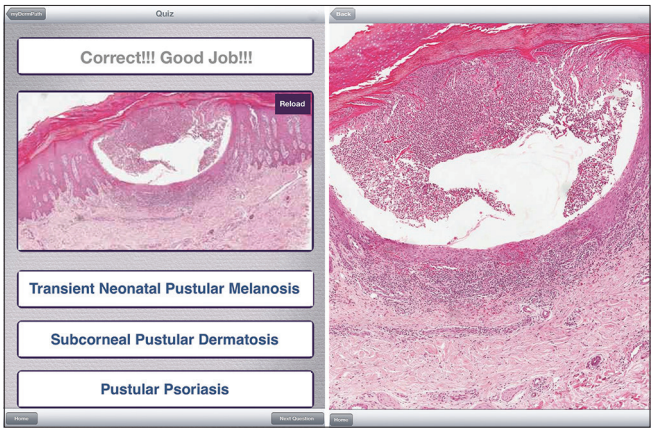

Figure 6: Educational assessment A: A quiz feature is available to the user to evaluate their dermatopathology knowledge. The image above shows a correct answer was provided after selecting "pustular psoriasis." B: Higher resolution photomicrograph linked to each question from the quiz page

used in other medical specialty (e.g., surgery, radiology, anesthesiology, family medicine, etc.).[4-10] While recent studies have demonstrated their efficacy,[11,12] more studies are needed to validate formally these apps in this emerging mobile health (mHealth) era. This technical note highlights the importance of technological developments in healthcare, and an example of how pathologists can embrace them.

Potential effective uses of smartphone applications in the future include daily health monitoring, complementing medical devices and assisting with clinical diagnoses. With the ubiquity of smartphones, applications can track, store, and deliver health-related information in real time. Physicians should be keen to recognize these available solutions and use them to better care for their patients. Medical applications can also be used as a reference to assist with diagnoses. Newer applications may develop image algorithms to help classify or develop differential diagnoses.

Several application development tools are available for those interested in creating medical apps. The first of which includes seeking a software or application developer to work in tandem to create the app of interest. To self-learn Apple Xcode or Andriod Studio, online courses are available, like udemy.com. Other direct app development websites such as, apparchitect.com, appmakr.com, or appsbar.com, enable simple systems to create apps without the need for prior software coding knowledge.

MyDermPath is a comprehensive, user-friendly smartphone app intended for pathologists, dermatologists, and their trainees. The app provides the

user with access to hundreds of diagnostically helpful images of high quality that are well organized, easy searchable, and available on demand. The benefit of creating medical apps is the portability and real-time access physicians have to the information. These applications can be used for educational and eventually clinical purposes. Quiz features in these applications can be used to evaluate progression in each postgraduate year. Furthermore, the digital slides organized in these applications can be tremendously resourceful for easy retrievability, widespread sharing of rare cases, and ensuring all pathologists are looking at exactly the same section of tissue. Using a user login system, performance can be tracked and possibly uploaded to graduate medical education software. Comparing pathology residency in-service exams for each resident with the implementation of an app may be a possible education validation measure. There are myriads of uses for medical applications. One barrier to creating smartphone applications is the cost of development. Application developers can charge up to $30,000. Another barrier to using the application is potential hospital locations without internet connectivity, where web-hosted data in the application may not be available. Nevertheless, we anticipate that in the future many more smartphone apps will become available for the pathology community.

The FDA has released nonbinding mobile medical application recommendations, but it is clear that they will only regulate applications that pose a threat to patient safety if misused. A mobile app can be easily developed by anyone without medical knowledge. The FDA will most likely regulate mobile apps that are either used as an accessory to a medical device or ones that transform a smartphone or tablet into a regulated medical device.[13] This is because such apps have the ability to pose harm if they malfunction. However, the vast majority of educational smartphone applications such as the one developed here at present lie outside the FDA's declared jurisdiction.

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Conflicts of Interest
There are no conflicts of interest.

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