

Novel use of smart tablet computer for ophthalmology

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平板电脑在眼科中的探索性应用

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摘要

目的:鉴别及分类存在于 iPad 智能平板电脑的由苹果公司应用商店提供的适用于眼科临床实践的眼科相关应用程序。

方法:于 2013-01/2013-08,搜索由苹果应用商店提供的眼科相关的应用程序。符合条件的应用程序经过鉴别并下载于 iPad 平板电脑上,并根据应用程序的原始内容和我们的使用经验进行分类。同时我们还描述了 iPad 平板电脑中自带的即时视频通话(FaceTime®)和自动存储技术(iCloud®)的使用方法。我们同时也搜索了包括微软公司的 Window Phone 和谷歌公司的 Android 操作系统中的眼科相关性应用程序。

结果:通过关键词“ophthalmology”和“eye”分别搜索到 111 个和 452 个符合条件的眼科相关性应用程序。iPad 平板电脑在眼科实践中的应用可以被分为 5 个方面。根据我们的应用实践,我们在最后也总结了 iPad 平板电脑在眼科应用中的优缺点。尽管如此,在另外两个操作平台中的眼科相关应用程序的数量还是比较有限。

结论:iPad 平板电脑所安装的自带和第三方应用程序能够在检查、远程医学、信息参考、疾病教育和文献检索等方面提供便利。我们需要更多的研究去证实 iPad 平板电脑在专业领域特别是眼科检查方面的实用性和可靠性。

关键词:iPad;智能平板电脑;眼科;远程医学;iPhone

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Abstract

• **AIM:** To identify and categorize ophthalmology-relevant apps for the iPad tablet computer as a source for ophthalmic practices on the Apple's App Store.

• **METHODS:** The Apple's App Store was searched for ophthalmology-relevant apps from January 2013 to August 2013. Eligible apps were identified and downloaded into the iPad tablet computers, and then categorized according to the apps' initial contents and our using experiences. Methods about how to use the iPad's built-in functions of instant video call (FaceTime®) and automatic data storage technology (iCloud®) were also described together with the apps. Other operating systems of Microsoft's Window Phone and Google's Android were also searched for ophthalmology-relevant apps.

• **RESULTS:** The keywords for searching on the Apple's App Store were “ophthalmology” and “eye”. And we could found 111 eligible apps with the former keyword, and 452 ones with the latter one. The integrated uses of the iPad tablet computer were then categorized into five aspects. Based on our clinical practice, we finally summarized the advantages and disadvantages of the iPad tablet computer for ophthalmic practices. However, ophthalmology-relevant apps were found to be very limited in number on the other two platforms.

• **CONCLUSION:** The integrated use of self built-in apps and third-party apps can facilitate our clinical work in examination, telemedicine, reference, disease education and literature searching. More studies are needed to verify its validation and reliability in the professional fields, especially eye examinations.

• **KEYWORDS:** iPad; smart tablet computer; ophthalmology; telemedicine; iPhone

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INTRODUCTION

Smart devices have shown their efficacy in some professional fields because of their rapid development. Most smart tablet computers are equipped with powerful operating systems, high-resolution screens, and megapixel cameras. Some physicians have tried to adopt smart devices, such as iPhones and iPads to facilitate their work^[1-10]. In the USA, about 80% physicians own smart phones and about

62% have smart tablets^[11]. In August 2012, the Department of Health And Human Services of USA admitted that mobile devices have been used as part of the powerful requirements for electronic health records (EHR) systems.

Ophthalmology is not the exception from this trend. Recently, there are some reports about the novel use of smart phones in ophthalmology^[2-4,9]. Although there is overlap of apps and function in smart phones and smart tablets, smart tablet may have its priority upon smart phone for its larger display screen and better visibility. However, currently there is little report about the clinical use of smart tablet computers in ophthalmology.

The present article focused mainly on the iPad's (Apple Inc., Cupertino, CA, USA) value in ophthalmology, for its dominant adoption rate in the market^[11]. The iPad's self built-in functions FaceTime® (video calls between two Apple's devices) and iClouds® (automatic data storage in the cloud terminal) were described together with other apps.

MATERIALS AND METHODS

We conducted a systemic review of ophthalmology-relevant apps on the Apple's App Store from January 2013 to August 2013. Ophthalmology and eye were the search terms on the App Store (accessed August 1, 2013). The iPad 3 tablet computer (Apple Inc., Cupertino, CA, USA) was mainly used for us to download and evaluate the apps available on the App Store according to the two search terms. The iPhone 4 (Apple Inc., Cupertino, CA, USA) and laptop computer (K29, Lenovo Inc., Beijing, China) were used accordingly when the apps on the iPad need a third supporting digital device to broaden their functions. The contents and functions were evaluated independently by two experienced ophthalmologist (Zhang ZT and Wei YT). Firstly the reviewers judged whether the apps were eligible to be ophthalmology-relevant, and then categorized the eligible apps according to the apps' initial content and the reviewers' using experience. The iPad's built-in functions of instant video call (FaceTime®) and automatic data storage technology (iCloud®) were also described together with the apps. Using the same protocol, other operating systems of Microsoft's Window Phone and Google's Android were also searched for ophthalmology-relevant apps. Discordance about the apps' eligibility and categories between the two reviewers was resolved through discussion until 100% agreement was reached on the final interpretation of the data.

RESULTS

There were 111 apps searched with ophthalmology, and 1296 ones with the keyword "eye", the former 111 ones were all ophthalmology-related, and there were about 35% of the latter ones ophthalmology-related. The uses of iPad tablet computer with supporting apps and built-in functions could be categorized into five aspects.

Eye Examination Tools Several commonly used tests can be taken without assistance of any other devices, including visual acuity (near and distance visual chart), fixation, color test, Amsler grid, pupil gauge, and visual field test (Figure 1).

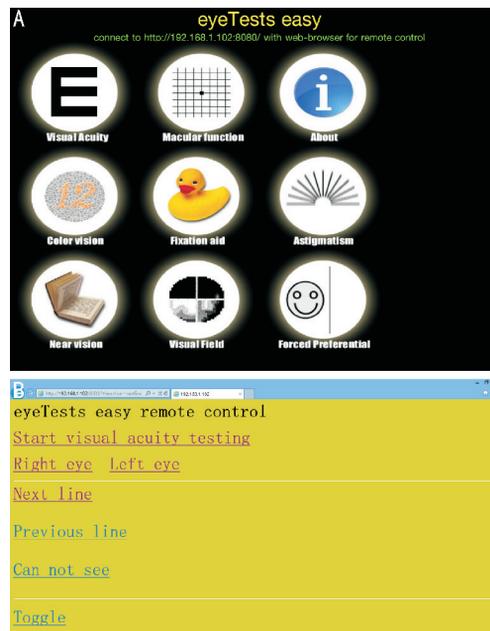


Figure 1 Screenshots of the devices running the app "eyeTests" A: Screenshots of the iPad tablet computer running the app "eyeTests easy" with various testing tools; B: Personal computer connecting with the iPad via wireless network to have remote control of the iPad's visual charts.

There were about 50 apps for eye examinations. About 40% were only for one specific examination and the other apps had various kinds of examinations cooperated. Apps for only or with visual acuity test were the most among the apps, taking the part of about 50%. For example, "Eye Chart Pro" (Dok LLC) was one advanced app for only visual acuity test also with several novel functions, one convenient fact was that wireless connection could be set up, so the letters on the iPad screen could be remote controlled by the corresponding iPhone on hand. There were several kinds of charts for us to choose, including Snellen chart, Tumbling E chart and Landolt C chart, the charts could be switched and testing distance could be adjusted to meet different conditions, our recent study has verified its accuracy for large part of patients^[12]. The app "eyeTests easy" (George Kong softwares) was one multifunctional app which could be controlled remotely by our personal computer through web-browser. Another unique function was that it had one forced preferential module specific for children's visual acuity test. And the entire test results could be sent as email simultaneously for tele-diagnosis and tele-consultation (Figure 1), another tests of color vision, near/distance visual acuity, visual field, astigmatism and macular function could be roughly taken with it. Physicians could download the interested apps to facilitate their ophthalmic examinations, especially when conventional examination tools are unavailable in the community or remote areas.

Patient/Student Education The tablet computer has its potential application to promote or innovate the way of patients' disease education and students' course education. Ophthalmology information could be easily delivered in a

multimedia form with the iPad. The “Animated Pocket Dictionary of Ophthalmology” (Expanded Apps, Inc) was a quick, handy, visually compelling medical app, with more than 100 medical terms featuring the anatomy, physiology, and diseases of the eyes. All the 3D animations had clear narration; the average video length was about 45s. Almost all eye anatomies and diseases ranging from anterior segment to the fundus were contained (Figure 2). The app “cataractSurgery” (George Kong softwares) was a simulation/game of capsulorhexis for the test of hand-eye coordination; we could have test and practice of capsulorhexis and phacoemulsification in the app (Figure 2). The app may be adapted into simultaneous training of beginners and pre-phaco education of patients. “Eyetube” (Bryn Mawr Communications LLC) provided free digital access to the world’s largest online surgical video archive dedicated to ophthalmologists, covering the sections of cataract and refractive surgery, retina, cornea, glaucoma, oculoplastics and laser vision correction. The EyeDecide™ app (Orca MD) is intended to educate individuals about their particular medical problems and alternative treatments, the app cooperated 3D eye anatomy, eye disease videos and annotations, and considerable specialists for patients to refer to.

Reference Tools We could easily and quickly refer to iPad for some diagnosis and treatment guidelines instead of searching in the textbooks. A smart tablet may be useful in case of emergency when the hardcopy reference tools are unavailable. “Ophthalmology i-pocketcards” (Borm Bruckmeier Publishing LLC) had a large content of eye diseases, which contained brief guidelines for some common diseases (Figure 2). There was a quick orientation for doctors when come with acute diseases such as temporal arteritis, endophthalmitis and central artery occlusion. Some commonly used guidelines with classification details and treatment protocols were included in it. Physicians in both the emergency department and sick wards can have quick reference to the app to make their work more effective and accurate. “eyePatients” (George Kong softwares) was an app with integrated functions. Patients’ clinical data (names, gender, visual acuity, previous treating, intraocular pressure, and diagnosis could be input and managed with iPad, making it possible and convenient for doctors to have a quick overview and follow-up of their patients’ conditions.

Telemedicine for Distant Diagnosis and Consultation

From iOS 4, Apple has had cooperated FaceTime into iPhone (Apple Inc., Cupertino, CA, USA) and iPad, users can have video call with fingertips to the screen *via* cellular network or wifi (wireless fidelity). In our clinical work, the native function of live video call provides us a quick and convenient access to other counterparts only with two iPad/iPhones in the clinic or operation room. Images and videos can be obtained with the built-in camera of iPhone 4/iPhone 4s linked to the eyepiece of a slit lamp microscope by a specific designed adapter(Figure 3). We can share patients’ slit lamp eye pictures simultaneously with other doctors to have group consultation with video call (Figure 3). In the operation

room, all the surgery process can be live broadcast. Patients’ clinical images can be easily captured and the surgical videos can be easily recorded with iPad/iPhone for subsequent analysis. iCloud was another highlight of iPad/iPhone for telemedicine, which can automatically save images and videos in the Apple’s devices in the cloud storage, patients’ clinical data are simultaneously available in the corresponding iPad/iPhone/Mac PC. Telemedicine became effective and low-cost, distant diagnosis and consultation are possible only if where cellular network or wireless net is available, the high adoption rate of smart devices among physicians is a solid foundation for us to popularize this kind of telemedicine.

Literature Searching and Document Management Some ophthalmologic journals are now available on iPad, including *Ophthalmology*, *American Journal of Ophthalmology*, *Clinical & Experimental Ophthalmology*, *Retina*, etc. Subscribers can download the journals’ full texts into their iPad. Compared with traditional hardcopies, journals of iPad version are timely updated and environmentally friendly. In our practical use of the iPad version of the journals, we are satisfied with the high download speed and easy searching. The app “PubMed On Tap” (ReferenceOnTap) searches PubMed to find and display reference information and associated full-texts (Figure 2). Some apps enable us to edit documents on iPad without the help of personal computers. “Pages” (Apple, Inc.) was an app developed by Apple to edit and read documents in forms of word and pages. Other apps like “Docs To Go” (DataViz, Inc.) and “Office Assistant” (Elinasoft Technologies Ltd.) are multifunctional not only in reading but also in editing and storing documents. Documents could be automatically saved in the cloud terminal, and were easily available and shared with others via cloud terminal or emails.

Ophthalmology – relevant Apps on Other Operating Platforms

Google’s Android and Microsoft’s Window Mobile systems are two other commonly used operating systems for tablet computers. We had a search for ophthalmology-relevant apps on the Google’s Play Store with the keywords ophthalmology and eye (accessed August 1, 2013), 99 ones were found with the keyword ophthalmology and were all ophthalmology-relevant; with the keyword eye, there were 500 apps found, but only about 30% were ophthalmology-relevant. Uses of the apps were nearly the same with those found on the Apple’s App Store. Some commonly used functions such as literature searching, visual acuity tests and document management have supporting apps both on the Apple’s and Android’s platforms. Additionally, there are some novel apps only available for the Android tablet computer that could not be found on Apple’s App Store, such as the app “MyEyeDrops” (developed by Singapore National Eye Center), which is designed for glaucoma patients’ personal management of anti-glaucoma drugs. However, some useful apps were unavailable on the Android’s platform, such as the apps “Eye Chart Pro”, “The Animated Pocket Dictionary of Ophthalmology”, etc. All ophthalmology journals’ tablet version can neither be found on Google’s Play Store.

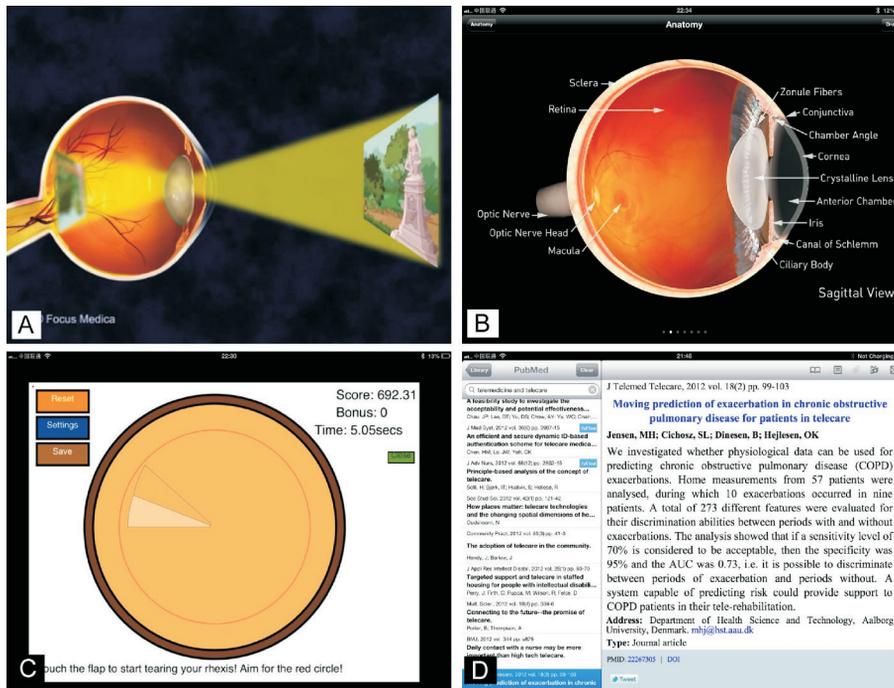


Figure 2 Screenshots of the iPad running ophthalmology – related apps A: The app “Animated Pocket Dictionary of Ophthalmology” with 3–dimensional illustration of the disease of cataract; B: The app “Sight Selector” demonstrating the sagittal view of the eye; C: The app “cataractSurgery” providing simulation/game of capsulorhexis; D: The app “PubMed On Tap” (ReferenceOnTap) searching PubMed to find and display interested papers.

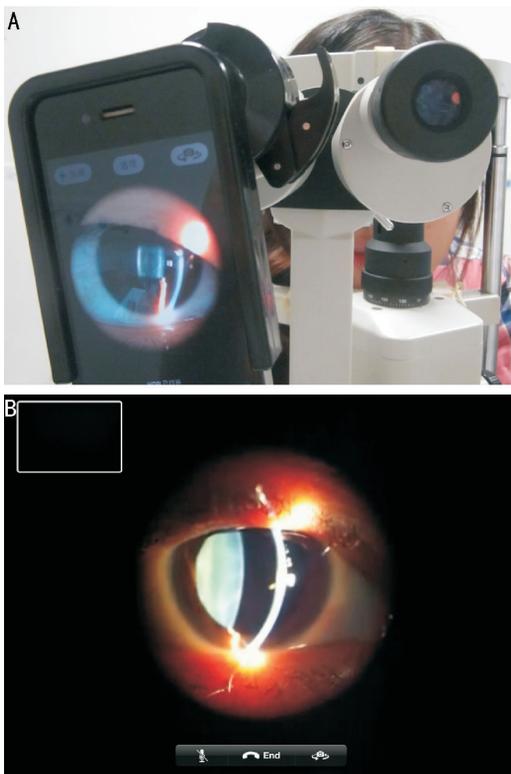


Figure 3 How to use the FaceTime for eye test A: iPhone camera adapter (Magnifi® ; Arcturus Labs LLC., CA, USA) linking the iPhone 4 to the eye piece of the slit lamp microscope (Topcon, Japan), image of the eye’s anterior segment (magnification, ×16) can be clearly demonstrated on the screen; B: Screenshot from the New iPad, which was having video call with the iPhone 4 with FaceTime, the eye’s image sent from the iPhone is clear enough.

Finally, on Microsoft’s Windows Store, with the keywords “ophthalmology and eye” (accessed August 1, 2013), there was only one app found with the former one and not fully ophthalmology–relevant; 389 ones were found with the latter one, but only a small portion (about 5%) was ophthalmology–relevant, which were mostly about visual acuity chart and color blindness test.

DISCUSSION

We found that there was an application boom of smart tablets in almost all clinical departments in recent years, including orthopedic, radiology, anesthesia, cardiology, surgery and so on^[1-10]. It should be noted that, Apple’s iPhone released in 2007 was a great stimulation for ophthalmologists to explore smart portable devices’ potential in their work. They primarily used iPhone to capture patient’s images under microscope with the iPhone camera located in front of the eyepieces, from anterior segment to ocular fundus^[2,3]. Some latest applications of smart devices in ophthalmic practice are evolving to more professional, they were reported to be used in tele – evaluation of fundus images^[9]. All these articles available focused mainly on one specific function of the devices. The uses of them mostly took places in the hospital, and some were for tele – diagnosis and consultation. The results told us that there might be an optimistic prospect of the further adoptions of smart tablets in our clinical practice. But there were few reports about the integrated uses of smart tablet computers in one department, and there is little report about the latest functions FaceTime® and iCloud®. Most of the current reports are about one specific application or function of

smart tablets and smart phones.

In our experience, the advantages of the iPad tablet computer in clinic include: 1) high speed; 2) powerful operating system; 3) high-resolution screens with proper width of 9.7 inches; 4) portable; 5) availability of a large number of ophthalmology-related apps; 6) can be remote controlled by iPhone or PC. The newly functions of video call and cloud storage are two solid foundations and key points for the further development and use of iPad and iPhone in the field of telemedicine. Because tele-consultation and tele-diagnosis can be easily realized only with two smart devices, without any assistance of other devices, it is easy, quick and low-cost. And the high adoption rate of smart tablets within physicians can make it practical to bring with.

There were also some disadvantages which may limit its clinical application: 1) telemedicine cannot be taken when either side has no internet connection or cellular network; 2) inadequate support of peripherals to broaden smart devices' functions, difficult or even impossible to have live broadcast of examination and operation without an adapter connecting the smart devices to the eyepieces; 3) a large proportion of apps with only English version cannot be easily accepted in non-English speaking countries; 4) iPad and iPhone are not compatible with non-Apple computer/system.

In conclusion, the integrated use of self built-in apps and third-party apps can facilitate our clinical work in examination, telemedicine, reference, disease education and literature searching. Although the uses of iPad in ophthalmology were multifunctional and convenient, more studies are needed to verify its validation and reliability in the professional fields, especially eye examinations. It is a problem whether the smart tablets can take place of the traditional ways of some examinations. There is also lack of enough supporting peripherals and apps designed for the physicians to make telemedicine and telecare more practical.

Because smart devices have a broad range of users in the world, it may be necessary for the app developers to have a world perspective to make their apps more compatible to different languages and different standards in different countries.

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