

# iPhones for eye surgeons

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## Introduction

In a survey of mobile phone ownership, 99% of health professionals own a mobile phone, with 81% of these being a smartphone.<sup>1</sup> The most popular smartphone currently being the Apple iPhone. Mobile phones and the internet have arguably been two of the most important developments in recent decades and the development of smartphones has combined these to allow many handheld capabilities beyond basic voice and text communication including advanced computing, digital photography, and geo-positioning.

Such devices are popular because of their high quality graphical user interfaces and intuitive control. The felt necessity by most adults to carry a mobile phone device with them at all times has meant that the increased capabilities of smartphones have come at no extra pocket space and in many cases for medical professionals has replaced the trusted handbook that once sat there.

Ophthalmologists are notorious for their interest in technology and gadgetry and so it comes as no surprise that the use of smartphones such as iPhones by ophthalmologists is wide spread.

For the purpose of this article we will look at the currently available applications and uses for an iPhone by an ophthalmologist (other platforms exist that provide the same or similar smartphone applications).

The potential functions of the ophthalmology related iPhone applications currently available can be divided into the following broad categories:

- (1) Patient assessment tools
- (2) Patient education/visual aids
- (3) Health care profession education and reference
- (4) Patient records/administrative tools and
- (5) Multiple functionalities.

## Patient assessment tools

Comprehensive assessment and examination of patients with ocular problems require the use of an array of diagnostic tools. In the ophthalmology, clinical setting of these tests are readily available but in the accident and emergency setting with an exiguous 'Eye Examination Room' or during emergency call outs these tools can be available at a touch of a button. There are several applications, which can assess visual acuity using either the familiar Snellen visual acuity test or modern interactive visual acuity tests. Some of the applications have tests for colour vision, astigmatism, pupil size, oculomotor reflexes, and red desaturation (see Table 1).

## Patient education/visual aids

Patients will often ask questions in clinic about their condition; What is it? Why do I have it? How is it treated? Some clinics even employ specialist nurses to undertake patient counselling activities, such as with macular degeneration and glaucoma. Providing patients with narrated video content can help answer all these questions in a way that discussion alone cannot. The portability of the iPhone makes this ideal for providing information to patients in clinic, but for the more technologically confident patient, they can download the application to their own iPhone device and review the information at their leisure, and show it to friends and relatives, relieving them of the burden of translating the sometimes complicated explanations of their ophthalmological condition (see Table 2).

## Health care profession education and reference

Learning and professional development for health care professionals and students is changing since the introduction of the smartphone.<sup>2</sup> With the limited number of hours available to catch up on the latest results from

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**Table 1** List of iPhone applications, which can be used by patients to test basic visual acuity and health care professionals to perform more detailed assessments of visual function









<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
 (Sabina technology LLP)	0.3 MB	No ratings	£1.49	An interactive amsler grid test for patients, which can be used to record areas of distortion. 'Push notification' reminds patients to conduct tests regularly.
 (Park house systems)	851 KB 206 KB	No ratings	Free £0.69	This application allows patients diagnosed with a macula disease to monitor any change in their vision. Health care professionals can also use it to check patients for potential macular abnormalities.
 (Maturi consulting LLC)	1.1 MB	No ratings	£1.49	Personal amsler and visual acuity testing application.
 (Allergan Inc.)	2.2 MB	No ratings	Free	Three vision test; <ul style="list-style-type: none"> <li>● Tumbling 'E' test</li> <li>● Tumbling shape test and</li> <li>● The amsler test</li> </ul> Plus information on glaucoma, cataract, and diabetic retinopathy.
 (Scott kehrberg)	0.1 MB	No ratings	£0.69	Snellen chart and amsler grid to check vision. The application also allows user to store their spectacle and contact lens prescription.
 (Dmitriy glebenok)	22.3 MB	3 Stars (27 reviewers)	Free	Visual acuity, ishihara colour test, astigmatism test, retinal functional test, visual field test, and face memory test. Also included in this application is a section on entertainment and fun, eye exercises and practical information, and help.
 (McApps)	1.0 MB	2 Stars (8 reviewers)	£0.69	Visual acuity test, amsler test, and colour-blind tests.
 (McApps)	1.1 MB	No ratings	£0.69	Series of eyesight and vision exams.

Table 1 (Continued)























<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
iSight test  (Kay pictures Ltd)	1.3 MB	5 Stars (8 reviewers)	£8.99	Vision testing including Kay pictures.
Vision test  (3 sided cube)	7.7 MB	4 Stars (84 reviewers)	Free	Visual acuity test, astigmatism test, duochrome test, colour test, far field vision test, optician finder, eye quiz, eye advice, and facts.
Vision! test  (Wow systems informatica Lda.)	584 KB	No ratings	£0.69	Simple vision test.
Eye test pro  (Thomas mitchell)	6.2 MB	5 Stars (18 reviewers)	£0.69	A comprehensive application for eye care professionals, which includes Snellen chart, individual testing letters, contrast sensitivity testing, duochrome tests, cross cylinder test, number plate assessment test, reading test, ishihara test, and amsler chart distance fixation images for ophthalmoscopy.
EyeXam  (Global eye ventures LLC)	18.3 MB	3 and fraction 12; Stars (16 reviewers)	Free	Includes tests for visual acuity, colour perception, astigmatism, eye dominance, and links to obtain more information.
Eye test  (cateater LLC)	7.7 MB	No ratings	£0.69	Tests for visual acuity, colour blindness, astigmatism, duochrome, and macular degeneration.
Eye Exam  (Nuno carvalho entertainment)	626 KB	No ratings	£1.49	Self tests for near and distance visual acuity.
Senses–What you see?  (Baltronic)	6.1 MB	No ratings	Free	Designed to conduct vision screening, mainly in children and youth. The examination uses colour vision and contrast differentiation tests.

Table 1 (Continued)

Application name (Developer)	Size	Customer rating	Cost	Description
Opt Eyecheck—eye examinations/colour blind...  (Cynet infotech LLC)	2.1 MB	No ratings	£0.69	Includes a near vision, colour vision, amsler grid, and contrast sensitivity checks.
Visual acuity  (Kybervision consulting, R&D)	2.6 MB	No ratings	£6.99	Visual acuity test for health care professionals using the logMAR acuity. For the non-health care professionals they recommend the fast acuity, hotv acuity, or the solan acuity.
Fast acuity  (Kybervision consulting, R&D)	582 KB	No ratings	£1.99	Interactive eye chart for the non-professional.
HOTV acuity  (Kybervision consulting, R&D)	570 KB	No ratings	£0.69	For pre-school children and illiterate people.
Sloan acuity  (Kybervision consulting, R&D)	582 KB	No ratings	£0.69	Test acuity in literate people.
Eye Chart HD  (Dok LLC)	3.0 MB	2½ Star (43 reviewers)	Free	Snellen and Tumbling E chart.
Colour vision test free  (Meeni techno)	2.0 MB	No ratings	Free	Colour vision tests.
Colour blind test  (Tomato Co. Ltd.)	0.6 MB	3 Stars (14 556 reviewers)	Free	Check if you are colour blind.

**Table 1** (Continued)

<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
 Colour vision test (Rila software)	4.6 MB	No ratings	£0.69	Contains 16 colour plates.
 Pseudochromatic Colour test (Cassiopeia information technologies)	1.2 MB	3½ Stars (502 reviewers)	Free	Colour plates.
 Pupil sizer (Kevin lease)	105 KB	No ratings	£0.69	Simple Application to estimate pupil size.
 Pocket eye exam (Russell matney)	1.3 MB	No ratings	£1.49	Tests include: <ul style="list-style-type: none"> <li>● Ishihara plate</li> <li>● OKN strip</li> <li>● Pupil Chart</li> <li>● Red desaturation</li> <li>● Visual acuity test.</li> </ul>
 Random eye chart generator (Dok LLC)	157 KB	No ratings	£1.49	Features: Snellen charts and Illiterate E chart can be used as a screening tool.
 OKN + (Touch Diagnostics, LLC)	162 KB	No ratings	£1.99	OKN test and red desaturation test.
 Optodrum (Linsay associates, LLC)	278 KB	No ratings	£1.99	Replacement for the OKN drums, different patterns with adjustable width and speed.
 Visual acuity converter (EB Eye limited)	892 KB	No ratings	£2.99	Converts between the commonly used visual acuity notations, calculates astigmatism, biometry, optical formulas, toric IOL calculator, and refraction converter.

**Table 2** List of iPhone applications, which can be used by healthcare professionals or patients for education about ophthalmic conditions and treatments, and applications that can be used as visual aids











<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
Eye Model  (Evandro Souza)	4.2MB	2 Stars (5 reviewers)	£0.69	Interactive model eye, allowing different viewing angles and different layers. Good for demonstrating eye anatomy to patients while explaining their problems.
Sight selector  (Patient education concepts Inc.)	Lite = 33.6MB Premium = 602 MB	No ratings	Lite free premium £324.99	Free version of application built into add-on modules that can be bought separately. Each module helps to educate patients about a particular condition or procedure ranging from laser vision correction to macular degeneration.
Eye health  (Stroika)	3.4MB	No ratings	£2.99	A reference for students and patients alike, this application describes common conditions, their causes, and illustrates them with pictures and diagrams. Also contains an illustrated glossary.
MiniAtlas glaucoma  (ec-europe)	35.1 MB	No ratings	£4.99	This application helps you to explain to your patient the diagnosis of glaucoma, its management, and its effects through the use of clear images and diagrams.
Mini atlas age-related macular degeneration  (ec-europe)	36.4 MB	No ratings	£4.99	A similar patient education application as the mini atlas glaucoma.
Eye patients mobile free  (George Kong Softwares)	7.3MB	No ratings	Free	This application can be used by patients to maintain a record of their own ophthalmic history, including medication instructions and IOP measurements (which can be presented in graphical form). It can also be used by doctors as a surgical/audit log.
Eye Snapi  (MobileDx)	0.5MB	No ratings	Free (with additional charges)	This free application allows patients to make measurements such as visual acuity and amsler charts, as well as take photographs, which can be emailed to a doctor for assessment. However, these emails are charged at \$0.99 each in America and it is not known whether UK users are charged a commensurate rate.

Table 2 (Continued)

Application name (Developer)	Size	Customer rating	Cost	Description
 Eye lifestyles (Patient education concepts Inc.)	62.0 MB	No ratings	£399.99	This patient education application helps to educate patients on advanced lifestyle vision and cataract surgery options. The cost of the application includes additional support, integrating the material into your pre-operative patient education process.
 Aid Colours (Tilenus consultores S.L)	0.2 MB	No ratings	£0.69	Colour-blind patients can use this application to identify the colour of a surface in front of the camera of the iPhone. The application will then return the written name of the colour of the surface tested.
 Colour detect (sunset software LLC)	0.5 MB	No ratings	£1.49	This application not only returns the name of a colour held in front of the iPhone camera, but will also provide the RGB coordinates for a given area on the photograph. Useful for colour-blind patients.

landmark studies this information can be distributed quickly and effectively with the use of modern technology. Applications that offer reference material may eliminate the need to carry heavy 'text books' and indeed provide essential reading material on the 'go'. Some of the applications provide videos and colour atlas quizzes, which will be useful for training and examination preparations. Others help plan refractive and intraocular lens calculation for cataract surgery and analysis of postoperative results, such as plots of surgical induced astigmatism (see Table 3).

#### Patient records/administrative tools

There is a demand for greater productivity and so being able to access patient information remotely and securely is paramount. Some products are flexible enough to allow information to be passed from a remote location, such as an optometrist, for advice to be fed back about management and referral in true telemedicine fashion. A number of solutions exist for this problem to suit every budget (see Tables 4 and 5).

#### Future hardware and possibilities

As well as downloadable software applications, there are in development several additional hardware tools. These

include an autorefractor (NETRA), cataract grader (CATRA) and ultrasound scanner. The NETRA autorefractor has in two separate pilot studies demonstrated good accuracy as compared with subjective refraction (mean difference in spherical equivalent of 0.18 D<sup>3</sup> and 0.24 D,<sup>4</sup> respectively), the same group who developed the NETRA at the Massachusetts Institute of Technology are developing the CATRA for self-grading of cataracts. MobiUS have created an FDA approved smartphone ultrasound imaging device, which uses a hand held wand and the smartphone as a portable imaging system. With small adaptations this could be suitable for ocular ultrasound examination.









Imaging of the eye via a slit lamp has been described previously,<sup>5</sup> with recently developed adaptors (Keeler Apple iPhone 4 PSL-imaging adapter, London, UK) now on the market. Imaging the fundus using an iPhone, indirect lens and ophthalmoscope<sup>6</sup> and an alternative technique without the need for the ophthalmoscope have been described.<sup>7</sup> iPhones have been used in tele-ophthalmology retinopathy of prematurity outreaches in India with success,<sup>8</sup> but to date have required large imaging devices such as the RetCam. With future developments it is likely that an attachable fundus camera will fit directly on to a smartphone with wide field images created by existing photo-stitching packages and making it a truly portable fundus camera.

**Table 3** List of iPhone apps, which can be used by health care professionals for reference and personal development






<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
Minor eye lid surgery  (Innovation technologies)	372MB	No ratings	£0.69	Contains basic procedures as videos.
Ophthalmology  (Faribu.com)	31.7MB	No ratings	£0.69	Basic education, and general ophthalmology information.
The Wills eye manual  (Skyscape)	273 KB	3 and fraction 12; Stars (5 reviewers)	£54.99	Essential for clinic and emergency use with several new sections and results from new studies.
OSN supersite  (The Wyanoke Group)	1.5MB	No ratings	Free	Ocular surgery news, surgical videos, and blogs meeting highlights from around the world.
Ophthalmology glossary  (deep powder software)	570MB	No ratings	£0.69	Glossary.
Retina atlas  (medina systems)	325MB	No ratings	£10.49	Interactive digital atlas of retinal disease.
iEye retina  (Isha innovations)	10.2MB	No ratings	£1.99	Retina reference and quiz, images of retinal pathology, and learning tool that can be used in the clinic.
Academy2GO–CIBA vision academy for eye care excellence  (visual eyes, Inc.)	461MB	2 Stars (15 reviewers)	Free	Education on the go.






Table 3 (Continued)

<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
EyeDock  (Todd M Zarwell OD)	3.3MB	1 Star (14 reviewers)	Free (membership required)	Contact lens power calculator.
OHT Calc  (Michael Brandt)	0.4MB	No ratings	£0.69	Glaucoma risk calculator based on OHTS and EGPS studies.
Optics Clinical Calculator  (Eva Schoenberg)	0.9MB	No ratings	£2.99	Refractive calculators.
PAK  (El Patagonauta)	2.1MB	No ratings	Free	Post myopic refractive surgery IOL Calculator and Calculator of safety parameters for LASIK.
Toric Lab  (Evandro Souza)	1.4MB	No ratings	£2.99	Calculate IOL power for cataract/refractive surgery.
LRI Calc  (Evandro Souza)	2.1MB	No ratings	£0.69	Pre-optical planning of limbal-relaxing incisions.
Eye Pro 2011  (EB Eye limited)	1.2 MB	No ratings	£18.99	Features for anterior segment surgeons, biometry visual acuity Converter, and astigmatism plots.
Astig PLOT  (EB eye limited)	1.0 MB	No ratings	£6.99	Statistical analysis of astigmatism in a group of eyes. Part of eye PRO 2011 application.



**Table 3** (Continued)

<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
 Eye vectors (Evandro Souza)	4.7MB	No ratings	£1.99	Vector analysis Toric IOLs or LRIs.
 PachyIOP (Farotech)	0.2MB	No ratings	£1.49	IOP conversion based on pachimetry.
 LASIK clinical calculator (Evan schoenberg)	0.5MB	No ratings	£2.99	Calcualtor for LASIK refractive surgery.
 Open Ophthalmology-Podcast Application (Wizzard Media)	4.2MB	No ratings	£6.99	Ophthalmology lectures as podcasts.
 Crossed cylinders (diffraction limited design LLC)	0.1MB	No ratings	£2.49	Calculate spherical equivalent and switch between positive and negative cyl.
 ODwire.org (End of time studios LLC)	4.9MB	No ratings	Free	Social network for eye care professionals, trade ideas, buy equipment, and much more. Open to optometrists, ophthalmologists, licensed opticians, and students.
 As seen from here-Podcast Application (Wizzard Media)	3.7MB	No ratings	£6.99	Podcast of interviews of recent peer-reviewed publications. Host Josh Young, MD American society of cataract and refractive surgery.

**Table 4** List of iPhone applications that facilitate patient medical record/imaging management and administration

<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
 OCT browser for iPhone (University of Pittsburgh)	33.4MB	No ratings	Free	This application allows you to carry OCT images on your iPhone using dedicated OCT browser software. Images are compressed, and owing to the slower speeds of older iPhone models, works best on iPhone 3GS and 4.
 i2i CARE tele-ophthalmology (i2i telesolutions)	8.6MB	No ratings	£0.69 (although additional setup costs anticipated)	Images can be taken with a mobile or stationary ophthalmic camera and uploaded to a TelePACS server. These images can then be accessed through this application locally or remotely. Images can be compared with previous ones.
 Eye route mobile (Topcon medical systems Inc.)	18.6MB	No ratings	£13.99 (although additional setup costs anticipated)	Another imaging electronic medical record solution, designed to integrate with other Topcon equipment, allowing remote access and reporting of patient images.

**Table 5** Applications with multiple functions

<i>Application name (Developer)</i>	<i>Size</i>	<i>Customer rating</i>	<i>Cost</i>	<i>Description</i>
 Eye handbook (Cloud nine development LLC)	11.7MB	3 Stars (196 reviewers)	Free	Many features including reference, links to journals, eye atlas, tests, recording patient details, collaboration with the American Academy of ophthalmology and much more.
 iChart 2000 (Potters bar eye care limited)	41.6MB	3 and fraction 12; Stars (10 reviewers)	£15.99	Tools include: near vision and 3m assessment, patient information—images and video to help explain conditions to patients, tool kit to calculate eye-related calculations.

### Concluding remarks

Rapidly advancing technology has literally put knowledge in the palm of our hands. The possibilities for investigations, teaching, information sharing, research, collaboration, and ultimately improved patient care are endless.

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