"How will the patient with ophthalmic problems be cared for in 30 years' time?"

I would like to challenge those reading this to picture themselves somewhere in 30 years' time, having survived a post-apocalyptic Trump era, navigated the melting ice caps and outlasted (hopefully) the social media age. A time in which parents have chosen their children's height, hair colour and skin tone, a period whereby you drive to work in an aerocar and experience a 3 day working week. Sceptical? I would hope so, as it is easier to fall into the ensnaring trap of nostalgia than reality, when considering the practicalities of life in the future. As much as our daily lives may not resemble that of The Jetsons, there are plenty of reasons to be excited in the midst of economic austerity, greenhouse gases and megalomaniac political leaders. It is predicted that the number of people with visual impairment in the UK will double in the next 3 decades to 4 million; therefore, if ever there was a time for ingenuity and unrealistic ambition, perhaps it should be in the next few years[1].

Presentation

Where to start? Well, the beginning of the patient journey would be most relevant, as it is usually the source of greatest delay and frustration, for both patients and clinicians. I would like to believe that in 3 decades' time, we have made use of the tremendous telecommunications improvements that are currently in the pipeline[2]. It would be logical to assume that wireless networks will be wider, faster and more accessible, not just in public places but, crucially, within primary and secondary care facilities. 'What difference would this make for ophthalmic patients?', I hear you ask. Primarily, it would allow a feasible line of direct communication between General Practitioners, Optometrists and other allied health professionals with ophthalmologists[3]. The huge spectrum bandwidths, in conjunction with 'smarter' smartphones would mean that an 'over-the-phone' consultation will take on a whole different meaning. With 3.5GHz spectrum bands already incoming, the possibility of taking and sending anterior segment/fundal images to an ophthalmologist is very real. 'What about information governance?', I hear you proclaim! Cloud-based services are due to grow exponentially in the next decade and resultant cloud data centres **should** have the capacity for safe storage of massive amounts of patient data.

The benefits of this arrangement would be two-fold. Firstly, it would allow a quicker clinical opinion from an ophthalmologist meaning fewer unnecessary referrals, less unnecessary clinic visits for patients and, potentially, speedier initiation of appropriate treatments. Moreover, it would submerge Ophthalmology into the realm of virtual clinics, having already dipped her toes in the

water[4]. Against the background rhetoric of increasing patient load, longer life expectancies and fewer clinicians, virtual clinics may just hold the answer. It may *even* finally be the reason the NHS (should it still exist) adopts a singular platform across its services. No more scrambling for patient information and faxing over previous medical notes between Trusts! Ultimately, the goal in 30 years should be this; a shift in emphasis from placing the burden of patient management from Secondary/Tertiary Care towards Primary Care, where possible. Patients may not even have to see an ophthalmologist to present their symptoms, have relevant investigations and be started on appropriate treatment.

Intervention

Thus far, we have a hypothetical patient who has presented in the Community or Emergency Department and has been remotely managed by an Ophthalmologist sitting in an invitingly warm, creaky armchair. What then, of the patients who **do** need to be seen and treated in an Eye Clinic or theatre? The elephant in the room when it comes to future healthcare is certainly Artificial Intelligence. On the one hand, we (the clinician community) are twitchy with excitement at the possibility of artificial eyes, robotic surgery and digital diagnosis[5]. On the other hand, we are ultimately worried about our own welfare; that we may have to remain sitting in our warm, creaky armchairs because our place in the clinical food chain has been replaced by faultless, omnipotent machinery. Do I believe that in 30 years patients will be operated artificially, with several robots independently dissecting through the anterior chamber, much like a futuristic Hollywood sci-fi blockbuster? The short answer is no. For the same reason that Uber's self-driving car lead to the death of a pedestrian, I believe the presence of clinical experience will always be indispensable.

However, AI is already in the pipeline and Google's DeepMind demonstrates how image analysis can make diagnosis efficient and reliable, with initial research showing the algorithm to surpass the performance of trained clinicians[6]. The question is whether AI systems will be able to make the jump to employing 'Deep Learning' in a clinical capacity. Will such facilities be able to replicate the deciphering of new information, comparable to a consultant with many years of experience? With artificial neural networks on the way, this may well be a clinical reality in 3 decades' time. A more realistic and imminent change to patient care is the use of robotic eye surgery. The R2D2 (no 'futuristic Hollywood sci-fi blockbuster' pun intended!) robot has recently been used for the first time, in the management of an epiretinal membrane; an example of how robots can be used synergistically, rather than as a substitute for ophthalmologists[7]. Such surgery

will be commonplace over the next 10-15 years, offering patients a precise experience from surgery. Dovetailing robotic automation and vitreoretinal procedures could dramatically reduce surgery times and increase the efficiency of services in the future.

Outside of the operating theatre, we may finally be able to offer substantive therapies to a subgroup of patients who, quite rightfully, may currently feel lost within the speciality. Inherited retinal dystrophies remain a devastating source of visual loss but recent leaps in genetic technologies make the possibility of gene therapy genuinely feasible over the coming decades. The first approved trials of 'Luxturna', a gene therapy targeting RPE65-mediated inherited retinal disease, have recently got off the ground, representing a watershed shift in translational ophthalmology[8]. With Next Generation Sequencing (NGS) offering faster and cheaper genome/exome sequencing, it is tangible that we are on the precipice of a genetic 'Golden Age'. Congenital cataract screening will be routine which means the next logical progression would be screening platforms for diseases such as age-related macular degeneration, using NGS facilities[9]. We must expect a transition from focusing on monogenic disease discovery, to identifying polygenic disease mechanisms as sequencing become more cost-effective.

The Future

Of course, there is only benefit in therapeutic advancements, so far as the capabilities of those in whose hands they lie. The crux of how patients with ophthalmic problems will be cared for, will largely be dictated by the next generation of ophthalmologists, nurses, scientists, receptionists, chief executives and pharmaceutical companies. Healthcare has never been and never will be, just about individuals or technology. So who will be caring for ophthalmic patients in 30 years' time? Broadly, it will be those belonging to the 'millenial' group, born between 1980 and 2000; the digitally-native, impatient, globally-attuned cohort[10]. Less face-to-face communication, more Facetime-to-Facetime. Appointments and follow-ups will be made via the convenience of a smartphone app, patient records will be globally paperless and accessible whilst patient complaints will be left in the form of a voicenote! In some ways, there are obvious foreseeable advantages with the potential for national multi-disciplinary grand rounds, referral systems and cogent screening programmes. Others may attest to a less personable, more matter-of-fact style of care, where Hospital numbers carry more importance than patient names.

Ophthalmology will always be fraught with difficult clinical decisions, that can significantly impact the quality of life of a patient. Millenials, with their networking habits and digital communication skill-set, will be better placed reaching out to peers from across continents and

time-zones for advice. This will, ultimately, culminate in a more informed decision for patients and, possibly, a better long-term outcome.

Finally…

Let us now go back to the scenario of imagining ourselves in 30 years' time. Except now, you have awoken with a red, tender eye. You immediately open your National Health Service app to book an emergency appointment with your GP. On attending, your GP makes a brave yet disappointing attempt at using an ophthalmoscope before using the online referral system to contact the ophthalmologist on-call, who is able to see a high-definition projection of your eye from the on-call room. After carefully scouring your online medical record, she is concerned about the possibility of orbital cellulitis and requests that you be admitted for further examination. After your automated CT scan, you are digitally diagnosed with a sub-periosteal abscess, which is then robotically drained in theatre. After a complication-free recovery period, you are discharged back home. Now imagine that you are admitted on a day when, unfortunately, the national servers are down. Spare a thought for the poor ward clerk and junior doctors furiously dusting off fax machines and photocopiers!

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