Anoushka Sharp Elective Report 2023 – Ophthalmology at Kaplan Hospital

Introduction

I would like to start with a big, heartfelt thank you to Dr Arieh Markovich, head of Ophthalmology at Kaplan Hospital, for supervising my elective, and to the Student Jewish Medical Association for awarding me an elective scholarship.

During my elective, I spent time at Kaplan Hospital in Rehovot, Atidim Medical Centre in Tel Aviv, and Dr Markovich's home clinic.

I observed in-patient and outpatient appointments, surgeries under general and local anaesthetic, ophthalmic imaging and laser treatments. A particularly memorable highlight was looking through the assistant's microscope during cataract surgery, obtaining a 3D view of the eye and swapping between observing the magnified view of the eye for a detailed insight into the surgery and admiring the microscopically small and precise hand movements of Dr Markovich, the surgeon.

I found it interesting to compare the various uses of light waves in ophthalmology – within diagnostic machinery such as OCT, Pentacam, autorefractor, slit scanner, Placido rings, slit lamp and fundoscopy, and within laser treatments such as LASIK, YAG and photocoagulation.

I hope that learning more about geometric optics and wave equations alongside concepts from bioengineering and electromagnetism will enable me to innovate creatively, enabling faster acquisition of more clinical information, and greater opportunity for ophthalmologists to work remotely.

I feel particularly grateful to the doctors at Kaplan hospital for introducing me to useful resources for learning optics and ophthalmology.

Outside of hospital, it was interesting to speak with Israelis from different backgrounds about a wide range of topics including army service, medical school, training pathways for doctors, university life, recreation, family life, and the political situation including weekly demonstrations. The opportunity to explore beautiful nature and vibrant culture within Israel added an invaluable aspect of adventure to this very educational elective experience.

Below is a summary of my four learning objectives.

LO 1: compare prevalence of common eye diseases in Israel to the rest of the world

The most common eye diseases causing blindness or visual impairment in adults, both globally and in Israel, are cataract, uncorrected refractive error, diabetic retinopathy, glaucoma, and age-related macular degeneration.

In high income countries (including Israel), greater burden comes from progressive degenerative disease such as age related macular degeneration, whereas in low income countries, greater burden comes from treatable diseases with earlier ages of onset, such as cataract and uncorrected refractive error.

During my elective, I was exposed to common eye diseases such as cataract, diabetic retinopathy, and uveitis, as well as rarer diseases including keratoconus, corneal ulcers, dermoid cysts and congenital ptosis.

LO 2: compare the healthcare system in Israel to that in the UK

Israel passed its National Health Insurance Law in 1995, granting all Israeli residents the right to a 'basic healthcare package' provided by a 'Kupat Holim' of their choosing.

Kupat Holim are non-profit organisations, run separately from the Israeli government. There are four in Israel - Clalit (the largest), Maccabi, Meuhedet and Leumit. The basic care package is updated each year and is the same in all Kupat Holim. The basic care package includes diagnostic tests, treatments, regular medications subsidised at 50-90%, GP and specialist appointments, and a stipend to cover receiving treatment abroad.

Competition between Kupat Holim is created through their 'extra insurance' packages which offer various combinations of extra healthcare – as of 2017, purchased by over 75% of Israelis. There is an annual opportunity for Israelis to switch Kupat Holim. This incentivises the Kupat Holim to provide high healthcare standards and attractive extra insurance packages.

Commercial private healthcare companies exist alongside the non-profit Kupat Holim. Private healthcare insurance, used by 1/3 of the population, may be an individual purchase or a perk from work. Attractions offered by private healthcare companies include the opportunity to choose specific hospitals and doctors, a luxurious, hotel-style patient environment, and the right to consent to transplant without government approval.

In the UK, citizens are entitled to free healthcare provided by the government-run NHS and may purchase supplementary private healthcare.

Key differences between the UK and Israeli healthcare include the economic funding of public healthcare (by tax in the UK, by insurance in Israel), and competition between public healthcare providers (apparent in Israel, not in the UK).

Key similarities between the UK and Israeli healthcare include the parallel existence of public and private healthcare, and the universal right to free healthcare stated within government law.

During my elective, I observed YAG laser treatment and cataract surgery at Kaplan Hospital in Rehovot (run by Clalit, a Kupat Holim) and Atidim Medical Center in Tel Aviv (run by Enaim, a private healthcare company).

LO 3: discuss provisions for the visually impaired in Israel

The National Registry for the Blind in Israel was founded in 1987. Their research from 1999 reports prevalence and incidence of blindness as 0.31% and 0.037% respectively, with the most common causes of blindness including age-related macular degeneration, glaucoma, cataract, myopic maculopathy, and diabetic retinopathy.

The Israeli Law Office defines blindness as the fulfilment of one of three criteria: complete absence of vision; 3/60 vision or less in strongest eye with vision aids; field of vision under 20^0 in strongest eye with vision aids (the visual field for each eye typically spans 120^0 horizontally and 90 degrees vertically).

Blind Israeli residents are issued a permanent or temporary 'certificate of blindness' by the Ministry of Welfare and Social Services, following assessment by an ophthalmologist. This grants them a monthly stipend of 2364 NIS, a state-sponsored blind dog, an accessible parking permit, and income tax exemption.

During my stay in Israel, I observed braille on elevator buttons in the hospital and on medication packets, and I noticed that green pedestrian crossing lights were accompanied by clicking noises.

LO 4: explore the use of light waves in ophthalmic imaging

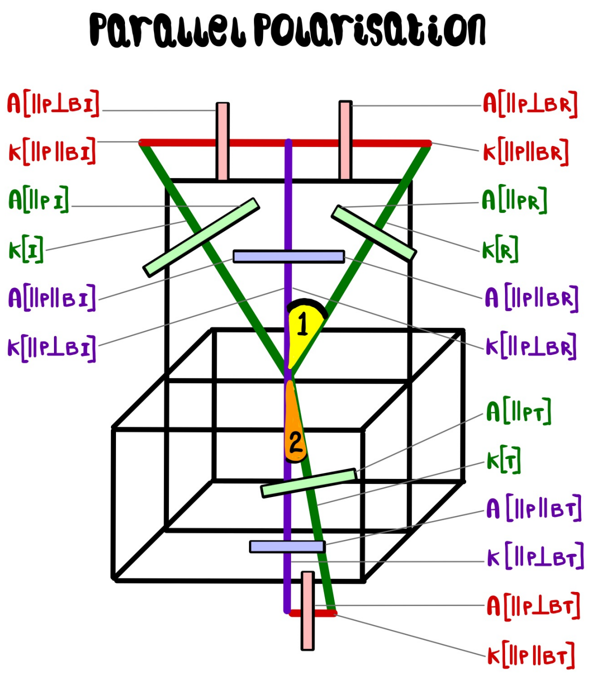
Phenomena involved in ophthalmic imaging (and laser treatment) include reflection, refraction, scattering, diffraction, and absorption. These can all be modelled by classical electromagnetism: Maxwell's equations in matter, conservation laws (used to derive Snell's law and Fresnel equations), and resonance (describing dispersion and absorption).

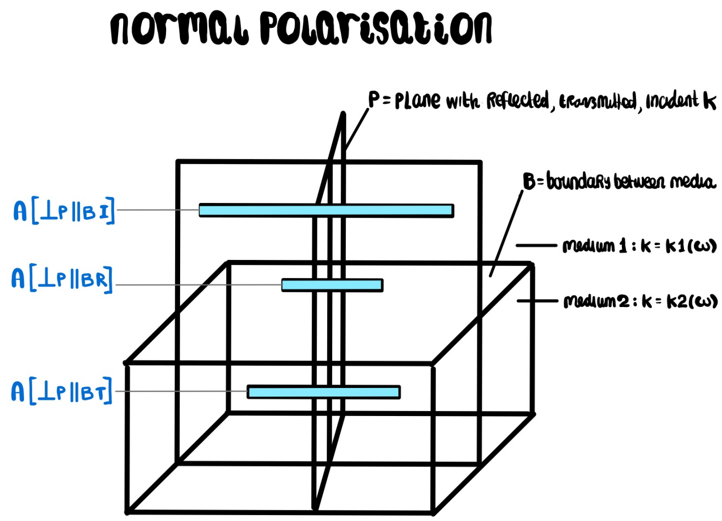
Equations are found in the table below.

Name	Equation	Symbols
Maxwell's equations in matter	$\nabla.\epsilon\mathbf{E} = \rho_{free}$ $\nabla.\mathbf{B} = 0$ $\nabla \times \mathbf{E} = -\partial\mathbf{B}/\partial t$ $\nabla. \mathbf{B}/\mu - \partial\epsilon\mathbf{E}/\partial t = \mathbf{J}_{free}$	ϵ = electric permittivity μ = magnetic permeability $\mathbf{E}$ = applied electric field $\mathbf{B}$ = applied magnetic field ρ_{free} = free charges $\mathbf{J}_{free}$ = free currents ρ = charge density $\mathbf{J}$ = current density
Conservation laws	I = T = R for $\mathbf{k}(\parallel P,\parallel B)$ $\mathbf{A}(\parallel P,\perp B)$ I = T + R for $\mathbf{k}(\parallel P,\perp B)$ $\mathbf{A}(\perp P,\parallel B)$ $\mathbf{A}(\parallel P,\parallel B)$	I = incident R = reflected T = transmitted $\mathbf{k}$ = wave vector $\mathbf{A}$ = amplitude vector $\perp P$ = component perpendicular to plane containing incident, transmitted and reflected waves $\parallel P$ = component parallel to plane containing incident, transmitted and reflected waves $\perp B$ = component perpendicular to boundary between media $\parallel B$ = component parallel to boundary between media Θi = angle of incidence Θt = angle of refraction $\cos(\theta i) = [\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)]$ $\cos(\theta t) = [\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)]$
Snell's law	$\mathbf{k}(\parallel P,\parallel B,I) = \mathbf{k}(\parallel P,\parallel B,T) = \mathbf{k}(\parallel P,\parallel B,R)$	
Fresnel equations for normal polarisation	$\mathbf{A}(\perp P,T)/\mathbf{A}(\perp P,I) =$ $2\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)]$ / $(\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)]+\mathbf{k}(T)[\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)])$ $\mathbf{A}(\perp P,R)/\mathbf{A}(\perp P,I) =$ $(\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)]-\mathbf{k}(T)[\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)])$ / $(\mathbf{k}(I)\ [\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)]+\mathbf{k}(T)\ [\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)])$	
Fresnel equations for parallel polarisation	$\mathbf{A}(\parallel P,T)/\mathbf{A}(\parallel P,I) =$ $2\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)]$ / $(\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)]+\mathbf{k}(T)\ [\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)])$ $\mathbf{A}(\parallel P,R)/\mathbf{A}(\parallel P,I) =$ $(\mathbf{k}(I)[\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)]-\mathbf{k}(T)\ [\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)])$ / $(\mathbf{k}(I)\ [\mathbf{k}(\parallel P,\parallel B,T)/\mathbf{k}(T)]+\mathbf{k}(T)[\mathbf{k}(\parallel P,\parallel B,I)/\mathbf{k}(I)])$	
Resonance	$p = \alpha\ \mathbf{E}$ $\alpha = (q^2 / (m(\omega0^2 - \omega^2 - i\gamma\omega))$ $\epsilon = \epsilon0 + n\ \alpha$ $\epsilon_r = \epsilon0 - (nq^2/m)(\omega^2 - \omega0^2)/((\omega^2 - \omega0^2)^2 - \gamma^2\omega^2)$ $\epsilon_c = (nq^2/m)(\gamma\omega)/((\omega^2 - \omega0^2)^2 - \gamma^2\omega^2)$ $\mathbf{k}_r = \sqrt{}(\omega^2 / \mu^2)(\|\epsilon\|^2 + \epsilon_r^2)$ $\mathbf{k}_c = \sqrt{}(\omega^2 / \mu^2)(\|\epsilon\|^2 - \epsilon_r^2)$ $v = \omega/\|\mathbf{k}\|$ $v = 1/\sqrt{}(\mu\epsilon)$	p = polarisation α = polarisability of an atom $\mathbf{E}$ = applied electric field m = mass (of atom) ω = temporal frequency of incident wave $\omega0$ = natural frequency of atom vibration γ = damping constant of matter n = atomic density ϵ = electric permittivity of medium $\epsilon0$ = electric permittivity of vaccuum ϵ_r = real part of ϵ

		ϵ_c = complex part of ϵ **k** = wave vector $\mathbf{k}_r$ = real part of **k** $\mathbf{k}_c$ = complex part of **k** μ = magnetic permeability v = wave speed

The diagram below illustrates components that appear in the conservation laws, Snell's law and the Fresnel equations.





Ophthalmic imaging devices using light waves include the autorefractor, Pentacam, Placido discs, slit scanner, slit lamp, wavefront aberrometer, scanning laser polarimeter, slit lamp, fundoscope, surgical microscope, OCT and CT.

During my elective, I observed the autorefractor, Pentacam, surgical microscope, slit lamp, and OCT machines in action.

All modalities shine infra-red, visible, ultraviolet, or X-ray light into the eye, then detect reflected or transmitted light. Each modality employs a unique physical set-up and data-processing algorithm to obtain a unique assortment of clinical information. This might include shapes of various intraocular structures, refractive index of the eye, and the strength and axis of astigmatism.

Comparing these technologies and their subtleties while appreciating the physical principles that connect them together will be a good starting point for understanding, explaining and innovating within ophthalmic imaging.

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