Wavefront guided customised laser vision correction for UK forces

Royal Society of Medicine

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Financial Statement

Abbott Medical Optics, USA Revision Optics, (RVO) USA Oculentis Bv, Netherlands

UK forces



Night Vision Goggles

Much easier to use without glasses or contact lenses. It is especially important to correct astigmatism Not possible to use glasses or contact lenses when HALO jumping into water or during military diving operations



Contact lenses move out of position during high G manoeuvres and dry eye is an issue in unpressurised cockpits.

Courtesy Col Robert E. Smith II, USAF, MC, SFS

US Military Refractive Surgery Programme (19 Military Refractive Centres)



Courtesy Col Robert E. Smith II, USAF, MC, SFS

US Military Refractive Surgery Treatments (over 150,000)



Hammond et al, Refractive Surgery in the US Army 2000-2003

16,111 US Army 32,068 eyes treated 85.6% 6/6 92.4% 6/7.5 98.2% 6/12

93.7% rated overall readiness better than before Rx

Refractive surgery in the United States Army, 2000-2003. Hammond MD, Madigan WP Jr, Bower KS. Ophthalmology. 2005 Feb;112(2):184-90

Musa F, Tailor R, Gao A, Hutley E, Rauz S, Scott RA. Contact lens-related microbial keratitis in deployed British military personnel. Br J Ophthalmol. 2010 Aug;94:988-93.

Wearing contact lenses in hot dry places or in humid (jungle) conditions is associated with much higher risk of microbial keratitis. About 15% of microbial keratitis episodes result in loss of corneal tissue and scarring with reduced vision.

US Refractive Surgery

250 patient encounters during combat operations

60% spectacle / contact lens related

20% "Desert dust" keratitis22 patients lost glasses

15 patients contact lens ulcers

Refractive Surgery Issues Only 1 patient with PRK complication (haze)



Courtesy Col Robert E. Smith II, USAF, MC, SFS

Refractive Surgery Incidents (after Major Combat Operations)

PRK: Haze: 4 cases 3 sent home 1 treated in theatre; RTD LASIK:

Flap Dislocations: 2 cases Aerovac'd and successfully treated at Landstuhl AMC, Germany

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- Infinity focus or infinity at night
- Commonly small treatments / cylinders
- Surface treatment v LASIK

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- Issues are dry eyes, time to recovery of visual quality



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Individualised wavefront treatment

- 1. High quality wavefront data (iDesign)
- 2. Good mathematical reconstruction
- 3. Iris registration & offset control
- 4. Cosine energy adjustment
- 5. High fidelity delivery using the excimer laser
- 6. Good surgical technique

WaveScan

Untreated Cornea

Aberrated cornea



iDesign

Highdefinition sensor

5 times the data density of the previous generation sensor



1. High quality WF data

Good clean HS data

Accurate determination of the HS spot centroid

Good error checking, consistency, rejection & constringency algorithms

Good reconstruction (Fourier & Zonal > Zernike)

2. Good mathematical reconstruction



Zernike Reconstruction



Fourier Reconstruction



2. Good mathematical reconstruction



















coma



4. Cosine energy adjustment

 θ is the angle between the local beam direction and the surface normal of the cornea

$_effective = I_beam*cos(\theta)$

5. High fidelity delivery using the excimer laser

Anode

Pre-ionisation pins

Interior of laser chamber of StarS4-IR excimer Cathode laser system

5. High fidelity delivery using the excimer laser



Fourier Review Screen









Error Induced from Cyclotorsion

Angle Error (Degrees)



What Are The Differences Between Traditional & Custom WF Rx

- Non-WF custom treatment
- Subjective
- Cylinder axis not objective

Head tilt – no axis alignment

Rx based over pupil (tracker)

Wavefront-guided iris-registered Objective taking into account subjective target Cylinder axis alignment by laser software (cylotorsional alignment)

Head tilt accounted for by alignment on laser matching alignment on wavefront sensor

Rx based over pupil (tracker) capture=delivery







Julian Stevens

Optical quality of the ablation The optical zone of correction applied <u>Wavefront guided</u>





Surface Treatment v femtoLASIK

- LASIK has the risk of flap dislodgement with trauma
- LASEK once healed has minimal ocular weakening



Target Ablations

1. Wavefront Guided

- 2. Larger treatment zone to reduce sph ab
- 3. Target +0.50 D for night refractive shift and night myopia

Ablation Optical Planning Wavefront Guided





AD.





ertlicht.

Dry Eyes



- 1. Oasis 640x punctal plugs
- Preservative free hyaluronate tear drops (Clinitas 0.4%)

LASEK Technique

- 1. 20% Ethanol 15 seconds
- 2. 8.0mm epithelial clearance
- 3. Wavefront guided
- 4. MMC 0.02% for 10 seconds
- 5. AcuVue Oasis contact lens for 6 days
- 6. Preservative free post-op drops

Refractive Surgery is life changing in the civilian world but can be life saving in the military

Age

Mean 32 years Range 21 – 50 years

Male / Female

Male87%Female13%

Results

Mean Sphere

-2.5 D SE

Range

+4.0 to -8.00

Results

344 eyes treated

Mean pre-op Cyl

-0.89 dc (up to -4.50 dc)

Results

Mean post-op Sph +0.32 D (St dev +0.24 D)

Mean post-op Cyl -0.27 dc (St dev +0.27 dc)

Mean post-op SE +0.20 D SE (St dev 0.27 D SE)

Results



Results



Results

No eye lost BSCVA

Results

SF treatments were smaller on average Mean Rx -1.5 D SE (n=62)

Night Vision Spherical Aberration

Spherical Aberration







ConescentralphotopicRodsperipheralscotopic

More rods than cones (17:1) Rods 1000x more sensitive than cones

Mesopic Vision

Twilight Both cones & rods functioning

Dark Adaptation



Is the relatively greater brightness of Purkinje Shift shorter wavelengths (blue-green), compared with longer wavelengths upon shifting from photopic to scotopic vision PURKINJE SHIFT BLUE-GREEN ELLOW-GREEN 100 SCOTOPIC PHOTOPIC 510 555 RELATIVE SENSITIVITY (%) 50 RED FIL CUTOFF 111m 400 500 700 600

ROBERT E. MILLER II,

THOMAS J. TREDICI, 1992

BLUE

WAVE LENGTH IN NANOMETERS

GREEN

YELLOW

TER

RED

Is the relatively greater brightness of shorter wavelengths (blue-green), compared with longer wavelengths upon shifting from photopic to scotopic vision

Purkinje Shift



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Night myopia is when there is over-accommodation in the dark or dim light, or due to a lack of image contrast

- 1. Accommodation
- 2. Colour temperature
- 3. Infinity not 6 metres
- 4. Pupil dilation and positive spherical aberration
- 5. Paracentral vision for rod (scotopic) conditions

Night Myopia

Nevil Maskelyne 1789



Night Myopia

Accommodation

- Individually determined dark focus
- Negative lens worn for best vision
- Monocular assessment using an optometer overestimates the dark focus compared to binocular assessment

Most common optimal correction for low-light is a negative sphere for ½ the monocular dark focus

Night Myopia

Fejer TP, Can J Ophthalmol 30 1995

17% of 380 people had night myopia of 0.75 D or more (age 16-80) Age 16 to 25 is 38% 4% had night myopia of 2.50 D Assessment with Badal laser optometer Treatment with minus lenses 65% marked improvement, 26% moderate improvement

Conclusion

Hugely successful treatment programme

Subjective satisfaction exceptional

Extremely motivated individuals

Operational issue of time of downgrade

Time return to duty and return to deployment



UK forces getting rid of their glasses