A new concept in eye data acquisition and analysis of strabismus, pupil size & eyelid position

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Revisiting some measurements

Despite enormous advances in technology over the last few years we still gather some clinical data in primary care practice using techniques that have been around for a century, for example, to measure:

- Pupil size
- HVID
- Eye lid position
- Pupil eccentricity
- Eye position
Volk Eye Check is a hand held device that captures and fully automates, in real time, the analysis and display of diagnostic eye data.
• Data acquisition typically with 2 or 3 to 3 flash photographs
• Real time analysis
• Data displayed on device and instantly uploaded as pdf to medical record, tablet or PC
**Eye Check**

- **Patient Report**
  - **Patient ID**: ej
  - **Age**: 23
  - **Gender**: Female
  - **Session date**: 05/12/2014 - 14:31

- **Right pupil size**: 3.76 mm
- **Left pupil size**: 3.94 mm
- **Diff. pupil size**: 0.17 mm
- **No manifest deviation**: 0.00 mm
- **IPD (given)**: 61.00 mm
- **Right HVID**: 12.19 mm
- **Left HVID**: 12.15 mm
- **HVID difference**: 0.04 mm
- **Diff. palpebral aperture**: 0.18 mm
- **MRD R top**: 4.60 mm
- **MRD R bottom**: 5.10 mm
- **MRD L top**: 4.60 mm
- **MRD L bottom**: 4.74 mm
- **Right pupil nasal ecc.**: 0.09 mm
- **Right pupil vertical ecc.**: 0.30 mm
- **Left pupil nasal ecc.**: 0.27 mm
- **Left pupil vertical ecc.**: 0.39 mm
- **Light Level**: 67.00

**Contact Lens**

- **Patient Report**
  - **Patient ID**: EAJ3
  - **Age**: 23
  - **Gender**: Female
  - **Session date**: 10/12/2014 - 14:11

- **RIGHT**
  - **Pupil Diameter**: 4.42 mm
  - **Pupil Center To Upper Lid**: 3.15 mm
  - **Pupil Center To Lower Lid**: 5.22 mm
  - **Horizontal Visible Iris Diameter**: 12.22 mm
  - **Vertical Iris Diameter**: 11.31 mm
  - **Diagonal Iris Diameter**: 11.75 mm
  - **Corneal sag**: 2.78 mm
  - **Horizontal Pupil Eccentricity**: 0.28 mm
  - **Vertical Pupil Eccentricity**: 0.28 mm
  - **IPD**: 61.10 mm
  - **Pupil Diameter Difference**: 0.00 mm
  - **HVID Difference**: 0.00 mm
  - **Light Level**: 72

- **LEFT**
  - **Pupil Diameter**: 4.42 mm
  - **Pupil Center To Upper Lid**: 3.15 mm
  - **Pupil Center To Lower Lid**: 5.22 mm
  - **Horizontal Visible Iris Diameter**: 12.22 mm
  - **Vertical Iris Diameter**: 11.31 mm
  - **Diagonal Iris Diameter**: 11.75 mm
  - **Corneal sag**: 2.78 mm
  - **Horizontal Pupil Eccentricity**: 0.28 mm
  - **Vertical Pupil Eccentricity**: 0.28 mm
  - **IPD**: 61.10 mm
  - **Pupil Diameter Difference**: 0.00 mm
  - **HVID Difference**: 0.00 mm
  - **Light Level**: 72
Accuracy of the device

“Volk Precision Sticker”

- Accuracy of IPD $\Rightarrow < 0.5\%$ on average compared to 2 experienced practitioners
- Accuracy of HVID $\Rightarrow < 1.0\%$ on average compared to Medmont topographer
In absolute terms:

- **IPD** measurement accurate to within **0.3mm** on average compared to 2 experienced practitioners

- **HVID** accurate to within **0.1mm** on average compared to Medmont topographer
Are the eyes straight?

Assessment of eye position to detect strabismus is routinely carried out using three tests:

• **Cover test** (Clarke, 1893)
  - Requires skill – optometrist, orthoptist or ophthalmologist
  - Difficult to detect small amplitude strabismus – microtropia (AAPOS $<8^\Delta$)

• **Prism fusion test**
  - Smaller prism for infants – $6^\Delta$
  - As child gets older, can fuse larger prism powers
  - Look for fusion movements
  - Requires patient co-operation, skill and experience
  - Difficult on babies!

• **Hirschberg test** (1885)
  - Penlight is directed towards patient who is gazing in to it
  - Observation of the position of the corneal reflex (Purkinje image) relative to the centre of the pupil
Hirschberg Limitations

- **Corneal reflex** not usually positioned in the centre of the pupil but decentred due to **Angle Kappa** (sometimes called **lambda**)

- To determine the presence of strabismus, the practitioner must detect a relative difference in **corneal reflex** between right and left eyes

- Limitation of Hirschberg is that 1 mm (and perhaps 0.5mm) asymmetry is possible to discern

\[
1 \text{ mm} = 21^\Delta \quad \text{(Brodie, 1987)}
\]

Strabismus Detection and Measurement with VEC

- The present software version has a sensitivity of 84% to detect strabismus and a specificity of 98%

The next few slides show some case examples
Paediatric Case History # 1
2 year old autistic – no strabismus

• 2 year old autistic child attended for first eye examination
• Known delayed development
• Challenge to do cover test but no manifest deviation detected
• Insignificant hypermetropia under cycloplegic
• *Volk Eye Check* also showed no strabismus
• Report and *Volk Eye Check* pdf sent to GP
Patient report

Image not available

Patient ID: 34363
Age: 2
Gender: Male
Session date: 20th July 2014 - 10:56

- Right pupil size: 3.89 mm
- Left pupil size: 4.18 mm
- Diff. pupil size: 0.29 mm
- No manifest deviation: 0.00
- IPD (given): 48.00 mm
- Right HVID: 11.42 mm
Paediatric Case History # 2
5 year-old autistic with esotropia

• 5 year old autistic-spectrum male, first time eye examination after failing a routine school vision check which had reported 'one eye weaker than the other'
• Positive family history of “lazy eye”
• This patient was a challenge to examine because of his hypermobility and poor span of attention.
• Low hyperopia with mild astigmatism
• Determination of his visual acuities was inconclusive
• Near cover test suggested no manifest deviation but it was not possible to do a near prism fusion test or conventional Hirschberg
• However, *Volk Eye Check* documented presence of a small angle strabismus (9△)
• Referred for specialist orthoptic/ophthalmologist assessment
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Patient ID</td>
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</tr>
<tr>
<td>Age</td>
<td>5</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
</tr>
<tr>
<td>Session date</td>
<td>27th July 2014 - 08:56</td>
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<tr>
<td>Right pupil size</td>
<td>5.11 mm</td>
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<tr>
<td>Left pupil size</td>
<td>4.92 mm</td>
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<tr>
<td>Diff. pupil size</td>
<td>0.18 mm</td>
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<tr>
<td>Deviation</td>
<td>9.00 pd</td>
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<tr>
<td>IPD (given)</td>
<td>50.00 mm</td>
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<tr>
<td>Right HVID</td>
<td>12.18 mm</td>
</tr>
</tbody>
</table>
Paediatric Case History # 3
2 year old pseudo-strabismus

- Parents concerned that one eye “lazy”
- No family history of strabismus
- Epicanthus both eyes
- Appears straight to cover test at near
- Positive to Lang Test stereopsis 550”
- Cycloplegic refraction low hypermetrope
- 20D BIO normal fundi
### Patient Report

**Patient ID:** 29644  
**Age:** 2  
**Gender:** Female  
**Session Date:** 8th July 2014 - 12:31

<table>
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<tr>
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<tr>
<td>Right pupil size</td>
<td>3.59 mm</td>
</tr>
<tr>
<td>Left pupil size</td>
<td>3.84 mm</td>
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<tr>
<td>Diff. pupil size</td>
<td>0.25 mm</td>
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<tr>
<td>No manifest deviation</td>
<td>0.00</td>
</tr>
<tr>
<td>IPD (given)</td>
<td>46.00 mm</td>
</tr>
<tr>
<td>Right HVID</td>
<td>11.95 mm</td>
</tr>
</tbody>
</table>

**Notes:**
- The right pupil size is within the normal range.
- The left pupil size is slightly larger than the right.
- The difference in pupil size is within the normal range.
- No manifest deviation.
- The IPD (given) is within the normal range.
- The right HVID is within the normal range.
Paediatric Case History # 4
Esotropia associated with Duane

• *Volk Eye Check* used to OBJECTIVELY document size of strabismus in different directions of gaze
1. Primary Gaze

<table>
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<tr>
<th>Patient ID</th>
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<tbody>
<tr>
<td>Date of Birth</td>
<td>25/04/2009 (5y 9m)</td>
</tr>
<tr>
<td>Gender</td>
<td>F</td>
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<tr>
<td>Session date</td>
<td>27/01/2015 - 12:59</td>
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</table>

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right pupil size</td>
<td>3.54 mm</td>
</tr>
<tr>
<td>Left pupil size</td>
<td>3.50 mm</td>
</tr>
<tr>
<td>Diff. pupil size</td>
<td>0.04 mm</td>
</tr>
<tr>
<td>Deviation LE</td>
<td>17 pd</td>
</tr>
</tbody>
</table>
2. Gaze to the left

<table>
<thead>
<tr>
<th>Patient report</th>
<th>VOLK® eye check</th>
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</thead>
<tbody>
<tr>
<td>Deviation LE</td>
<td>39 pd</td>
</tr>
<tr>
<td>IPD</td>
<td>49.7 mm</td>
</tr>
<tr>
<td>Right HVID</td>
<td>11.44 mm</td>
</tr>
<tr>
<td>Patient ID</td>
<td>34990</td>
</tr>
<tr>
<td>Date of Birth</td>
<td>25/04/2009 (5y 9m)</td>
</tr>
<tr>
<td>Gender</td>
<td>F</td>
</tr>
<tr>
<td>Session date</td>
<td>27/01/2015 - 13:02</td>
</tr>
</tbody>
</table>
3. Gaze to the right
Paediatric Case History #5
Fully accommodative esotropia

- 9 year old girl with a large alternating esotropia estimated with the cover test to be $40^\Delta$.
- Previously been under the care of ophthalmologist and treated with spectacles for constant wear.
- Apart from the significant hypermetropia, the results of the eye examination were unremarkable.
- A *Volk Eye Check* session without spectacles measured the deviation to be $43^\Delta$.
- The cover test with her spectacles suggested no manifest deviation, confirmed and documented VEC.
- The child’s parents were shown the results to reassure that the spectacles eliminated the strabismus and reinforced understanding of their daughter’s condition and management.
Accommodative esotropia without Rx
Corrected with Rx

Patient report

Patient ID: 32752
Date of Birth: 25/12/2005 (9y 1m)
Gender: F
Session date: 27/01/2015 - 14:35

Right pupil size: 4.55 mm
Left pupil size: 4.72 mm
Diff. pupil size: 0.17 mm
No manifest deviation
Pupil Size

We are looking particularly for anisocoria
  • Horner
  • Adie

Most optometrists and ophthalmologists measure with a millimetre ruler BUT measuring pupil size can be difficult!

Photographs of two iris/pupil colours to illustrate difficulty in assessing the pupil/iris border, especially in darker irides
Horner Syndrome

- Sympathetic denervation
  - Preganglionic
  - Post ganglionic
- Miosis
- Ptosis
- Anhydrosis
- Heterochromic irides in congenital cases
- Preganglionic causes include lung and breast malignancy
- Postganglionic causes include neck lesions
- **Acquired cases require investigation**
Horner Case # 1
Acquired Horner secondary to neck surgery

• 59 year-old female presented 1 week following neck surgery worried about lid appearance RE
• Patient unaware of anisocoria
• Anisocoria diagnosed with Volk Eye Check
• Consultant spinal neurosurgeon informed and requested follow-up documentation

• Anisocoria increase demonstrated by changing illumination level – no need for bright and dark ?
Anisocoria at light index 85 (increased ambient lighting)
Anisocoria at light index 61 (reduced ambient lighting)
Horner Case # 2
Congenital Horner

• 5 month-old infant
• Mother concerned by left pupil appearing larger in room light
• More noticeable over last two or three months
• Emergency C-section + forceps

• Confirmed diagnosis with *Volk Eye Check*
• Documented Horner
• Referred to ophthalmologist with documentary clinical evidence
**Anisocoria 0.22 mm**

**Light level 80 (bright)**

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<td>Age</td>
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<tr>
<td>Gender</td>
<td>Female</td>
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<tr>
<td>Session date</td>
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<td>Right pupil size</td>
<td>2.66 mm</td>
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<tr>
<td>Left pupil size</td>
<td>2.89 mm</td>
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<tr>
<td>Diff. pupil size</td>
<td>0.22 mm</td>
</tr>
<tr>
<td>No manifest deviation</td>
<td>0.00</td>
</tr>
<tr>
<td>IPD (given)</td>
<td>40.00 mm</td>
</tr>
<tr>
<td>Right HVID</td>
<td>10.97 mm</td>
</tr>
<tr>
<td>Left HVID</td>
<td>10.97 mm</td>
</tr>
<tr>
<td>HVID difference</td>
<td>0.00 mm</td>
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<tr>
<td>Diff. palpebral aperture</td>
<td>0.19 mm</td>
</tr>
<tr>
<td>MRD R top</td>
<td>4.26 mm</td>
</tr>
<tr>
<td>MRD R bottom</td>
<td>4.30 mm</td>
</tr>
<tr>
<td>MRD L top</td>
<td>4.19 mm</td>
</tr>
<tr>
<td>MRD L bottom</td>
<td>4.49 mm</td>
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</table>

**Total relative ptosis OD**

\[
\text{MRD1 + MRD2} = 0.87 \text{mm}
\]
<table>
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<tr>
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<th>Value</th>
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<tr>
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<td>Gender</td>
<td>Female</td>
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<tr>
<td>Session date</td>
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<tr>
<td>Light level 66 (dim)</td>
<td></td>
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<tr>
<td>Anisocoria</td>
<td>1.04 mm</td>
</tr>
<tr>
<td>Total relative ptosis OD OD</td>
<td></td>
</tr>
<tr>
<td>MRD1 + MRD2</td>
<td>0.61 mm</td>
</tr>
</tbody>
</table>
Contact Lens Fitting

- Apart from corneal Topography /Keratometry, which parameters are important?
  - Pupil size
  - Pupil position (eccentricity)
  - VID (horizontal, vertical, oblique)
  - Corneal Sag
  - Inter-palpebral aperture
  - Distance from lower lid to pupil edge
  - Lower lid to lower limbus position
Contact Lens Module

• Visible Iris Diameter
  – Also important for buphthalmos
• Distance from pupil centre to upper and lower lid (not the same as MRD1 & MRD2)
• Pupil eccentricity
• Facility to input K’s to produce “sag” measurement

• Refines fitting procedures for CLs including multifocals and sclerals
Pacific University Study on HVID

Pacific University recently conducted a study on corneal diameter and findings indicate that 27% of contact lens fits fall outside the standard parameters and would benefit from a small or large diameter. This supports our weekly and bi-weekly modalities that are available in small (13.6) and large (14.8) diameters – Extreme H2O Weekly and Extreme H2O 54%.

27% of patients would benefit from a small or large diameter.

Reported comfort issues from 37% of patients with HVID ≤ 11.3
Reported comfort issues from 53% of patients with HVID ≥ 12.3
Pupil Eccentricity

- Not measured... until now
- Important for specialist contact lenses such as concentric and translating multifocals
Pupil Eccentricity

- Eyes with significantly decentred pupils in relation to the optical centre of the contact lenses, either due to:
  - eccentric anatomical position or
  - a poorly fitting contact lens

will suffer loss of image quality due to induced astigmatism and coma

Nasal/temporal and vertical eccentricity of right pupil in 203 patients, in mm
Pupil Diameter

• Very useful for practitioners to be familiar with the power profiles of the standard and customised lenses which they use because they will be able to fit the most appropriate design contact lenses after measuring the pupil diameter of each patient.

Simultaneous Vision Soft MF

- Most soft lens multifocal designs are manufactured with variable power with rotational symmetry about the lens centre.
- e.g., for distance vision well centred, *centre near design*
  - Purevision multifocal lens pupil > 4.8mm
  - Air Optix Aqua pupil >3.4mm

(Plainis, Atchison et al. 2013)
Contact Lens Case Histories

with acknowledgment to

Alex Levit BSc(Hons) FCOptom (CL; CVP)

Contact Lens Practitioner
& Head of Contact Lens Dept, Central Middlesex Hospital, London

Uses the Volk Eye Check routinely on all contact lens patients
Contact Lens Case History  # 1

57 year old female wearing daily multifocal contact lenses fitted elsewhere

**Spectacle Rx**  
R. +1.75/-0.75 x 120 = 6/6+2  
L. +1.50/-0.25 x 95 = 6/5  
Add +2.50DS for reading = N4 at 40cm

**Present CL Rx**  
R. +2.00DS with a high Addition RE (non- dominant eye)  
L. +1.25DS low addition (dominant eye)  
Her daily disposable MF contact lenses displace 1.5mm *temporally*  
*Volk Eye Check* shows her to have a positive angle lambda (*nasal* visual axis displacement) with *nasal* pupil displacement (0.3 mm)
<table>
<thead>
<tr>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.43 mm</td>
<td>3.54 mm</td>
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<tr>
<td>3.79 mm</td>
<td>4.26 mm</td>
</tr>
<tr>
<td>5.61 mm</td>
<td>4.99 mm</td>
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<tr>
<td>11.90 mm</td>
<td>11.90 mm</td>
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<tr>
<td>11.02 mm</td>
<td>11.02 mm</td>
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<tr>
<td>11.44 mm</td>
<td>11.44 mm</td>
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<tr>
<td>2.72 mm</td>
<td>2.70 mm</td>
</tr>
<tr>
<td>0.31 mm</td>
<td>0.26 mm</td>
</tr>
<tr>
<td>0.15 mm</td>
<td>0.15 mm</td>
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</table>

- **Pupil Diameter**
- **Pupil Center To Upper Lid**
- **Pupil Center To Lower Lid**
- **Horizontal Visible Iris Diameter**
- **Vertical Iris Diameter**
- **Diagonal Iris Diameter**
- **Corneal sag**
- **Horizontal Pupil Eccentricity**
- **Vertical Pupil Eccentricity**
Total displacement of CL optical centres
R & L 1.5mm (lens displacement temporally)
  + 0.3 mmm (pupil displaced nasally)
Total eccentricity of lens centre from visual axis = 1.8 mm
She experienced blurred vision
• Distance vision 6/7.5 Binoc
• Near vision N10

**Refitted** with PolyVue HDX multifocals TD 14.00mm
• centred well
• Rx R. +1.75DS L. +1.50DS
• Distance vision improved to 6/6
• Full reading add = reading vision improved to N5
**VEC** enabled the optometrist to the **analyse the reason for the failure** of the previous contact lenses and to determine the strategy to obtain a successful result and a happy patient.
54 year old male was seen for the first time
Low hypermetrope with minimal astigmatism
Previously been fitted unsuccessfully elsewhere with both monovision and multifocal contact lenses
Generally unhappy with his vision
Wanted a second opinion with a view to being fitted with multifocal contact lenses
VEC (Contact Lens Module) session reported large HVIDs with small pupils in normal lighting conditions.

<table>
<thead>
<tr>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.66 mm</td>
<td>2.66 mm</td>
</tr>
<tr>
<td>5.37 mm</td>
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<tr>
<td>6.16 mm</td>
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<td>12.52 mm</td>
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<tr>
<td>11.59 mm</td>
<td>11.59 mm</td>
</tr>
<tr>
<td>12.04 mm</td>
<td>12.04 mm</td>
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</tbody>
</table>

This combination of data provided clinical evidence that this patient would be unsuitable for conventional MF.

Rather than waste chair-time trying ‘off the shelf’ lenses the patient was advised custom lenses would be the most appropriate option.
Contact Lens Case History  # 3

- 27 year old myope
- Large HVID
- Large SAG
- Ks R & L 7.20/7.30
- Go straight to large TD
e.g., 8.30/15.50
CLPL GM3
Mark Ennovy Saphir (si-H)
G80 designs
Margin Reflex Distance (MRD)

The distance of the centre of the corneal reflex to superior lid margin (MRD1) and inferior lid margin (MRD2)
Why measure MRD?

• Important measure for documenting ptosis
  • Endocrinology: thyroid eye disease
  • Neuro-ophthalmology e.g. Horner

• For ptosis repair under Novitas (largest medicare carrier in USA) MRD1 must be <2mm to be medically covered
Conditions affecting MRD

• Blepharochalsis
• Dermatochalasis
• Ptosis
Blepharoptosis (ptosis)

An abnormal low-lying upper eyelid margin with the eye in primary gaze

- Left ptosis
- Lid crease is absent on the left
- The crease is up in the sulcus
- and the patient is elevating her brows
Dermatochalasis

- Dermatochalasis is a normal, physiological condition.
- It affects virtually all patients over the age of 50, to varying degrees.
- It is commonly asymptomatic and requires little intervention.
- Treatment of dermatochalasis is generally surgical – blepharoplasty.
Blepharochalasis

In contradistinction, blepharochalasis is:

• Relatively rare condition
• Characterised by recurrent attacks of eye lid oedema, usually the upper eye lids
• Pathological syndrome that can result in significant visual impairment of young, active adults

Collin et al (1979)
9 year-old boy with blepharochalasis. 
*Note “cigarette paper” skin*

From http://escholarship.org/uc/item/14g254jd
MRD Case Example #1

- Bilateral pseudophake
- Difficulty with vision
- Improves if opens his eyes very wide
- Bilateral ptosis
- Discussed surgery
LE  MRD 1 = 2.05mm
### MRD Case Example #2

- **71 year old female**
- **Referred to oculoplastics surgeon**

**Ptosis LE MRD1 = 1.85 mm**
Summary

The *Volk Eye Check* is a fully automated real time data capture and analysis device that provides an eclectic range of data.

- General optometry
- Vision therapy and orthoptics
- Contact lens practise
- Neuro-ophthalmology
- Oculoplastics
The *Volk Eye Check* is a powerful diagnostic assistance tool for all optometrists.

- **Strabismus** screening and measurement
- **Pupil** measurement and diagnostic assistant
- **Contact Lens** determines important data to
  - Save chair time in routine contact lens fitting
  - Enhance multifocal choice, design and fitting for
    - Presbyopia
    - Myopia control