Trans Epithelial Surface Ablation
A personal reflection over a collective experience

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15th International SCHWIND User Meeting
July 17-20, 2014
Vancouver, Canada
The efficacy and safety of my first 300 eyes treated with the SCHWIND ARMARIS

14th International SCHWIND User Meeting
17-20 January 2013

Dr Sajjad Mughal
Optimax Laser Eye Clinics
Birmingham
United Kingdom
City of Birmingham
World Famous Brands: 
‘a city of a thousand trades’
Introduction

Trans-PRK should appear to offer:

- One-step treatment
- Non-Touch technique
- Fast epithelial healing
- Quicker recovery
- Colleague chatter!!
The Mechanism

- Central epithelial thickness 55 µm*
- Peripheral epithelial thickness at 8 mm diameter 65 µm* (Reinstein DZ et al. J Refract Surg. 2008 Jun;24(6):571-81)
- One profile (epithelium removal + refraction)
- Epithelium removal part is refractive neutral, thus no extra refraction is induced
- Calculation based on two different ablation values per pulse; higher for epithelium
The Advantages

- Simultaneous ablation of the epithelium and the stroma to **shorten the overall treatment time**
- **Minimise corneal dehydration**
- Epithelial tissue removal can be **optimised to avoid** myopic-like corrections (−0.75 D).
- Superimposing a defined epithelial thickness profile with a refractive **aspheric ablation profile**.
- The diameter of epithelial removal can be calculated to match the ablation zone thus **decreasing the wound surface area**
- Less instrumentation (**less infection**)
The Disadvantages

- We will cover this at the end
What is known?

- Clinch et al. (1998)
  - Summit; mechanical removal optimal results

- Kanitkar et al. (2000)
  - Visx S3; no difference in healing time, less pain in alcohol assisted

- Lee et al. (2005)
  - Visx S3; No differences in pain/haze/UCVA
  - Trans-PRK yielded overcorrection

- Ghadhfan et al. (2007)
  - NIDEK EC5000; Trans-PRK yielded better outcomes

- Buzzonetti et al. (2009)
  - NIDEK CXIII: PTK mode to be safe and effective
What is known?

<table>
<thead>
<tr>
<th></th>
<th>Fadlalah</th>
<th>Aslanides</th>
<th>Luger</th>
<th>Bazet</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of eyes</td>
<td>50</td>
<td>30</td>
<td>33</td>
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<td>Mean Defocus (D)</td>
<td>-0.21 ± 0.61</td>
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<td>-0.07 ± 0.35</td>
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<td>Mean Astigmatism (D)</td>
<td>+0.43 ± 0.62</td>
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<tr>
<td>MSE (D)</td>
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<td>-0.04 ± 0.02</td>
<td>+0.07 ± 0.23</td>
<td></td>
</tr>
<tr>
<td>UDVA</td>
<td>0.67</td>
<td>0.97</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Let’s just revisit principles of PTK

- This is equal depth ablation at all positions
- So why does it induce hyperopic shift?
This is equal depth ablation at all positions.

So why does it induce hyperopic shift?

i) Central epithelium is thinner by 10µm and ablation will be 10µm deeper simulating -0.75 myopia, i.e., Inducing a +0.75D hyperopic shift.
This is equal depth ablation at all positions

So why does it induce hyperopic shift?

i) Central epithelium is thinner by 10µm and ablation will be 10µm deeper simulating -0.75 myopia, i.e., Inducing a +0.75D hyperopic shift.

ii) Reduce axial length inducing minimal hyperopic of <0.25D per 100µm of tissue ablation.
FLAT DEPTH PTK PRINCIPLES

- This is equal depth ablation at all positions
- So why does it induce hyperopic shift?
  - i) Central epithelium is thinner by 10µm and ablation will be 10µm deeper simulating -0.75 myopia, i.e., inducing a +0.75D hyperopic shift.
  - ii) Reduce axial length inducing minimal hyperopia of <0.25D per 100µm of tissue ablation.
  - iii) Peripheral loss of laser energy (~40%) results in less ablation thus enlarging the gap between central and peripheral stromal ablation.
This is equal depth ablation at all positions

So why does it induce hyperopic shift?

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ii) Reduce axial length inducing minimal hyperopia of <0.25D per 100µm of tissue ablation.

iii) Peripheral loss of laser energy (~40%) results in less ablation thus enlarging the gap between central and peripheral stromal ablation

Summation of i), ii), iii) gives +1.50D hyperopic shift
Other Considerations

- The cornea is **flatter nasally**, hence epithelial thickness unequally distributed.
- The ablation is usually on the entrance pupil centre, or the corneal vertex, or in between these two. **The thinnest point could be anywhere.**
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- The cornea is **flatter nasally**, hence epithelial thickness unequally distributed.

- The ablation is usually on the entrance pupil centre, or the corneal vertex, or in between these two. **The thinnest point could be anywhere.**

- In eyes with **large angle kappa** (hyperopes), the discrepancy between the ablation centre and the point of minimal epithelial thickness may even be larger, leading to unpredictable asymmetrical stromal excessive ablation (or OZ perimeter reduction).

- Similarly, the chances of such misalignment may be high in inferior steepening, retreatments, keratoconus. **Hence, treat on the visual axis in healthy eyes.**
PREVIOUS STUDIES: Faslallah, Aslanides, Luger

Published studies using this specific model of TransPRK on regular normal untreated non-pathologic corneas have shown NO refractive differences between laser transepithelial and mechanical or alcohol assisted epithelial removal.
Techniques in preparing cornea

Aslanides, 2012
- Iodine
- Tetracaine 0.5%
- Drape & speculum
- Full wet Merocel sponge
- 3 slow ‘painting movements’ on epithelium
- MMC for 30sec if ablation >75µm

Fadlallah, 2011
- 5mg Valium
- 1 drop oflocacin & proparacaine 3 times 5 minutes apart
- Draped & suction speculum
My Experience: Technique

- At medical review
  - Warn patient not to rub eyes whilst waiting
  - Inform staff
  - No further drops

- At time of surgery
  - 1 drop poxymetacaine 0.5%
  - Tegaderm UL
  - Speculum avoiding corneal contact
  - Exclude debris
  - ‘Step on it’
Choice of topical LA

- Proxymetacaine 0.5% induces (Birchall et al BJO 2001):
  - Less pain
  - Less reflex wetting

- Amethocaine 0.5% in SEM study (Boljka et al. BJO 1994):
  - Deposits on microvilli
  - Loss of microvilli
  - Increased desquamation
My early experience with 20 patients (mean age 26.2 (22-41))

<table>
<thead>
<tr>
<th></th>
<th>No. Of eyes</th>
<th>Mean sphere</th>
<th>Mean Cyl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-op</td>
<td>40</td>
<td>-3.59 (-2.0 to -5.25)</td>
<td>-0.40 (0 to -1.25)</td>
</tr>
<tr>
<td>TARGET</td>
<td>41% AIMING FOR EMMETROPIA 59% AIMING FOR +0.25DS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OZ SIZE</td>
<td>Mean was 6.82mm (6.3-7.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 1 month</td>
<td>34 (3 patient DNA)</td>
<td>+0.12 (0 to +0.50)</td>
<td>-0.36 (0 to -1.25)</td>
</tr>
<tr>
<td>At 3-6 months</td>
<td>32 (4 patient DNA)</td>
<td>-0.12 (+0.50 to -0.50)</td>
<td>-0.23 (0 to -0.50)</td>
</tr>
<tr>
<td>&gt;6/12</td>
<td>100%</td>
<td></td>
<td></td>
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<tr>
<td>&gt;6/6</td>
<td>75%; 6.25% patients had ‘trace haze’</td>
<td></td>
<td></td>
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My Experience: Case Study

<table>
<thead>
<tr>
<th></th>
<th>RE</th>
<th>LE</th>
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<tbody>
<tr>
<td>Pre-op</td>
<td>-3.25/ -0.50 axis 175</td>
<td>-3.50/ -0.25 axis 13</td>
</tr>
<tr>
<td>Scotopic pupil</td>
<td>8.59</td>
<td>7.69</td>
</tr>
<tr>
<td>AIM</td>
<td>+0.25</td>
<td>+0.25</td>
</tr>
<tr>
<td>0Z(mm)</td>
<td>7.50</td>
<td>7.50</td>
</tr>
<tr>
<td>TZ(mm)</td>
<td>1.56</td>
<td>1.51</td>
</tr>
<tr>
<td>TAZ(mm)</td>
<td>9.06</td>
<td>9.01</td>
</tr>
<tr>
<td>Pulse count</td>
<td>24,347</td>
<td>23,279</td>
</tr>
<tr>
<td>AD(µm)</td>
<td>137</td>
<td>133</td>
</tr>
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</table>
And another image
Significant Corneal Haze
# My Experience: Case Study

<table>
<thead>
<tr>
<th>Time</th>
<th>UCV</th>
<th>R sphere</th>
<th>R cyl</th>
<th>R axis</th>
<th>BCVA</th>
<th>Haze</th>
<th>UCVA</th>
<th>L sphere</th>
<th>L cyl</th>
<th>L axis</th>
<th>BCVA</th>
<th>Haze</th>
</tr>
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<tbody>
<tr>
<td>preop</td>
<td>-3.25</td>
<td>-0.50</td>
<td>175</td>
<td>1.0</td>
<td></td>
<td></td>
<td>-3.50</td>
<td>-0.25</td>
<td>13</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 day</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 wks</td>
<td>0.63</td>
<td>-0.25</td>
<td>-0.25</td>
<td>175</td>
<td>1.0</td>
<td>0.63</td>
<td>-0.50</td>
<td>-0.75</td>
<td>180</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 mth</td>
<td>0.79</td>
<td>0</td>
<td>-0.25</td>
<td>40</td>
<td>1.0</td>
<td>0.79</td>
<td>0</td>
<td>-0.25</td>
<td>165</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 mth</td>
<td>0.50</td>
<td>-0.25</td>
<td>-0.50</td>
<td>120</td>
<td>0.79</td>
<td>&lt;1.0</td>
<td>0.50</td>
<td>-0.50</td>
<td>-0.25</td>
<td>20</td>
<td>0.79</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>4 mth</td>
<td>0.25</td>
<td>-0.75</td>
<td>-0.50</td>
<td>90</td>
<td>0.40</td>
<td>2.0</td>
<td>0.16</td>
<td>-1.25</td>
<td>-0.50</td>
<td>155</td>
<td>0.32</td>
<td>2.0</td>
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<tr>
<td>5 mth</td>
<td>0.16</td>
<td>-2.75</td>
<td>-1.00</td>
<td>20</td>
<td>0.80</td>
<td>2.0</td>
<td>0.20</td>
<td>-2.50</td>
<td>0</td>
<td>0.80</td>
<td>2.0</td>
<td></td>
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<tr>
<td>6 mth</td>
<td>0.16</td>
<td>-1.50</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>1.0</td>
<td>0.20</td>
<td>-2.00</td>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
<td>1-2</td>
</tr>
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Now let's have a look at the collective results:

- 546 eyes from Database
- 5 surgeons
- 5 Schwind Amaris 750
- Were they all included?
Were they all included? NO
What happened?

- 147 were excluded
- Incomplete data
- Persistent DNA
- Monovision aim
- Laser setting adjustment >10%
- MMC used
Who made it?

399 eyes included

- Complete data
  - 1 & 3 months
- All myopic treatments
- Mean age 30 (18-53)
- FEMALE 54.9%
- MALE 44.1%
What was the pre-operative prescription?

- **MSE:** \(-3.88 \text{D} \pm 1.47\)  
  \((-1.25 \text{ to } -8.00)\)
- **Mean Sphere:** \(-3.58 \text{D} \pm 1.44\)  
  \((-0.50 \text{ to } -7.75)\)
- **Mean Cylinder:** \(-0.60 \text{D} \pm 0.53\)  
  \((0 \text{ to } -3.50)\)
Efficacy: SEQ Refractive Accuracy

Refractive outcome - Percentage within Attempted

89% +/- 0.5D
99% +/- 1.0D
Efficacy: Uncorrected Snellen VA

OPTIMAX

20/12.5 or better
20/16 20/20 20/25 20/30 20/40
20/50 or worse

UCVA - Percentage 'EFFICACY'

99% > 6/12
70% > 6/6
Efficacy: Uncorrected Cumulative Snellen VA
Safety: change in Snellen lines of BCVA

1% lost >2 lines of BCVA
Predictability: SEQ

Scatter: Attempted vs. Achieved SEQ 'PREDICTABILITY'

399 eyes

\( y = 0.95x \)

\( R^2 = 0.88 \)

overcorrected

undercorrected
Predictability: Change in Astigmatism

Scatter: Attempted change in CYL vs. SIRC

- 399 eyes

\[ y = 1.01x \]

\[ R^2 = 0.47 \]

OptiMax

Achieved [D] vs. Attempted Cyl [D]

overcorrected

undercorrected

y = 1.01x

\[ R^2 = 0.47 \]
Stability: of SEQ over 3 months

Achieved Correction SEQ over Time 'STABILITY'

-0.17
-0.20
-3.88

n=399

-6.00
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00

pre op 1 m 3 m

3.88

OPTIMAX
Other aspects at 3 months

- **MEAN OZ**: 6.91
- **MEAN TZ**: 8.24

**Sphere**
- -0.05 ± 0.33
  (+1.25 to -1.00)

**Cyl**
- -0.25 ± 0.25
  (0 to -1.75)

**What about corneal haze?**
Other aspects at 3 months

- MEAN OZ 6.91
- MEAN TZ 8.24

- Sphere
  - $-0.05 \pm 0.33$ (+1.25 to -1.00)

- Cyl
  - $-0.25 \pm 0.25$ (0 to -1.75)

HAZE

- 0 to 0.5: 91%
- 1: 7%
- 1.5: 1.5%
- 2.0: 0.5%
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<td>0.8</td>
<td>0.8</td>
<td>1.01</td>
</tr>
<tr>
<td>Haze (0-0.5)</td>
<td>90%</td>
<td></td>
<td></td>
<td></td>
<td>91%</td>
</tr>
<tr>
<td>Haze (1-1.5)</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
<td>7.5%</td>
</tr>
<tr>
<td>Haze (2)</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td>1.5%</td>
</tr>
<tr>
<td>Loss of 2 or more lines</td>
<td></td>
<td></td>
<td></td>
<td>5%</td>
<td>1%</td>
</tr>
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</table>
The disadvantages

- For high myopes
  - Corneal heating due to intense pulses
  - Large OZ needed if large pupils +/- high astigmatism
  - Less precise as longer surgical time

- Low myopes
  - Ensure wider OZ (7.00mm) to ablate epithelium fully

- It all depends on EPITHELIUM that we cannot measure
  - Thicker: small OZ and less AD
The disadvantages

- The thicker the epithelium the smaller the achieved OZ
- Achieved & planned OZ will match with increasing refractive power
- Wasted tissue if epithelium profile is thinner
The disadvantages

- The thicker the epithelium the smaller the achieved OZ
- Achieved & planned OZ will match with increasing refractive power
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- Epithelial thickness profile is not uniform as nasally it is more flatter
- Epithelial thickness profile may induce toricity
The disadvantages

- The thicker the epithelium the smaller the achieved OZ
- Achieved & planned OZ will match with increasing refractive power
- Wasted tissue if epithelium profile is thinner
- Epithelial thickness profile is not uniform as nasally it is more flatter
- Epithelial thickness profile may induce toricity
- A decentred epithelial thinnest point could induce coma and astigmatism up to 0.75D
- Laser treatment on the corneal vertex or EP may not match thinnest profile, thus treat on VISUAL AXIS
Schwind ‘rule of thumb’ recommendation from Mosquera et al. (BJO, 2013) for MYOPIA

- Below −1.00 D TransPRK not be used
- −1.00 D and −2.00 D, OZ of 7.3 mm
- −2.00 D and −3.00 D OZ of 6.8 mm
- Above −3.00 D OZ of at least 6.3 mm
Schwind ‘rule of thumb’ recommendation from Mosquera (BJO, 2013) for HYPEROPIA

- $< +1.50\text{D}$, no TransPRK

- $+1.50\text{D}$ to $+3.00\text{D}$, OZ of $7.2\text{mm}$

- $> +3.00\text{D}$ an OZ of at least $6.7\text{mm}$. 
My Experience: Exclusion criteria

- **Refractive**
  - -1.50DS or below & SEQ -8.00D or more.

- **Optical**
  - Poor oily tear film/poor wetting

- **Clinical**
  - Previous corneal surgery
  - Previous Keratitis or current epithelial disease
  - Dense scars within intended OZ
  - Inferior steepening on scans
  - Basement Membrane dystrophy
My biggest concerns

- The appearance of **uneven epithelial surface** following topical LA
  - Optimal way to prepare and reduce mechanical trauma
  - Should I convert to LASEK/PRK?
  - Negate benefit of corneal wavefront
- **Large pupil** sizes
- **Smallest OZ** possible
  - Particularly in higher myopes
- **Energy profile** of the ablation
- How **chilled** should the irrigation be
- Are **longer ablation times** a disadvantage
Is there room for improvement?

- Well yes, I think so
- Sir James Watt improved the steam engine
  - Rotary motion (1781)
  - Double-acting engine (1782)
  - Centrifugal governor for automatic control of the engine's speed (1786)
Thank you!

- 'I’m here, I’m here, what are you waiting for!