Cyclotorsion Outcomes With Bausch & Lomb Dynamic Rotational Eyetracker

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Cyclotorsion

- Rotation of the eye from seated to supine position
  - Non dynamic cyclotorsion
- Rotation of the eye during the LASIK procedure
  - Dynamic cyclotorsion

Rotation of the eye during the LASIK procedure

- Can only be compensated by the dynamic eyetracker which continually aligns the eye image to the eye under the laser
- e.g. Iris Recognition (IR) technology with active eyetracker from Bausch & Lomb

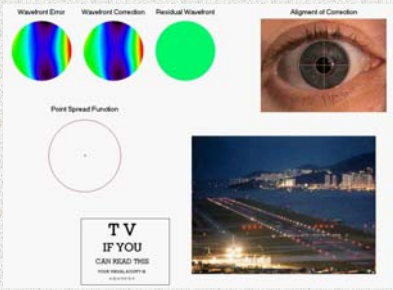
B&L Rotational Eyetracker

- The continuous automatic recognition process (25Hz) then provides information on the actual valid angle of rotation.
- The time delay for the last valid image is 0.8 sec
- 25 hz and 0.8 sec is more than enough since the eye does not rotate very quickly

Amount of cyclotorsion during LASIK

- For every degree of misalignment there is 3.3% loss of cylinder correction
- For a 6D astigmatic correction, if treatment is off axis by 5 º one would under correct the patient by 1.05D
- Bara S. and Guirao A. found in their studies that significant Higher Order aberrations could be induced if cyclorotational misalignment of 2º or greater occur

•Guirao A, Williams DR, Cox IG. Effect of rotation and translation on the expected benefit of an ideal method to correct the eye's higher-order aberrations. *J Opt Soc Am A*. 2001;18:1003-1015.
•Bara S, Mancebo T, Moreno-Barriuso E. Positioning tolerances for phase plates compensating aberrations of human eye. *Appl Opt*. 2000;39:3413-3420.



How is the Procedure Done?

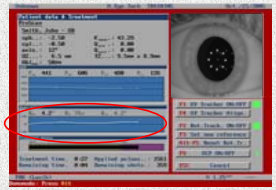
Rotational Eyetracker

Only Static RET : compensates rotation between upright position and supine (using Zywave image as reference)

Only dynamic RET : compensates intraoperative rotation (using reference image only of the laser starting when confirming X/Y log in)

Complete RET (static + dynamic) : compensates total torsional error without a gap beginning at the Zywave until end of ablation (using both kind of references images)

Throughout the laser procedure, the actual valid angle of rotation was displayed as a graph on the computer screen



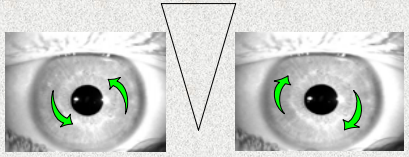
The maximum and minimum positions represented the largest and smallest deviation from the zero position respectively

Incyclotorsion vs. Excyclotorsion

- During data analysis all +ve values indicated the eyes were rotated incyclotorsionally and all –ve values indicated the eyes were rotated excyclotorsionally.

Cyclotorsion during LASIK Surgeon view

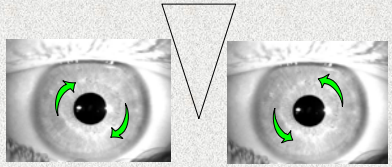
Incyclotorsion (+ve value)



LE RE

Cyclotorsion during LASIK Surgeon view

Excyclotorsion (-ve value)



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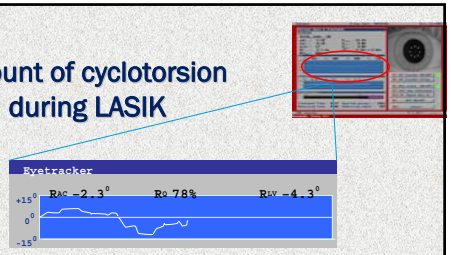
Amount of cyclotorsion during LASIK



R_{AC}: actual measured angle.

R_Q: safety factor for the actual measurement. (Limit for successful recognition 63%)

R_{LV}: last valid rotation angle. (max. valid 0,8 sec)

Shows development of rotation angle during treatment.

Outcomes of cyclotorsional study

- 81 consecutive patients, 159 eyes (81 RE, 78 LE)
- The corneas were marked on the slit-lamp before surgery
- The eyes are then aligned in accordance to the reference markings on cornea
- The amount of cyclotorsion during treatment was recorded as the maximum, minimum and the most frequent position

Amount of cyclotorsion during LASIK - Results

Amount of cyclotorsion

- The total amount of cyclotorsion ranged from 0.0 º to 13.4 º (mean: 2.35 ± 1.60)
- The most frequent position ranged from 0 º to 12.7 º (mean: 2.33 ± 2.97)
- The patient with most frequent position of 12.7 deg will have a cylinder undercorrection of 42%!

Amount of cyclotorsion during LASIK - Results

Incyclotorsion (InC)

- 42 eyes (26.4%, 14 right eyes and 28 left eyes) exhibited InC ranged from 0 º to +14.1 º.
- The total amount of InC ranged from 0 º to 7 º (mean: 2.37 ± 1.69).
- The most frequent position ranged from 0 º to 12.7 º (mean: 2.33 ± 2.97).

Amount of cyclotorsion during LASIK - Results

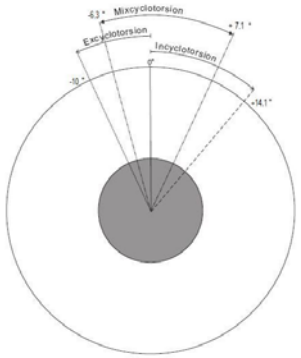
Excyclotorsion (ExC)

- 60 eyes (37.7%, 38 right eyes and 22 left eyes) exhibited ExC ranged from 0.0 º to -10.0 º.
- The amount of ExC ranged from 0.2 º to 6.3 º (mean: 2.14 ± 1.25).
- The most frequent position ranged from 0.0 º to -8.6 º (mean: -3.04 ± 2.41).

Amount of cyclotorsion during LASIK - Results

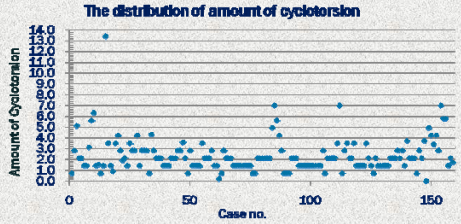
Mix-cyclotorsion (MixC)

- 57 eyes (35.8%, 29 right eyes and 28 left eyes) exhibited cyclotorsion in both directions and ranged from -6.3 º to 7.1 º.
- The amount of cyclotorsion in this group ranged from 1.4 º to 13.4 º (mean: 2.56 ± 1.85).
- The most frequent position ranged from -5.3 º to 1.4 º (mean: -0.06 ± 0.84).

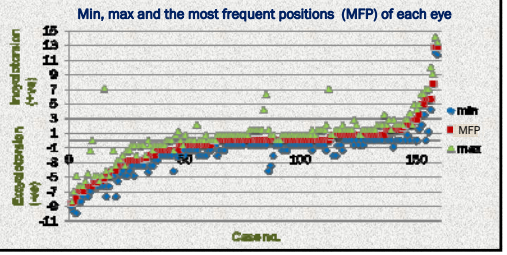


Range of Cyclotorsion

Amount of cyclotorsion during LASIK - Results



Amount of cyclotorsion during LASIK - Results



Amount of cyclotorsion during LASIK - Results

Summary of results

	Incyclotorsion			Excyclotorsion			Mix cyclotorsion		
	range	mean	STD	range	mean	STD	range	mean	STD
The most frequent position	0 - 12.7	2.33	±2.97	-8.6 - 0	-3.04	±2.41	-5.3 - 1.4	-0.05	±0.83
Amount of cyclotorsion	0 - 7	2.36	±1.68	0.2 - 6.3	2.13	±1.25	1.4 - 13.4	2.56	±1.84

Undercorrection of Cylinder

- One incyclotorsion eye remained at 12.7 deg most of the time – cylinder will be undercorrected by 42%
- One excyclotorsion eye remained at -8.6 deg most of the time – cylinder will be undercorrected by 28%

Amount of cyclotorsion during LASIK - Discussion

- There is eye rotation during LASIK treatment. The mean amount of cyclotorsion during LASIK was 2.351 ± 1.604
- The position of the eyes before the laser started was not necessarily the same as it was when the eyetracker was activated
- Active rotational eyetracker is important and useful in compensation of eye rotation through out the treatment procedure and hence increase the accuracy of the treatment(can be up to 13 deg!)

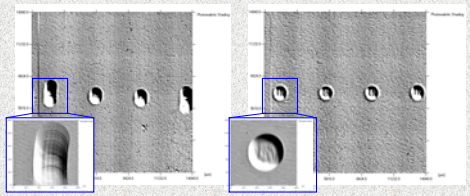
Amount of cyclotorsion during LASIK - Discussion

- It is important to take this deviation into account especially when treating high cyl patients or wavefront/topo guided treatment
- Even for eyes without high cyl. or HOA (e.g. pure sphere), cyclotorsional movements during the laser procedure can induce HOA

Dynamic Rotational EyeTracking (DRET)

Verification on Plastic:

The pattern created by the applied pulses was analysed by a surface analysis system.



DRET – Summary & Conclusion

- The combination of static cyclotorsion compensation together with dynamic rotational eye tracking provides a complete torsional tracking module.
- Intraoperative torsional misalignment can lead to significant induction of aberrations.
- Dynamic torsional tracking is not only important for high astigmatic or wavefront driven treatments, but also for rotational symmetric treatments (pure spheres or aspheric ablations).

Thank You

Dynamic Rotational EyeTracking (DRET)

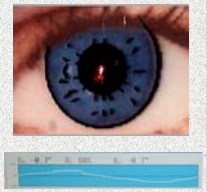
Technical Feasibility:

Special objects have been developed using plastic plates including iris structures.

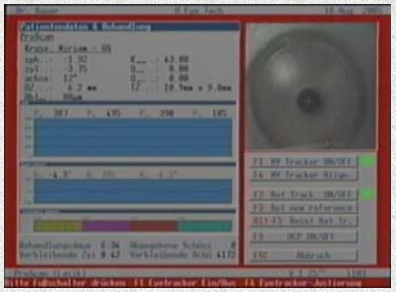
The rotational tracker has been logged on the iris pattern and a defined pulse sequence has been applied to the plastic objects.

Intraoperative movement including torsion was simulated manually by rotating the plates.

Created surface has been analysed.



Surgical Procedure



Amount of cyclotorsion during LASIK - Results