Customized laser surgery and CXL: Theory and clinical practice

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Define customised in 2008?

- Wavefront guided?
- Topography guided?
- Wavefront-optimised?
- Asphericity adjustment?
- Adjustment to pupil size?
- Adjustment to angle kappa?
- Customised flap (Intralase)?
- Customizing cornea biomechanics with cross-linking?

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Same pt other eye RMSH improved from 1.2 to 0.36 (!) LCS improved from C3 to C7 (!)
Wavefront-guided Enhancements Using the WaveLight Excimer Laser in Symptomatic Eyes Previously Treated With LASIK

A. John Kanellopoulos, MD, Lowrence H. Pe, MD

PURPOSE: To evaluate the clinical outcome using wavefront-guided enhancements using the WaveLight ALLEGRO system (WaveLight Medical, Inc., Munich, Germany). The purpose of this study was to evaluate the safety and efficacy of wavefront-guided enhancements using the ALLEGRO system.

METHODS: Twenty-six symptomatic eyes that underwent LASIK were evaluated. The WaveLight ALLEGRO system was used to perform enhancements on the excimer laser treatment. The enhancements were performed using the ALLEGRO system and were evaluated for the presence of improvements in symptom-free vision.

RESULTS: Twenty-six eyes of 26 patients underwent wavefront-guided enhancements. The results showed an improvement in symptom-free vision in all patients. The mean symptom-free vision improvement was 1.4 logMAR units.

CONCLUSIONS: Wavefront-guided enhancements using the WaveLight ALLEGRO system are safe and effective in improving symptom-free vision in patients with symptomatic vision.

PAINS AND METHODS

Twenty-six symptomatic eyes that underwent LASIK were evaluated. The WaveLight ALLEGRO system was used to perform enhancements on the excimer laser treatment. The enhancements were performed using the ALLEGRO system and were evaluated for the presence of improvements in symptom-free vision.

The source of this report is the American Academy of Ophthalmology.
Accommodation

Spherical Aberration During Accommodation for Different Eyes

Fig 10 Overall spherical aberration becomes more negative as the eye accommodates.
Center of pupil change with dilation (mydriasis)


If the wavefront is captured in **dim light and** referenced to the pupil center...

**Accurate before surgery**

Your wavefront ablation will be applied to the wrong area. Here, a **260 micron shift** in pupil center is seen!

But your ablation is in **bright light and** centered on the pupil....
Topography-guided Custom Retreatments in 27 Symptomatic Eyes

A. John Kanellopoulos, MD

ABSTRACT

PURPOSE: To evaluate the efficacy of topography-guided enhancements for subjects who relapsed after initial treatment.

METHODS: This prospective, non-comparative, single case series evaluated 30 eyes (27 patients) who underwent topography-guided retreatment with the ALLEGRETTO WAVE platform. Preand postoperative values were assessed using the Wavescan Topography System (WVSS). Retreatment efficacy and safety were evaluated using various clinical and visual outcomes.

RESULTS: The mean subjective error was 0.40±0.33 μm. The mean subjective improvement was 0.22±0.13 μm. The postoperative visual acuity was 0.02±0.02. The mean postoperative manifest refraction was 0.01±0.08.

CONCLUSIONS: Topography-guided retreatments may be effective in correcting the quality of vision. The patient had to be selected as a possible candidate for surgery due to spherical aberrations measured by WVSS.

APPROXIMATELY 5% TO 25% OF REFRACTIVE PROCEDURES RESULT IN A LESS THAN SATISFACTORY OUTCOME POST OPERATOR. ALTHOUGH SOME PATIENTS TEMPORARILY HAVE SOME FORM OF IRREGULAR ASYMMETRY, INDUCED BY SCARRING OR SCLERAL DISEASE, THE EYES' OPTICAL QUALITY REMAINS ALTERED. TOPOGRAHY-GUIDED RETREATMENTS PROVIDE A POTENTIAL OPTION TO CORRECT WITH STANDARD TREATMENTS BECAUSE OF THEIR MORE REGULAR NATURE AND THE OPTION TO ADJUST THEIR POSTOPERATIVE ASYMMETRY.

PATTERNS AND METHODS

This study was a prospective, single case series of 30 eyes (30 patients) who underwent topography-guided retreatment with the ALLEGRETTO WAVE platform (WaveLight, Inc., Irvine, CA). The mean age was 30 years (range, 18-54 years). The mean preoperative subjective error was 0.40±0.33 μm. The mean preoperative subjective improvement was 0.22±0.13 μm. The mean postoperative subjective improvement was 0.02±0.02. The mean postoperative manifest refraction was 0.01±0.08.

CONCLUSIONS: Topography-guided retreatments may be effective in correcting the quality of vision. The patient had to be selected as a possible candidate for surgery due to spherical aberrations measured by WVSS.

An estimated 5% to 25% of refractive procedures result in a less than satisfactory outcome postoperatively. Although some patients temporarily have some form of irregular asymmetry, induced by scarring or scleral disease, the eyes' optical quality remains altered. Topography-guided retreatments provide a potential option to correct with standard treatments because of their more regular nature and the option to adjust their postoperative asymmetry.

Patients with previous myopic or hyperopic laser surgery who were dissatisfied with their quality of vision and either had residual myopia, hyperopia, or mixed astigmatism were included in the study. The indications were: 1) small amounts...
Enlarging myopic optical zone:
Initially -10, 505µ LASIK: 4,5mmOZ, 125µ flap M2->plano ^BCVA 2 lines, but night halos

Topo-guided Tx to enlarge OZ to 6mm and adjusting Q value to -1.46

Initially halos gone,

Refraction: -1.25!
Post-trauma irregular astigmatism
Old K perf, s/p CE, IOL, s/p LASIK for +2.00 now -1.50 -250 160 irregular BCVA 20/40+
Topo-guided, Q adjustment to -0.3

Postop: UCVA 20/30, BCVA 20/25

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Post-surgery irregular astigmatism

Complicated CE-Aphakia-Artisan IOL-in an old LASIK pt
P -350 90 BCVA 20/60
Postop +0.50-0.50 90 UCVA 20/25
Re-centering OZ,
smoothing irregularities (Loss of K sliver in recuts)
Centering optical zone-hyperopia

Initially: +3.50 -3.00 180, post LASIK:+1.00-1.25 70 UCVA: 20/40 BCVA 20/25 pTOPOG: plano -0.25 UCVA 20/20
Enlarging optical zone-RK

10 year post-RK, Post-LASIK: +2.50 -1.50Cyl, debilitating night vision. P topo-guided -0.50 -0.50 marked improvement

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Enlarging optical zone-
Hyperopia

S/p LASIK for +4.50, now +1.00 and night vision
down C3, s/p topo-guided CS=C7

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Post-keratitis irregular astigmatism

Patient with old severe Cornea ulcer and paracentral flattening
-3.50-2.00 irregular cyl UCVA 20/200 to 20/25
BSCVA from 20/40- to 20/25
Treatment axis is centered on the visual axis and not pupil center.
Is Angle kappa significant in hyperopes?

- Measurement of angle kappa with synoptophore and Orbscan II in a normal population
  - Hikmet Basmak, MD\(^1\); Afsun Sahin, MD\(^2\); Nilgun Yildirim, MD\(^3\); Thanos D. Papakostas, MD\(^4,5\); and A. John Kanellopoulos, MD\(^4,5\) 2007 J Refract Surg-in
- There is a significant correlation between positive refractive errors and large positive angle kappa values. Refractive surgeons must take into account angle kappa especially in hyperopic patients in order to avoid complications related to decent ration of ablation zone.
Angle kappa adjustment topo-link

These figures depict the same planned excimer profile for the correction of hyperopic astigmatism on the left: centered on the pupillary center and on the right: adjusted by topography to take into consideration and adjust for angle kappa.
Keratoconus post LASIK: UCVA 20/400, removal of INTACS and then UVA. Post-op to 20/80
Dear Editor,

I report a patient who had post-LASIK ectasia and was managed in a novel fashion, without keratoplasty.

A 26-year-old male underwent uncorrected LASIK 3 months ago. Little detail was available from the patient and the surgeon. His original uncorrected visual acuity (UCVA) before LASIK was 20/40, and his spectacle-corrected visual acuity (BCVA) was 20/20 with correction of -2.00/-1.50/0.50. Initially, after the LASIK procedure, the patient reported that vision was good. During the following months, vision in that eye deteriorated. The original LASIK surgeon diagnosed ectasia and recommended the placement of Intacs (Addition Technologies, Del Plano, IL). After Intacs placement, vision did not improve, and the patient developed severe night vision issues.

One month after Intacs, the patient underwent photorefractive keratectomy (PRK) as the next step, and the patient came for a second opinion for PK 11 months after the original LASIK procedure and 3 months after Intacs implantation. Corneal topography is shown in Figure 1. The central corneal thickness was 410 µm, and the endothelial cell count was 2758 cells/mm² (Concan, Boston, MA). I discussed with the patient the following:

1. The poor long-term experience with Intacs in post-LASIK ectasia that I have reported.1
2. The benefits and risks of PK.
3. Combined ultraviolet radiation and riboflavin treatment to achieve collagen cross-linking and biomechanical stabilization of the ectasia.

After informed consent was given, I removed the Intacs. Two weeks later, I treated the ectatic cornea with a single application of combined ultraviolet radiation and riboflavin treatment to achieve collagen cross-linking at 3.0 mW/cm² for 30 minutes (KeraSure, dissolve, Menicon Srl, CA) combined with the use of 0.1% riboflavin ophthalmic solution in 20% dextrose 1:500.

The treatment was performed after 20% alcohol-assisted epithelial removal. The riboflavin solution was then applied for approximately 2 minutes to soak the stromal bed and protect the iris, crystalline lens, and retina from the ultraviolet A irradiation, and then 1 drop every 2 minutes for a total of 30 minutes. A bandage contact lens was placed onto the cornea for 5 days and the patient treated with topical corticosteroid (Fluocinolone Acetate 0.1%, Ocular, Allergan, Irvine, CA) and prednisolone acetate 1% (Pred Forte, Alcon, Allergan) 4 times a day for 10 days.

At 3 months, his UCVA improved from 20/400 to 20/70 and his BCVA from 30/200 to 20/40. Refraction changed from -3.00/-3.00/120 to -0.03/-0.50/113, and corneal topography changed as seen in Figure 1. The stability of these parameters and the corneal topography between months 1 and 3 of this treatment encouraged me to proceed with topography-guided photorefractive keratectomy (PK) to reduce the irregular astigmatism and try to provide the patient with a visual acuity not requiring the use of spectacles or a soft contact lens.

The central thickness at that point of 420 µm enabled a PK of his full spectacles correction with a topography-guided customized ablation on top of the LASIK flap (TCAT software, Wavefront excimer laser, WaveLight, Erlangen, Germany). At the first post-PK week, UCVA was 20/20 and BCVA 20/20, with a refraction of +0.50/-0.50/160. There was no corneal endothelial cell change. It is now 24 months after the operation and the patient enjoys UCVA of 20/20, although there are some mild night vision problems. Postoperative corneal topography is shown in Figure 1.

The most frequent management for post-LASIK ectasia has been PK.2 Previous reports of the use of combined ultraviolet radiation and riboflavin treatment to achieve collagen cross-linking mention a slowing down of keratoconus.3 We have reported the management of severe corneal irregularity with topography-guided treatments.4 This is the first report of management of post-LASIK ectasia with combined ultraviolet radiation and riboflavin treatment to achieve collagen cross-linking followed by conventional PK for visual rehabilitation. The apparent corneal stabilization, along with the successful visual rehabilitation, suggests that this approach may have a wider application as an alternative to therapeutic PK.5

Larger comparative studies and longer follow-up are obviously necessary to validate the long-term efficacy of this combined ultraviolet radiation and riboflavin treatment followed by a surface excimer laser treatment. Nevertheless, the refractive and topographic stability for 2 years appears to validate this minimally invasive treatment of corneal keratoplasia and leads me to believe that it may have an even wider application in the near future.

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References

Figure 1. Display of topography. 1. Corneal topography of the same eyes: left eye by the author, with central incision made and multiphase flattening as an effect of the lasers that were present. At this point, both spectacles-corrected visual acuity (BCVA) is 20/20. 2. Corneal topography 2 months after the removal of Intacs and 1 month after combined ultraviolet radiation and riboflavin treatment to achieve collagen cross-linking. The central curvature is still present, and the effect of the lasers present relative to the previous image is apparent mostly at the mires, which appear more visible. At this point, BCVA is 2/20. Bottom center. An enhanced central topographic ablation pattern at a laser treatment plane of the topography-guided procedure. It is noticeable that the ablation pattern is highly irregular, with a deeper ablation plane just anterior to the central mires, which number. However, the central incision is visible in the previous topography. 3. Corneal topography 9 months after topography-guided photorefractive keratectomy. The central cornea appears more regular and much flatter. At this point, BCVA and UCVA are 20/20 - Bottom left. Comparison map depicting the result of ablation of central topography (4 central mires) from central topography (1 area of the complication when we encountered it). Importantly, the difference resembles the topography-guided ablation pattern (bottom center), demonstrating effectively the symmetry of the treatment in reducing the pathological corneal irregularity, which, we believe, contributed to the dramatic improvement in BCVA.

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keratoconus

27 y/o left eye is treated and the right observed over 3 years
Collagen Cross-Linking (CCL) With Sequential Topography-Guided PRK
A Temporizing Alternative for Keratoconus to Penetrating Keratoplasty

A. John Kanellopoulos, MD††† and Perry S. Binder, MS, MD§

Purpose: To assess the effectiveness of ultraviolet A (UVA) irradiation-induced collagen cross-linking (CCL) on keratoconus (KC) progression.

Methods: A patient with bilateral, progressive KC underwent UVA irradiation (3 mW/cm² for 30 minutes) after topical 0.1% riboflavin drops over a debrided epithelial flap. Twelve months later, a topography-guided penetrating keratoplasty (PKR) was performed in 1 eye for a refractive error of −3.50 − 4.00 × 35° by using an attempted treatment of −2.50 − 3.00 × 135°. At all postoperative follow-up visits to 18 months, uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), keratometry, and topography were performed.

Results: In the treated left eye, the UCVA after the UVA CCL improved from 20/100 to 20/20, and the BSCVA improved from 20/50 to 20/40. Eighteen months after the topography-guided PKR, the UCVA was 20/20, and the BSCVA was 20/15, with a refractive error of −0.90 − 9.50 × 150°. The cornea was clear, and the endothelial cell count remained unchanged. The untreated right eye continued to progress during the same period.

Conclusions: The significant clinical improvement and the apparent stability of more than a year after UVA CCL, and subsequent PKR compared with the untreated mate eye, seems to validate this treatment approach for KC. An adjusted treatment may be considered in the ablation of cross-linked cornea tissue to avoid perforations.

Keywords: keratoconus, corneal stromal, surgical management, collagen cross-linking, ultraviolet A, riboflavin, topography-guided corneal ablation, visual rehabilitation.

CASE REPORT
A 26-year-old male patient had been treated with permeable contact lenses for 8 years before his presentation. Because of debilitating giant papillary conjunctivitis, he was no longer able to wear the contact lenses and was unable to provide functional vision.
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Cumulative average data

myopia and cylinder change following UVA CCL
A 24 y/o pilot

Pre: UCVA 20/200
-4.5 -1.50 X 180 20/30

2 months post: UCVA 20/20
-0.25 -0.75 X34

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16 months after the CCL
A partial custom PRK
An argument against PK?
Pre: UCVA: CF
-10.50 -3.5 X170 20/50
Post: UCVA 20/400
-9 -1.50 X75 20/25 uses SCL -7D

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Custom partial PRK and CCL
0.1% riboflavin + 7mW/cm² X 15 minutes
Conclusions

- The laser treatment—when employed conservatively—appears to add significantly to the "normalization" of the cornea surface,
- and the improvement in UCVA and BSCVA. As a result, cornea transplantation was avoided in most cases as means of treatment.
Conclusions

• Our experience additionally suggests synergistic effect when the two modalities (laser and CXL) were combined.
• Minor complications included post-op haze and delayed epithelial healing. There were minimal cases registered that failed to stabilize.
• In our experience the Alcon/Wavelight topography guided platform has been very effective in predictably offering cornea normalization and enhanced visual function.
Conclusions

• Laser surgery and CXL may be combined in order to visually rehabilitate eyes with progressive ectasia following LASIK and keratoconus.

• Larger studies and longer follow-up are necessary to validate these data.

• Hope this is better