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Advanced Optical Analysis of Ophthalmological Nd:YAG Laser Treatments

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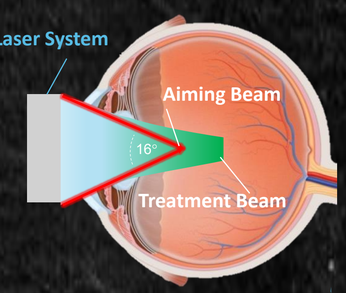
Background

The 1064 nm Nd:YAG laser that is routinely used in ophthalmology for intraocular surgery is in fact invisible. Typically, a pair of intersecting auxiliary diode-lasers with a visible wavelength of 635 nm, are used for aiming. Ideally their intersection coincides with the waist of the Nd:YAG laser. However, due to dispersion in the ocular tissue - and in the high-power diverging lens placed adjacent to the eye - the differing wavelengths result in progressive deviation between the two focal points. This problem becomes especially significant for posterior segment laser treatments, threatening the success rate and the safety. Accurate feedback on the location of the surgical laser's focal point would increase clinical accuracy in such treatments, avoiding potential complications.

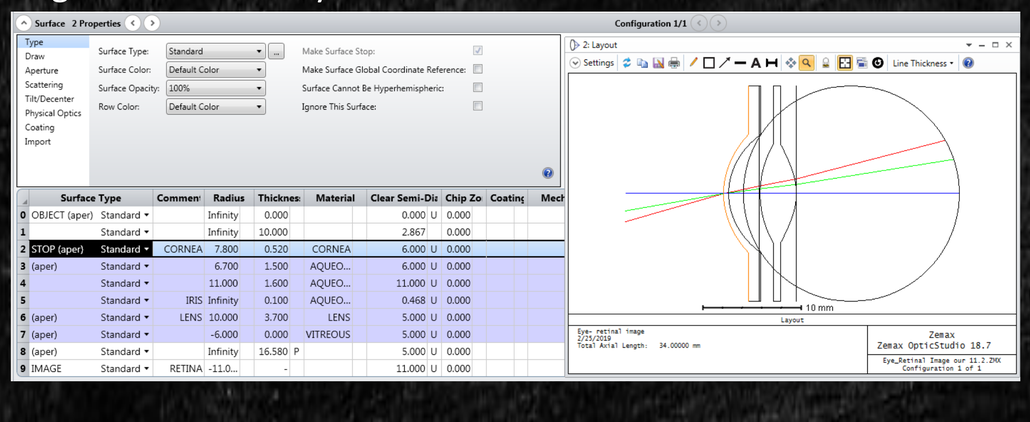


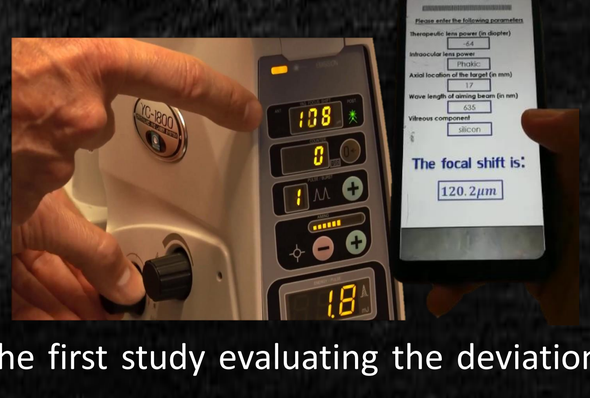
Objectives

This work set out to calibrate the positioning system of an Nd:YAG laser device for use in treatments in the posterior portion of the eye.

Methods

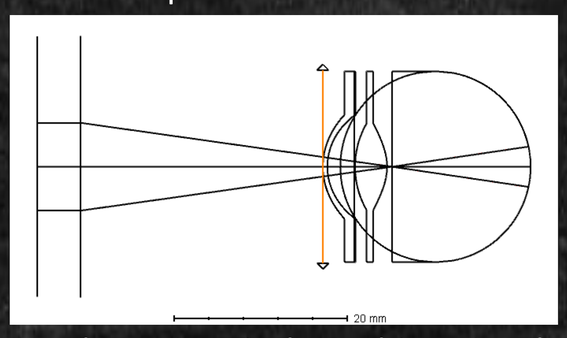
Hospital and laboratory studies were performed to characterize the Nidek YC-1800 Nd:YAG laser apparatus together with the Volk-Goldman Goniofundus lens. A computerized ray-tracing model was then created (using Zemax OpticStudio) to simulate optics in the eye and assess the difference between the focal points of the two beams. Analysis of ocular (sphero-)chromatic aberration was key. A calibration calculator was developed for the therapists' use which computes the focal deviation in each region within the eye.

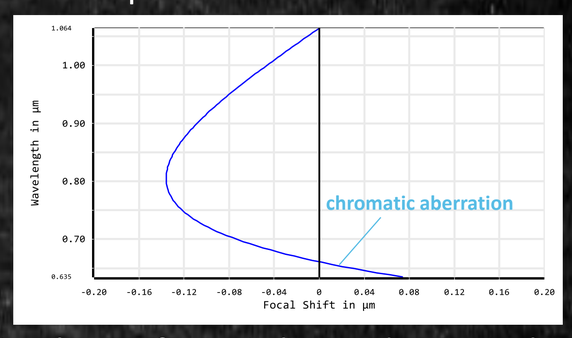




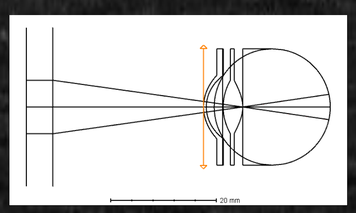
Results

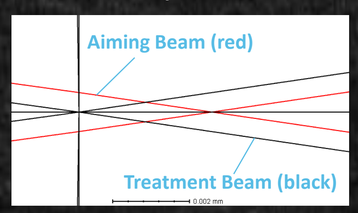
The focal points of the beams converge at 8 mm posterior to the cornea.

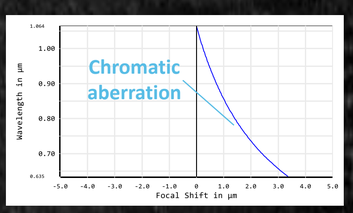




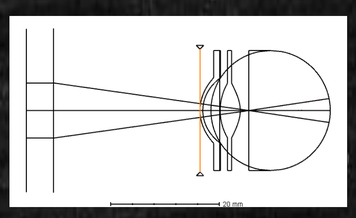
Further posteriorly to this point the aiming beam focus is located anteriorly to the Nd:YAG laser beam treatment plane.

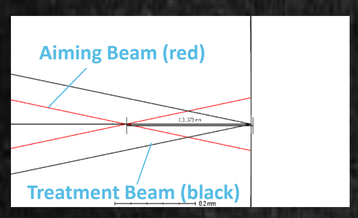


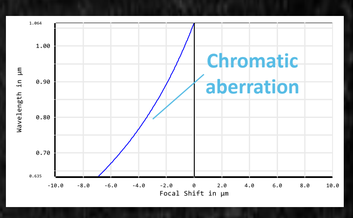




However, anteriorly to that point, 8 mm behind the cornea, the relationship between the laser beams is reversed and the aiming beam is actually located posteriorly to the Nd:YAG laser focal point.

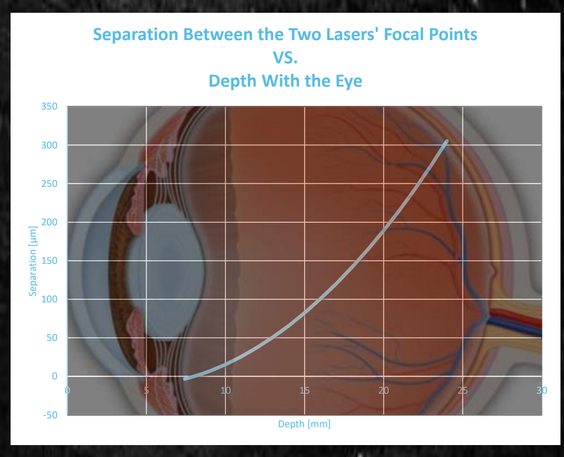






A table summarizing the separation between the focal point of the Nd:YAG laser beam and the point of coincidence of the aiming beams (left column), as a function of the distance from the device (Nd:YAG beam exit port) to the surface of the eye surface (middle column), and of the depth of the (nominal) focal point within the eye (right column). The focal length of the exit port is fixed so the depth within the eye is controlled by the distance from the device to the eye - retracting the device increases the distance and moves the focus to shallower depth.

Separation	Device Distance to Eye	Depth Within Eye
-3.363	28.58	7.42
-0.07442	28.00	8.00
3.2	27.50	8.50
6.88	27.00	9.00
15.45	26.00	10.00
25.64	25.00	11.00
37.42	24.00	12.00
50.8	23.00	13.00
65.77	22.00	14.00
82.33	21.00	15.00
100.5	20.00	16.00
120.2	19.00	17.00
141.5	18.00	18.00
164.5	17.00	19.00
189.1	16.00	20.00
215.4	15.00	21.00
243.5	14.00	22.00
273.4	13.00	23.00
305.3	12.00	24.00



Current Nd:YAG laser devices enable the operator to modify the focal point. This option allows the results of the study to be easily implemented by positioning the focal point accordingly.

Conclusions

To our knowledge this is the first study evaluating the deviation between the target predicted by the guidance beams and the actual focus of the Nd:YAG laser. The calibration calculator can be easily used to accurately adapt the laser device to the posterior region.