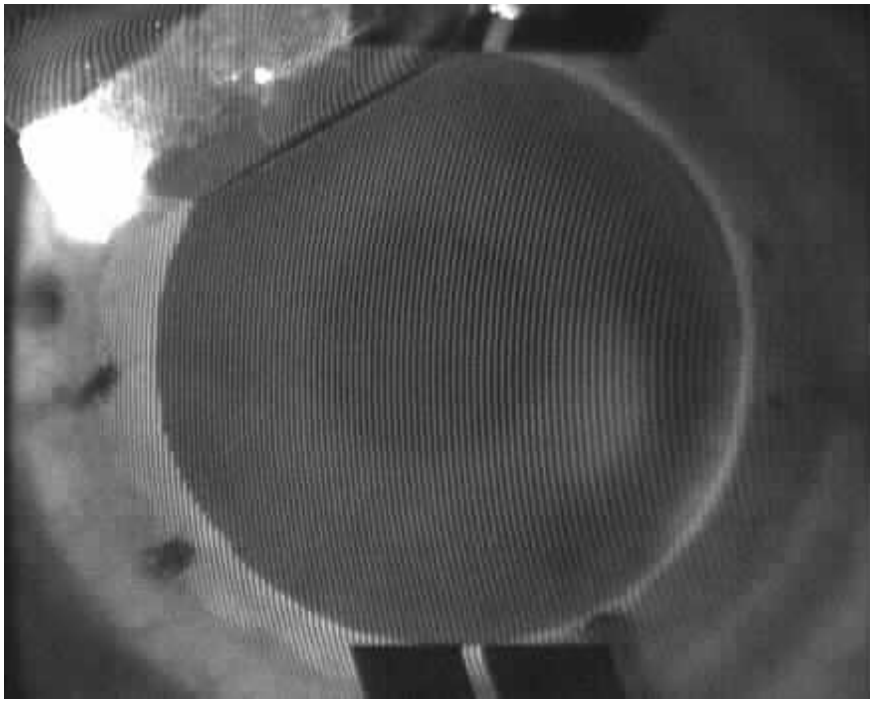

Results of the 2nd intraoperative topometries during refractive operations of

BioShape

Asclepion

by S.Schründer, MS (BioShape)

September 2000

Table of contents

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1 Patients and Methods

In this study we included another two patients. The following table gives the specific data for them.

Patient Initials	Prescription D	Optical Zone [mm]
JG	+3.0 +1.75/70°	6
CW	+3.25 +1.5/80°	6

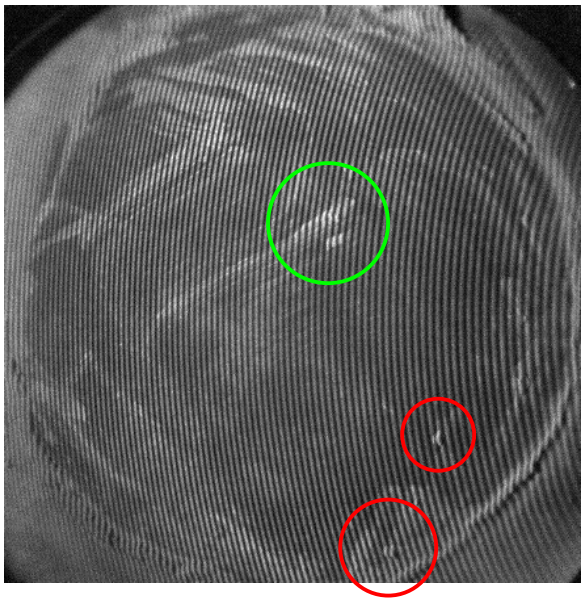
This time both patients were treated with PRKs. The epithelium was removed with a hockey knife and a rotating brush. The treatments were performed with an Asclepion Meditec MEL 70 flying spot laser. The eye tracking was done by recognizing a metal ring laying on the eye. Topographic measurements were taken before and after each treatment with the flexible arm of the treatment laser being pushed out of the way. Some alignment corrections were necessary after the treatments as the patients seem to have moved by some millimeters during in the mean time.

In the analysis of the data the centration of the treatment was judged from the center of the zone in which the epithelium was removed. This center does not necessarily correspond to the optical axis. Nevertheless it is a good approximation. The pupil was not visible in these images in contrast to those after Lasik treatments. Thus we also show the difference maps as they are assuming optimal centration.

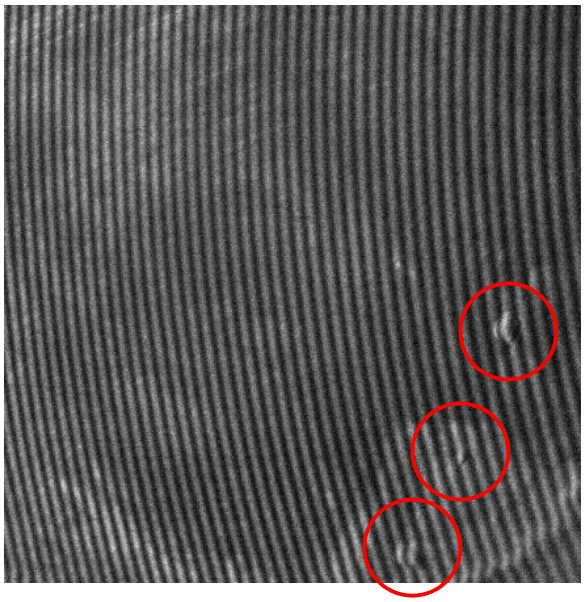
2 Results

2.1 Patient JG

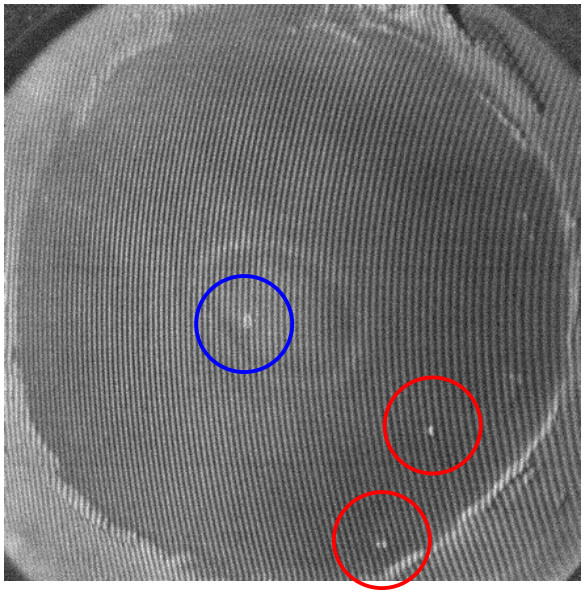
First the original fringe images as detected by the camera are shown. The brightness and contrast has been enhanced for better visibility. This has no influence on the evaluation.



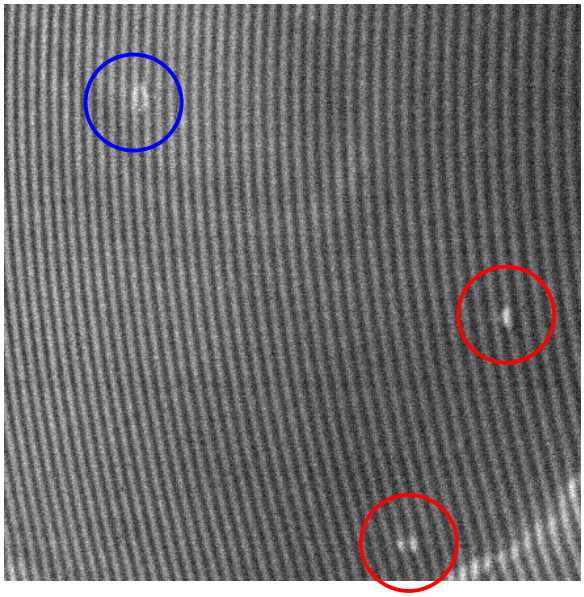
Fringes pre Op



2x magnified fringes pre Op



Fringes post Op

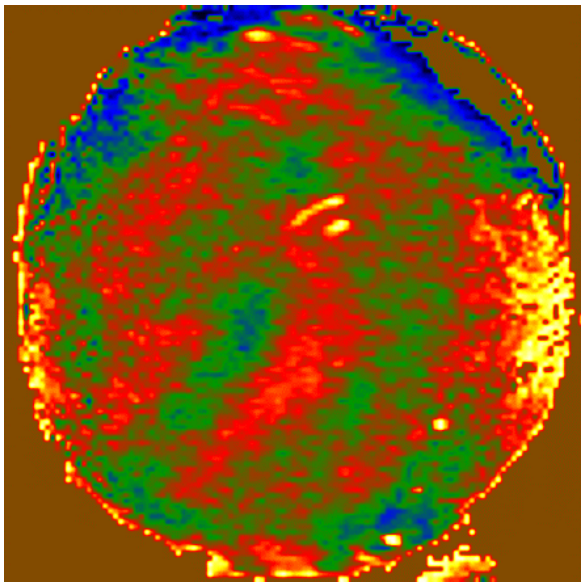


2x magnified fringes post Op

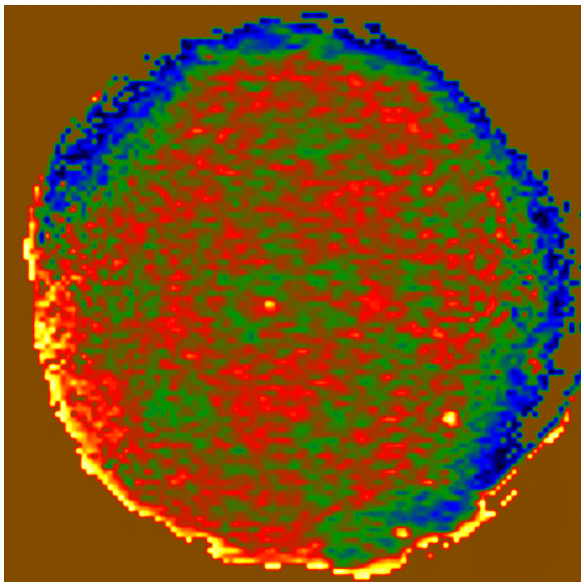
The pre Op images clearly reveal traces of remaining epithelium. The operator was not aware of these traces as he cannot see them under visible light illumination. In the center and in the lower right region there are some larger amount of tissue being left on bowman's layer (green and red circles). These epithelium rests are partly transmitted into the stroma during the treatment as shown in the post Op images. The tissue in the green circle has vanished as it probably only laid very loose on the cornea. It was blown off with

the first few pulses. The lower right tissue rests were more strongly adhering to the bowman membrane as they were not blown off. Within the blue circle there is an elevation of unclear origin which was visible at the beginning of the treatment.

These findings are confirmed in the following height maps.



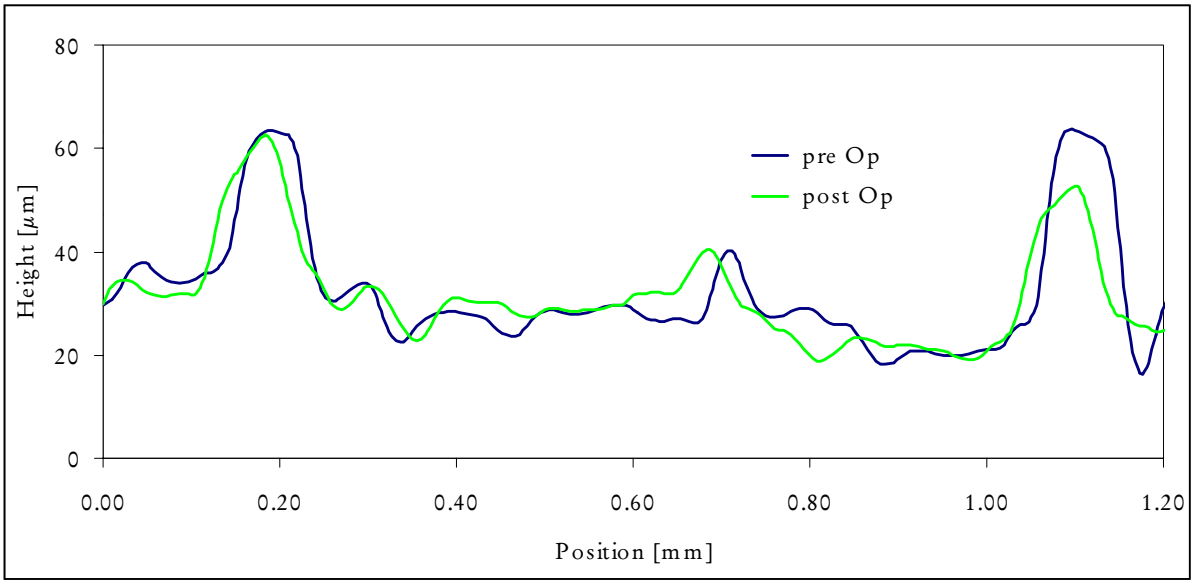
Pre Op height map



Post Op height map

These maps are produced by subtracting a polynomial fit function of fourth order from the original height data. The resulting map reveals the local irregularities that were already obvious in the fringe images.

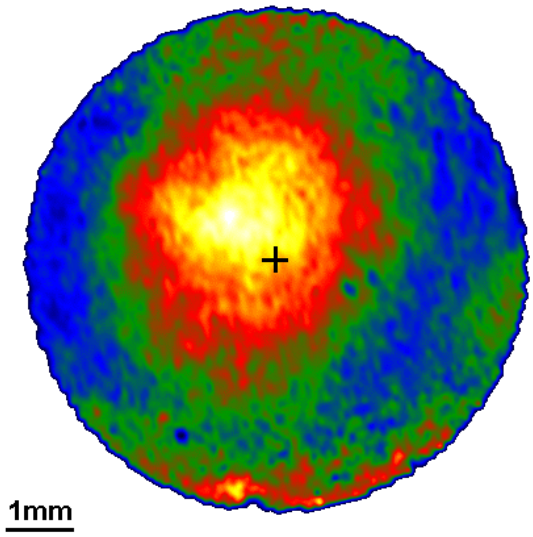
Here are some corresponding line scans through the three irregularities in the lower right.



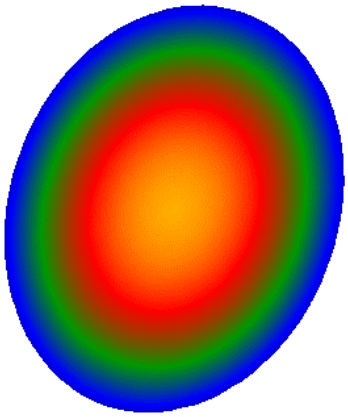
The considerable height of about 30 microns remains nearly unchanged which shows that the original irregular shape is reproduced in a deeper layer of the cornea by the treatment.

Let us now take a look at the laser treatment itself.

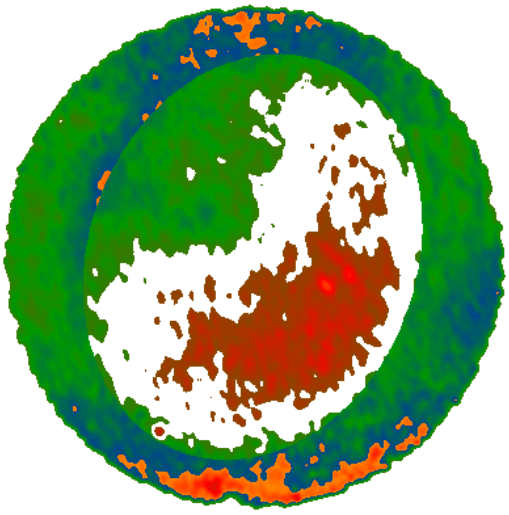
Here are again maps you might already be familiar with from the first report.



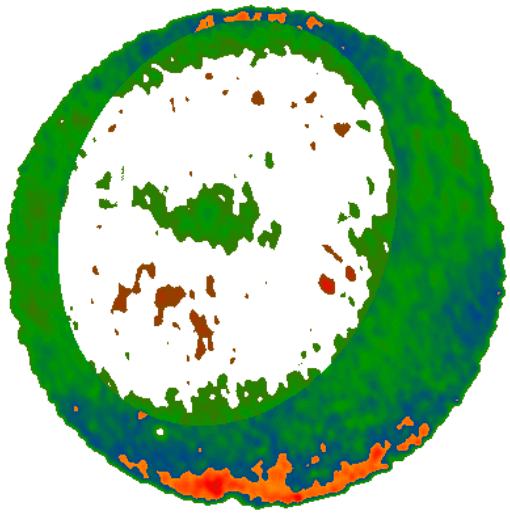
+3.0 +1.75/70° D treatment



corresponding simulation



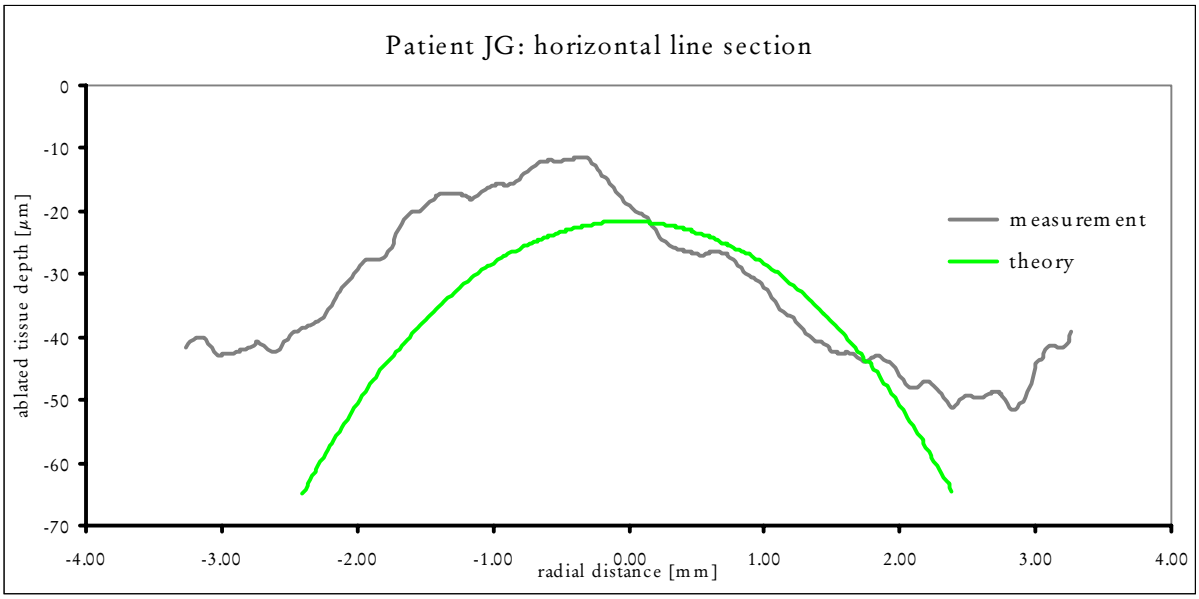
centered difference map

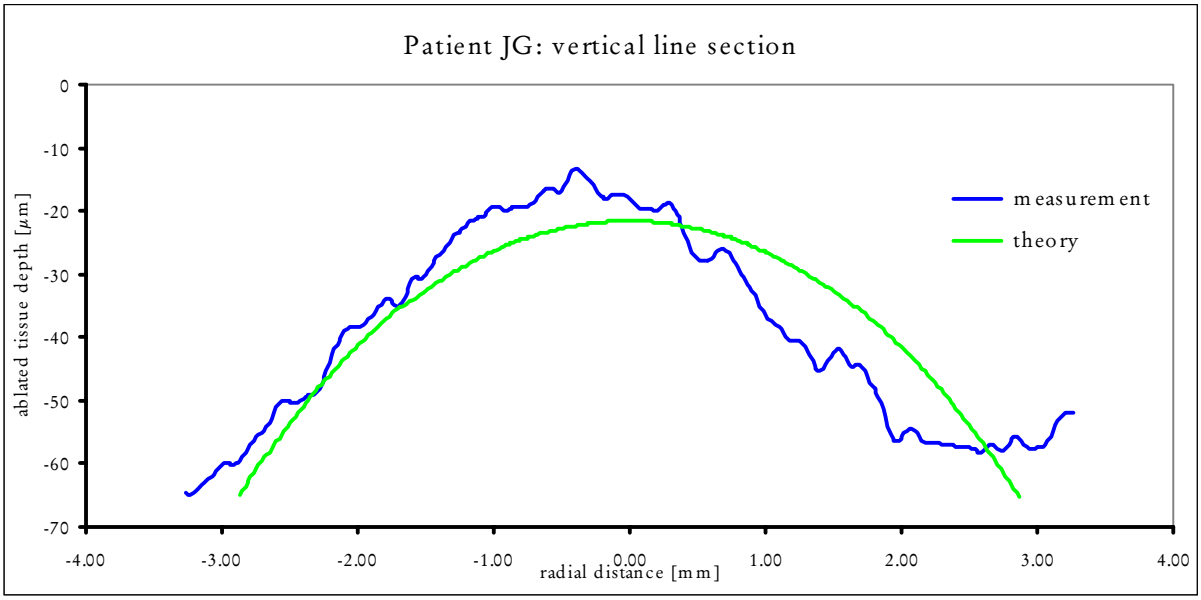


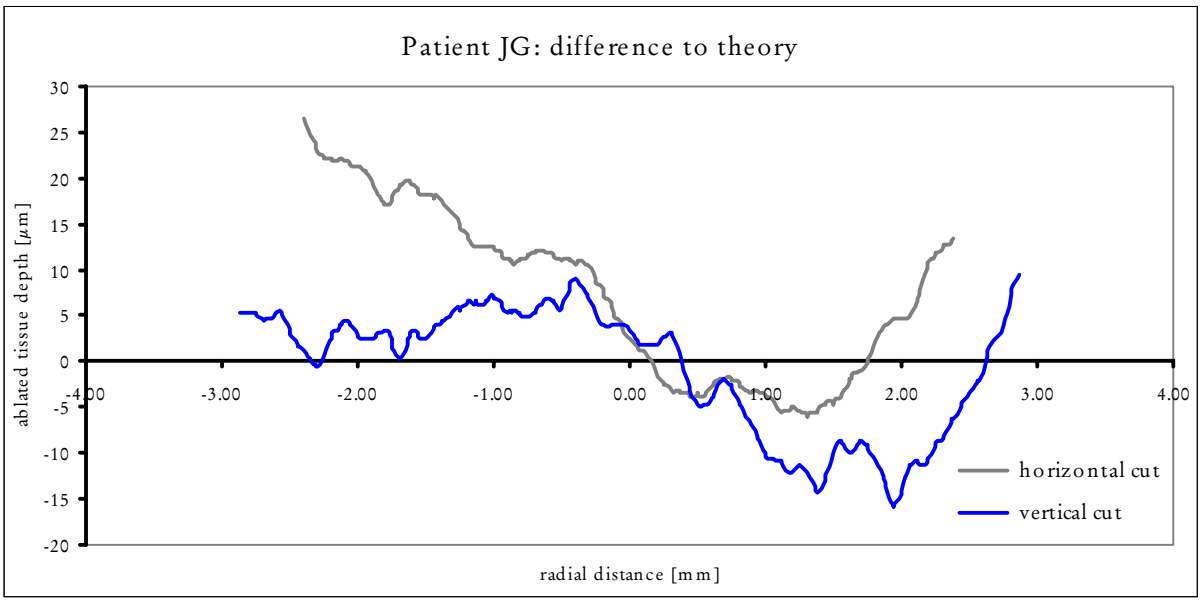
best positioned diff map

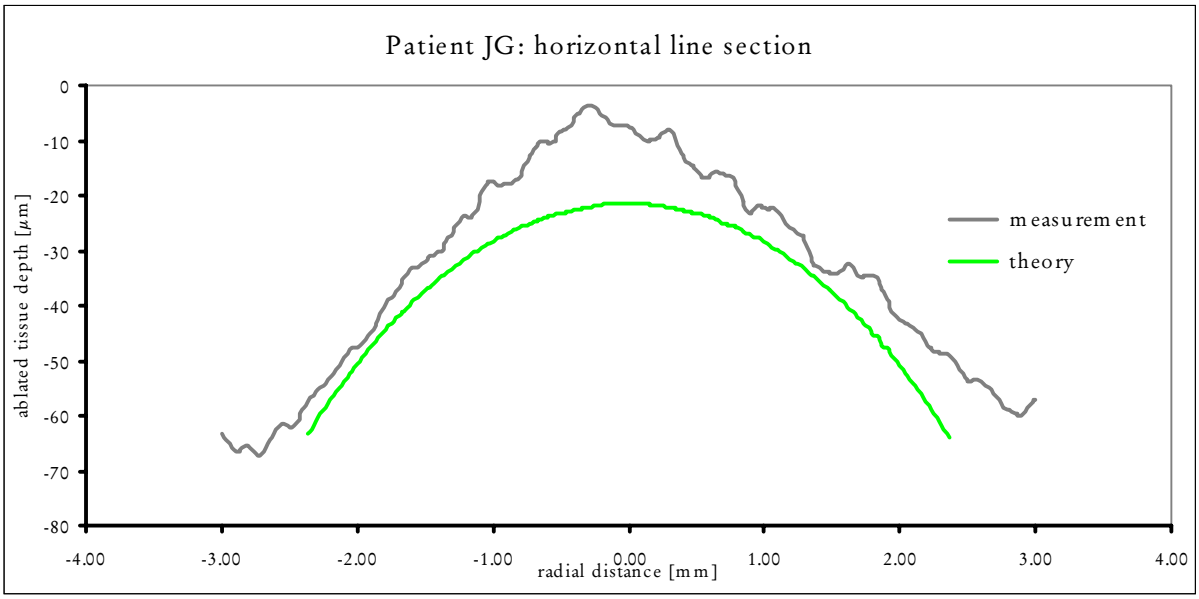
According to the area of epithelial removal there seems to be some decentration of less than a millimeter. If centration is neglected only some undercorrection in the center remains. This undercorrection might as well be interpreted as an overcorrection in the periphery.

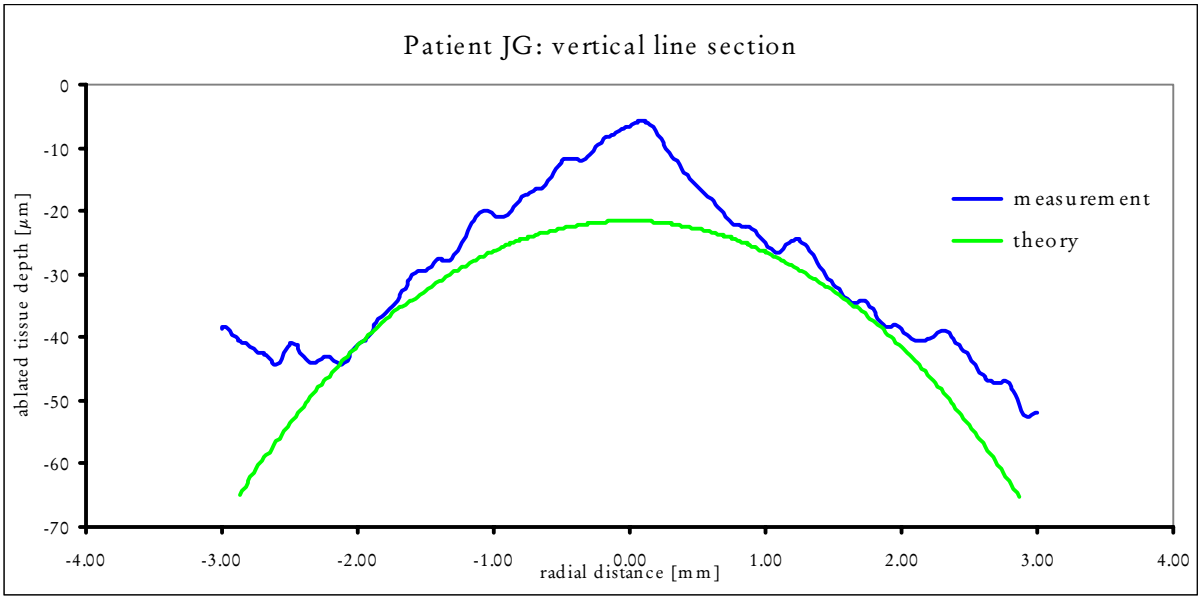
The following horizontal and vertical line scans confirm the results. The next page shows the scans for the decentered ablation. The page following that one gives the results for the well centered treatment. In the difference scan the incorrect central correction becomes obvious as the lines are far from being horizontal.

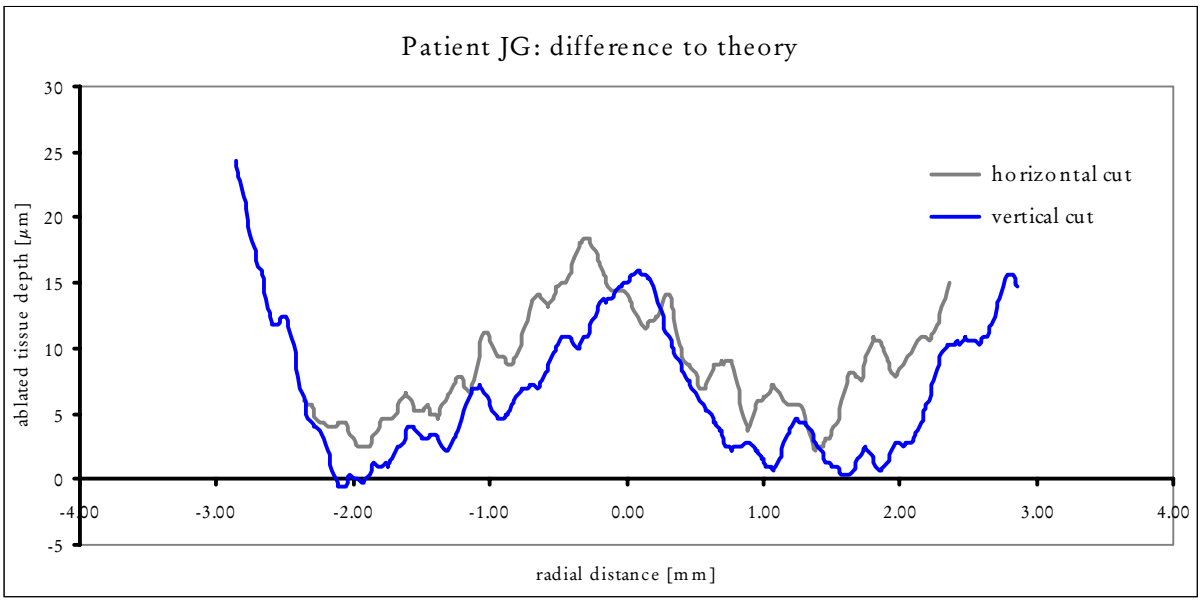

Patient JG: horizontal line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
measurement
theory


Patient JG: vertical line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
measurement
theory


Patient JG: difference to theory
ablated tissue depth [µm]
30
25
20
15
10
5
0
-5
-10
-15
-20
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
horizontal cut
vertical cut

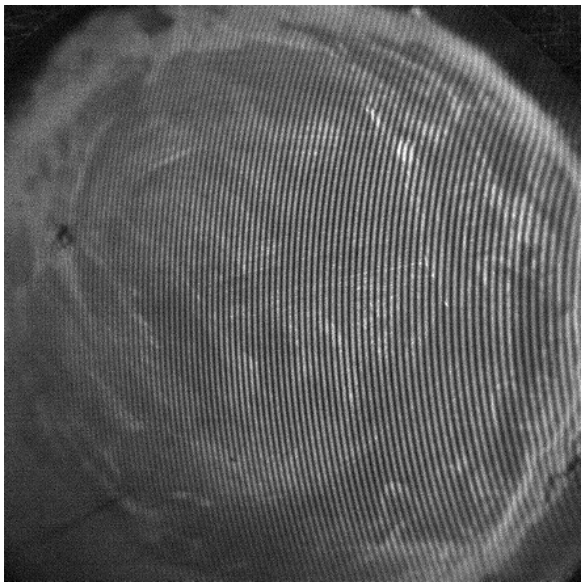

Patient JG: horizontal line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
-80
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
measurement
theory


Patient JG: vertical line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
measurement
theory

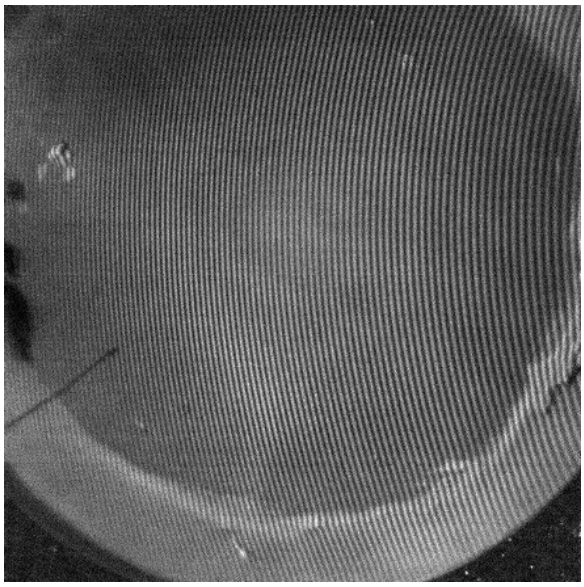

Patient JG: difference to theory
ablated tissue depth [µm]
30
25
20
15
10
5
0
-5
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]
horizontal cut
vertical cut

2.2 Patient CW

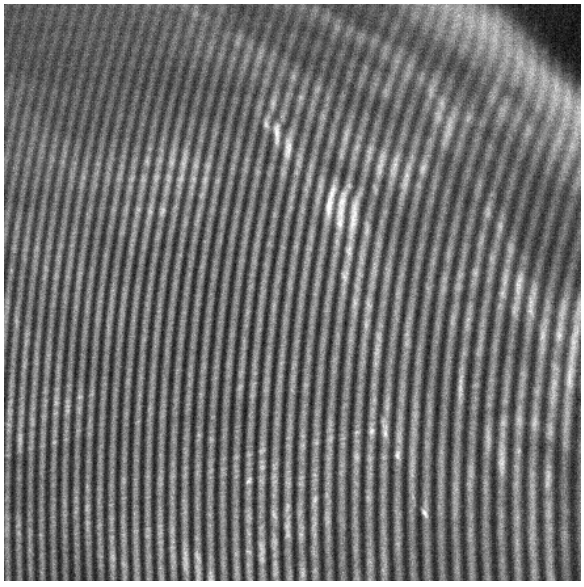
Again here are the fringe images with residual epithelium encircled.



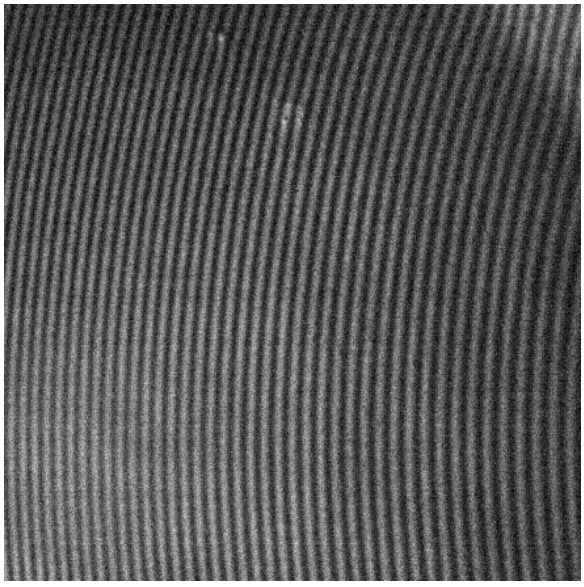
Pre Op with residual epithelium



Post Op



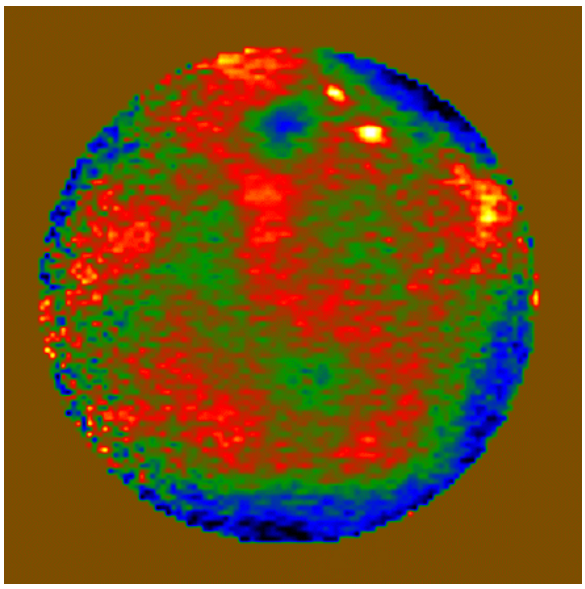
2x magnified pre Op



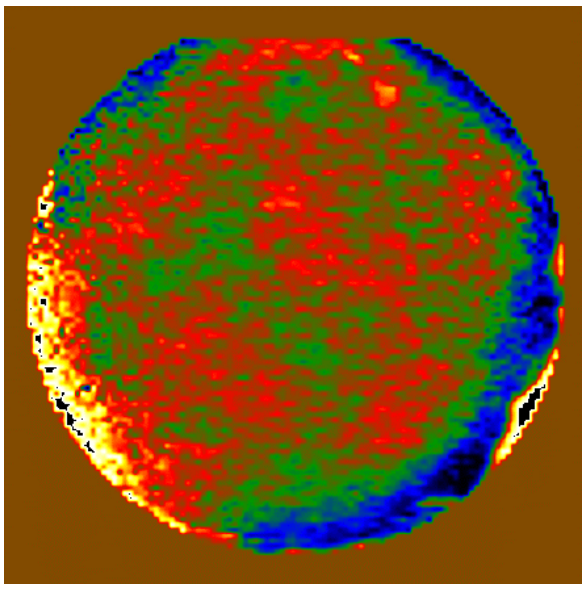
2x magnified post Op

Also in this patient there had been some epithelium left on the cornea before treatment start. This time it had been less and further away from the center of the cornea.

Take a look at the corresponding height maps again corrected with fit functions for the global curvature.



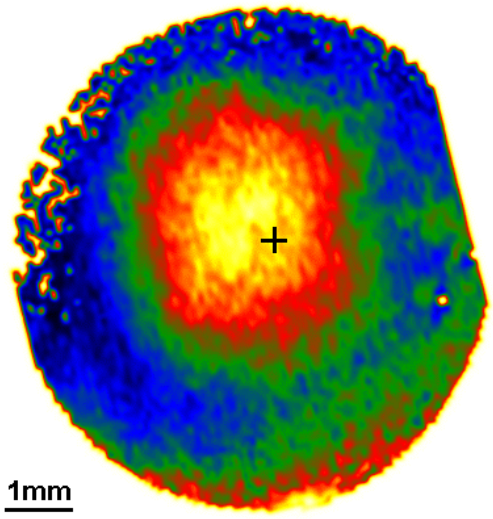
Pre Op height map



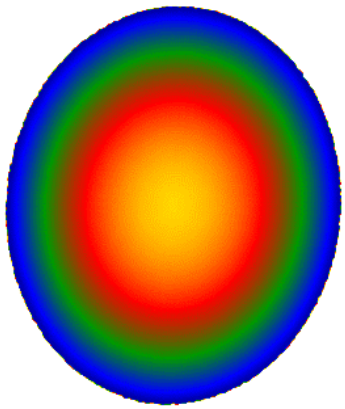
Post Op height map

Most of the irregularities seems to have vanished after the treatment. It was probably also just loose epithelium which was not totally removed. Please note the difference in roughness before and after the treatment.

What was the treatment like? Take a look:



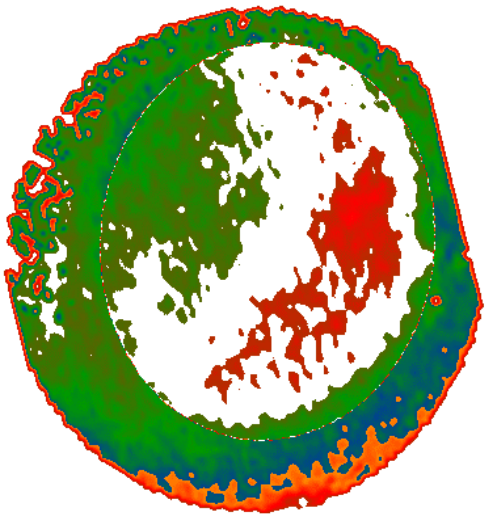
+3.25 +1.5/85° D treatment



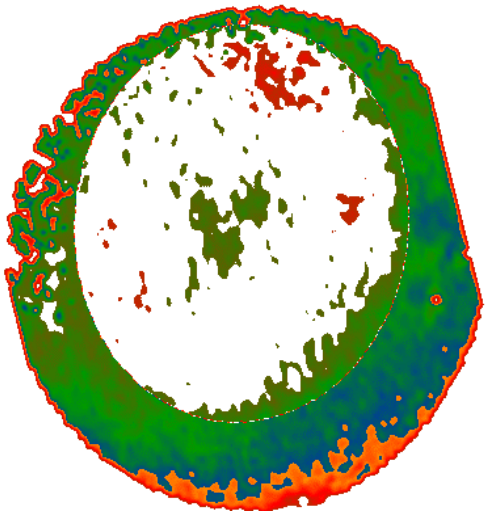
corresponding simulation

Again the centration as given by the edge of the removed epithelium was not perfect. It was offside in the same direction and by nearly the same amount as in the first patient. This might thus be an offset which is intended by the operator. The angle for the astigmatism treatment was incorrect. The best fitting angle was at 105° instead of the intended 85°. This can already be seen when looking at the simulated map.

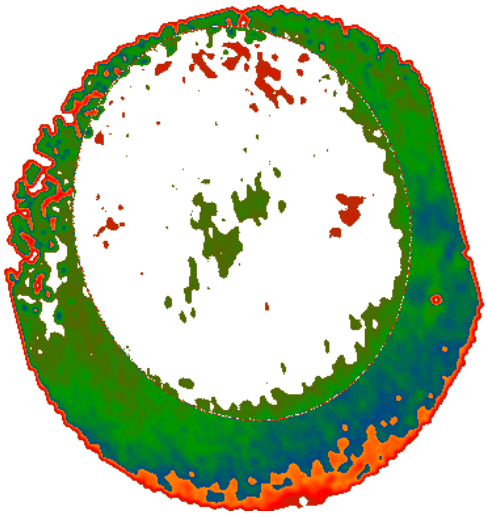
Let us take a good look at the difference maps:



centered difference map



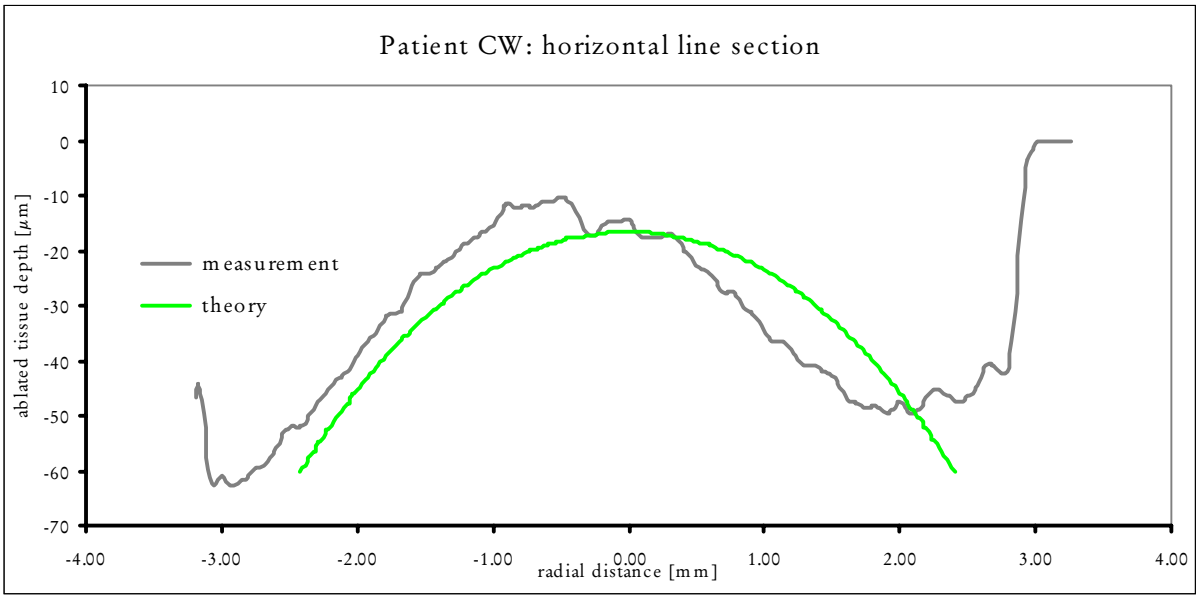
best positioned diff map at 85°

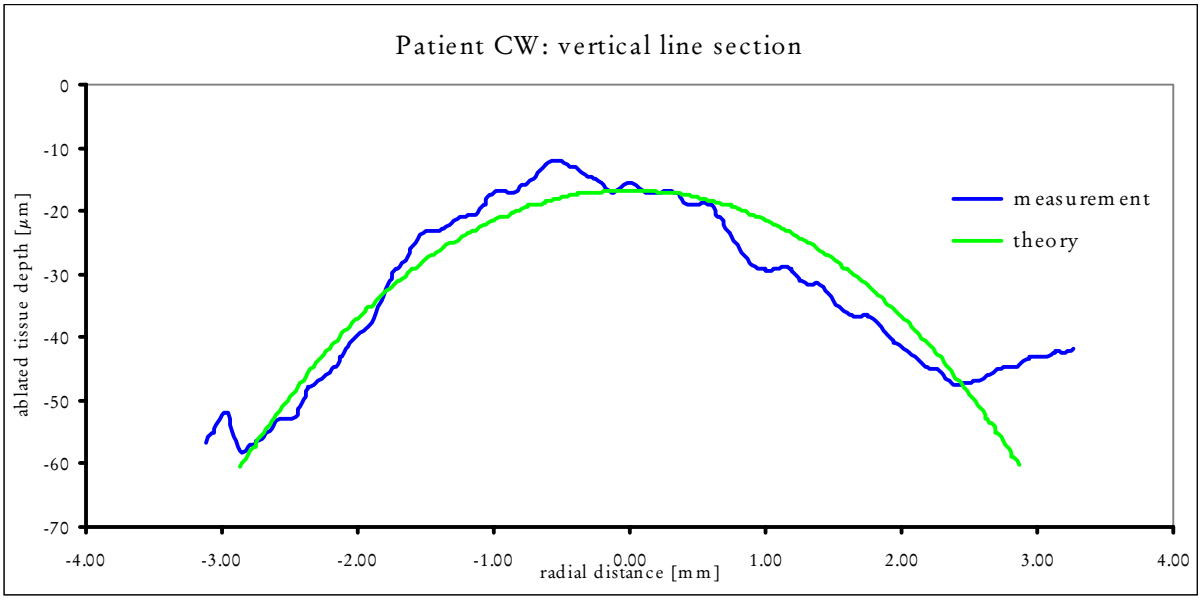


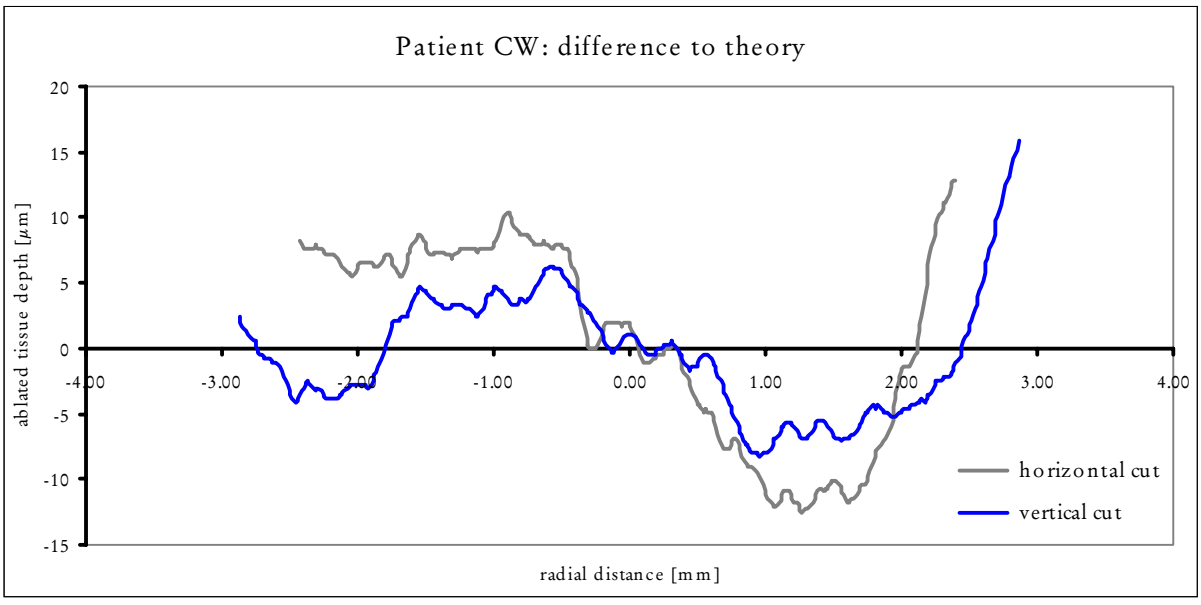
best positioned diff map at 105°

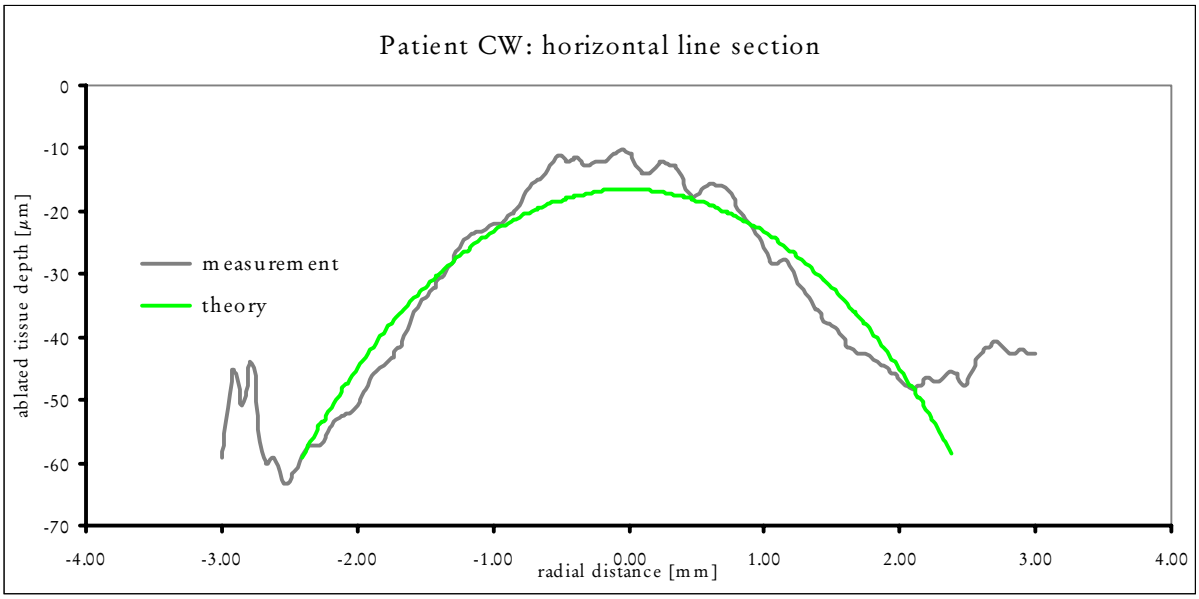
These two difference maps indicated that there is only a slight change when turning the axis by another 20 degrees. This is in part due to the relatively small error in connection with the shape of the treatment.

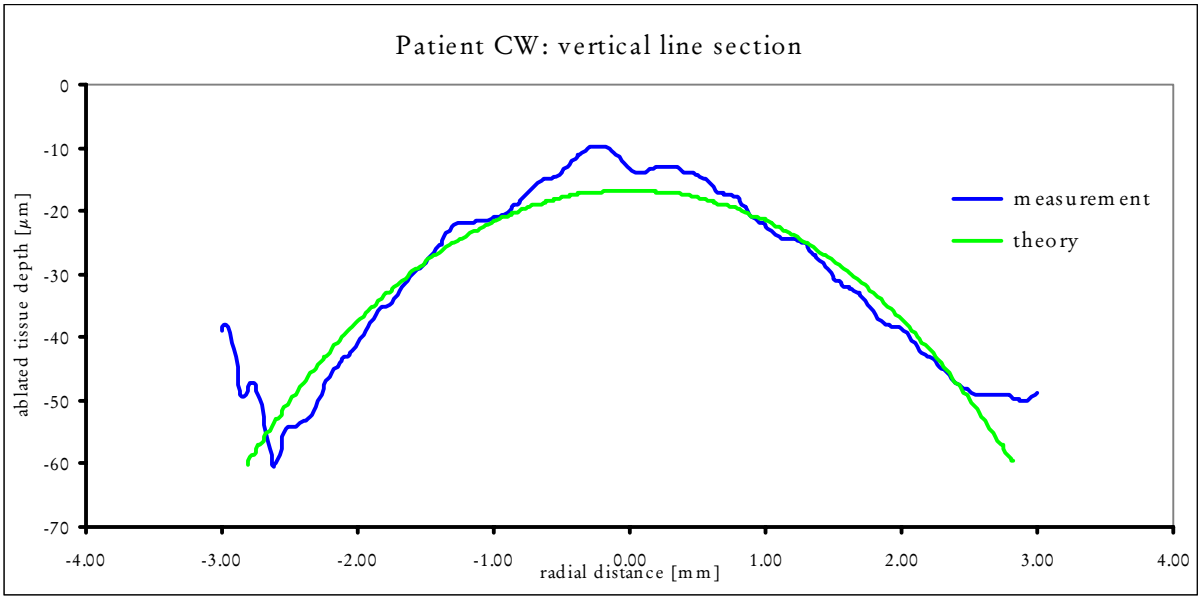
The following graphs show line scans through the centers. The first pages gives the scans for the badly centered treatment at 85°, the second those of the best centered treatment at 105°.

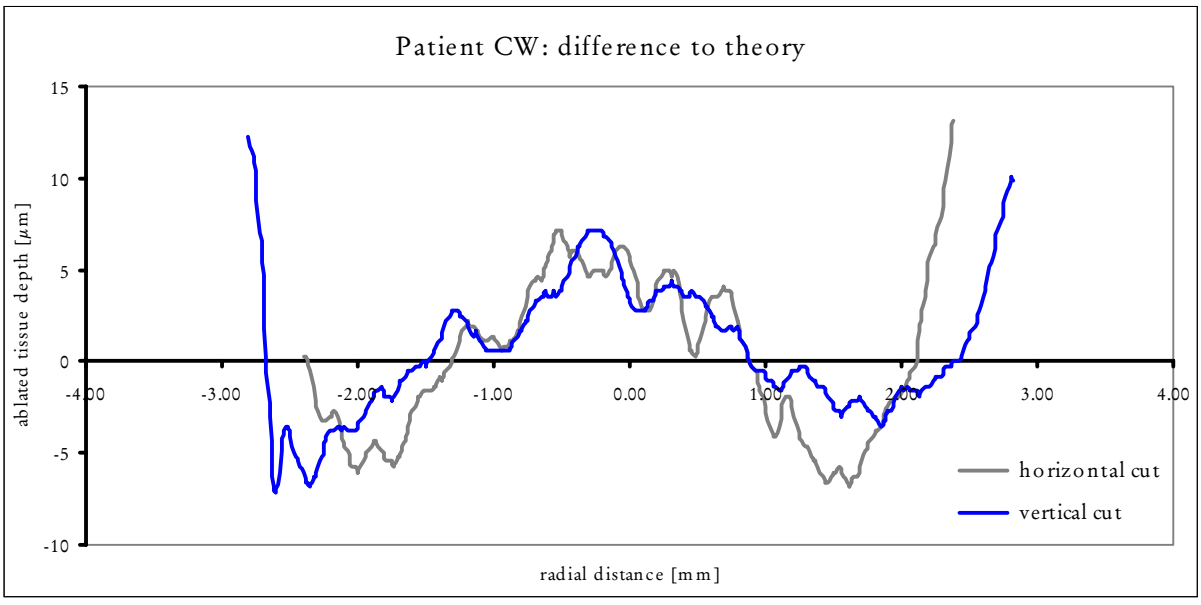

Patient CW: horizontal line section
ablated tissue depth [µm]
10
0
-10
-20
-30
-40
-50
-60
-70
measurement
theory
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]


Patient CW: vertical line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
measurement
theory
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]


Patient CW: difference to theory
ablated tissue depth [µm]
20
15
10
5
0
-5
-10
-15
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
horizontal cut
vertical cut
radial distance [mm]


Patient CW: horizontal line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
measurement
theory
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]


Patient CW: vertical line section
ablated tissue depth [µm]
0
-10
-20
-30
-40
-50
-60
-70
measurement
theory
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
radial distance [mm]


Patient CW: difference to theory
ablated tissue depth [µm]
15
10
5
0
-5
-10
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
horizontal cut
vertical cut
radial distance [mm]

3 Discussion

These new results were obtained form patients treated with the PRK method. Several considerable differences occurred. Some of them were connected with the treatment, others with the laser that also differed from that of our first measurements.

Most striking and probably also most important was the discovery of **residual epithelium** after its intended removal on the cornea. These tissue rests are transmitted into deeper corneal layers. It remains to be seen in how far the recovering epithelium manages to create a smooth surface in these regions or whether the tear film levels it. As it is definitely not intended to leave any tissue left on the cornea before the PRK treatment a uv fringe image will be of help when it comes to judging whether the treatment can already start or needs further preparation.

Both hyperopic treatments showed some **central undercorrection** of about 10 to 15 microns. These central undercorrections might as well be interpreted as peripheral overcorrections. There are several explanations for this finding based on variations in the ablation rate of the tissue. This variation might be due to the preparation of the eye. It might be connected with the cone that was used during the treatment to remove the evaporation products out of the beam path by an air flow. The corneas might as well just have had natural imhomogenities in their hydration or other ablation rate related structures.

Although the results of these two patient were less spectacular than those of the first measurements, there are still some new findings correlated with the preparation of the corneas. The treatments themselves revealed some deviation from the intended correction. **These would certainly have been avoided during an online controlled treatment.**

The results also prove a very important additional point. Any local fine corrections of a few microns to enhance **higher order aberrations** that might have been diagnosed beforehand with an aberrometer seem totally off topic as right now even the simple treatments are not executed predictably but rather in a random way with variations of much more than 5 microns. The results strongly indicate that there is an urgent need to improve the simple treatment outcomes by an online monitoring instead of thinking about fine tuning a surface shape that is far from being predictable.