Corneal stability and topography after different refractive procedures

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Summary

30 subjetcs with myopia, hyperopia and emmetropia, 30 subjects after Radial Keratotomy and 20 subjects after Excimer-Laser-Ablation were examined in this study. A TMS photokeratoscope was used to measure the changes of corneal topography due to a rapid increase of the intraocular pressure which was achieved with a 180 degree tilting table.

It could be shown that intact corneae react in a central and peripheral steepening of the corneal curvature whereas corneae after radial keratotomy react with a central flattening and a peripheral steepening. Subjects after Excimer-Laser-Ablation showed concerning the ablation depth almost no steepening of the corneal curvature.

Key words: Corneal stability - Corneal topography - Tilting table - Refractive surgery.

Introduction

Refractive corneal surgery e.g. radial keratotomy or Excimer-Laser-Ablation means destruction of one of the two stabilizing membranes of the cornea. This means destabilizing the structure withstanding the continous force of the intraocular pressure like in keratoconus, where it takes years and years to bulge the thinning centre forward, changing refractive power to myopia and finally to irregular astigmatism (2, 3, 6). Fluctuating visual acuity, progressive hyperopia after RK, regression of the refractive effect after Excimer-Ablation are well known.(1, 5) Does the physiological or daily changes of the intraocular pressure influence the corneal stability and topography? We know that the intact corneal curvature is stable the whole life. The cornea withstands the daily intraocular overpression without any changes. A relaxed steady state is between corneal stability and intraocular pressure.

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However, what happens to the corneal stability if the intraocular pressure changes? Even v. Helmholtz noticed a correlation between corneal curvature and intraocular pressure. However, his attempt to measure an increased intraocular pressure by measuring the corneal curvature with his ophthalmometer failed.

Method

To prove our hypothesis of destabilization of corneal structure after refractive procedures an in vivo technique was applied for the first time. A change of corneal stability was measured by changes of the corneal topography induced by an increase of intraocular pressure. (Fig. 1)

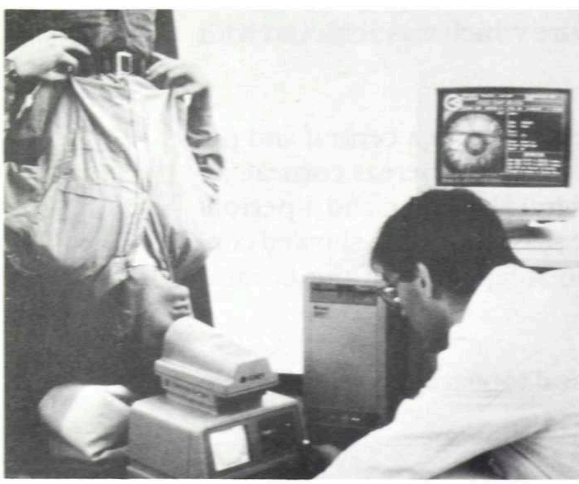


Fig. 1. Patient on tilting table.

A rapid increase of the intraocular pressure up to 40 mmHg without any external deformation of the eye can be achieved with a 180 degree tilting table due to the fluid shift and to hydrostatic pressure canges (4). We used the TMS photokeratoscope before and during increasing the intraocular pressure. The intraocular pressure of the examined subjects ranged between 8 and 15 mmHg in an upright position and between 30 and 40 mmHg in a downright position. (Fig. 2)

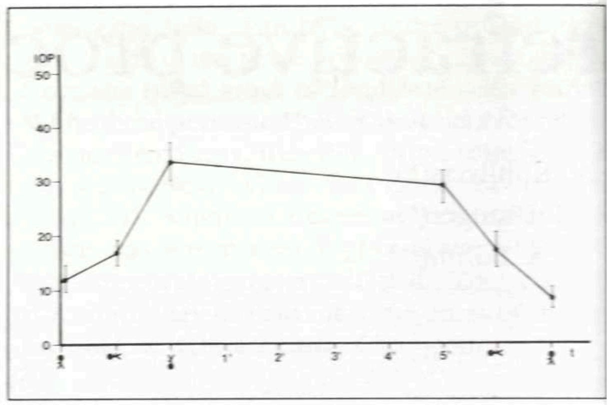


Fig. 2. Changes of IOP during tilting.

Patients

In our study we examined 10 emmetropic, myopic and 10 hyperopic subjects.

30 subjects after radial keratotomy with 4 to 8 corneal incisions and 20 subjects after Excimer - Laser - Ablation with a preoperative myopia between - 1,5 and - 24,0 dpt were examined.

Results

We examined each subject in an upright and in a 180 degree downright position on the tilting table. The image, (Fig. 3) describes the topography of a healthy cornea in upright position. The image, (Fig. 4) describes the topography in a downright position. Due to the rapid intraocular pressure increase each image of normal subjects with intact corneas showed during tilting a peripheral and central steepening of the corneal curvature. A difference between emmetropic, myopic and hyperopic subjects could not be observed. The mean values of subjects with intact corneas show that the periphery steepens more than the corneal center. (Fig. 5)

Completly different, however, react subjects after radial keratotomy. (Fig. 6) describes the topog-

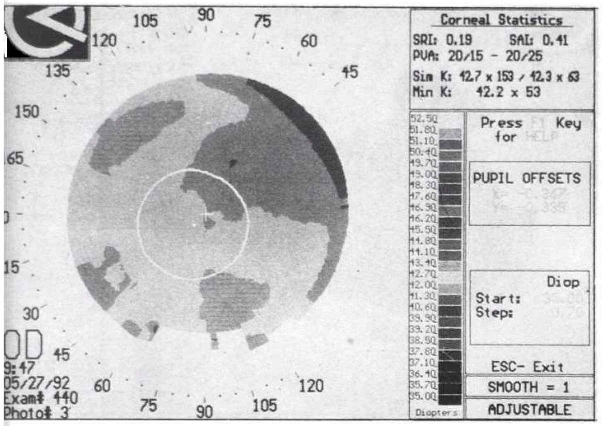


Fig. 3. Intact cornea upright.

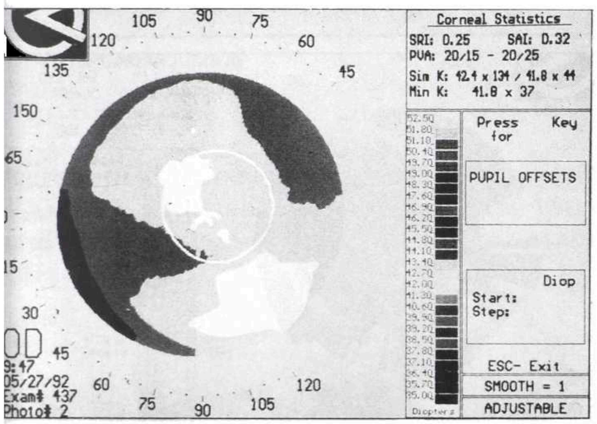


Fig. 4. Intact cornea downright.

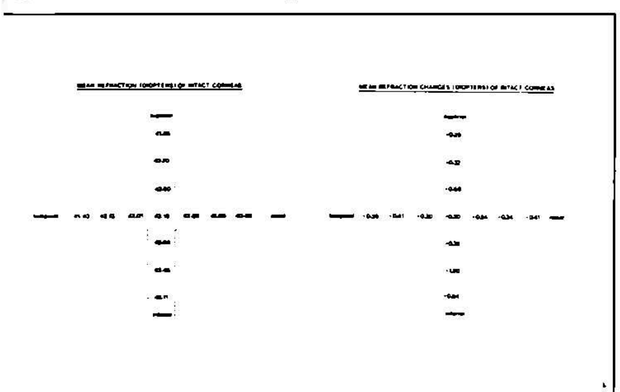


Fig. 5. Statistical values.

raphy of a cornea 3 years after RK in an upright position,(Fig. 7) in a 180 degree downright position. A peripheral steepening and a central flat-

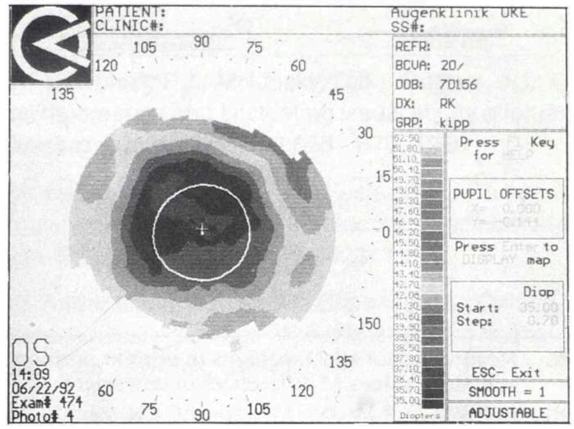


Fig. 6. Patient, 3 years after RK in upright position.

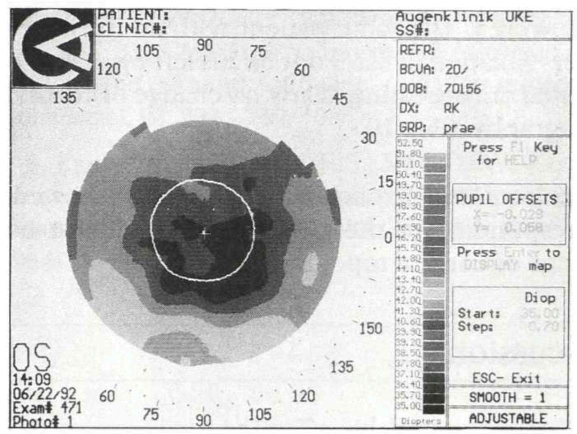


Fig. 7. Same patient in downright position.

tening of the corneal curvature could be observed at the corneal topographies. Each cornea of our subjects after RK showed a central flattening during the tilting maneuvre and intraocular pressure increase. The statistical mean values of all examined subjects prove these findings. (Fig. 8)

Only minimal steepening of the corneal centre could be observed after Excimer - Ablation. The central corneal curvature steepens less than intact corneae.

This right eye of a patient with a myopia of - 22,0 dpt showed during tilting a normal steepening of the central curvature. Fig. 3 and Fig. 4.

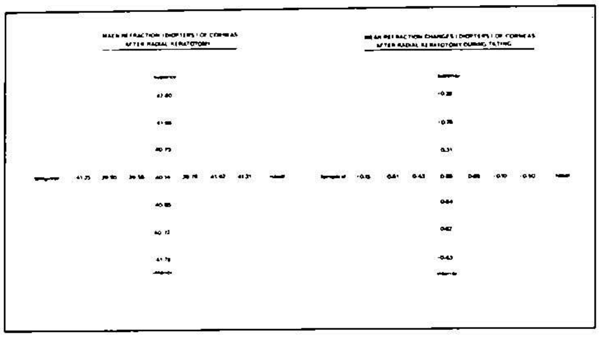


Fig. 8. Mean values of all RK-patients in upright position and mean values of differences in downright position.

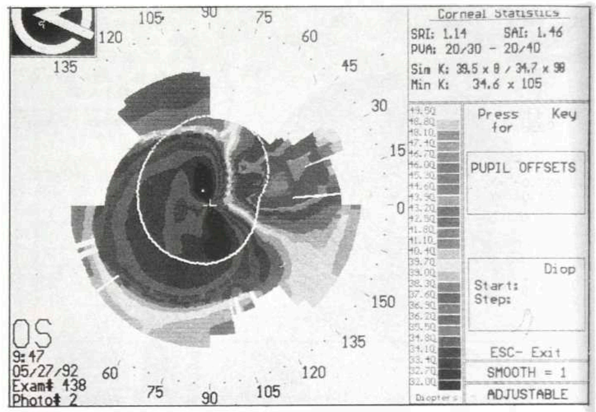


Fig. 9. Left eye after an Excimer-Laser correction of myopia of -22,0 dpt in upright position.

However, the same patient with an Excimer - Laser - Ablation of -22,0 dpt on his left eye, (Fig. 9) showed during tilting nearly no change of corneal topography. (Fig. 10)

Subjects after Excimer - Laser - Ablation showed, corresponding to the ablation depth, almost no change of corneal topography.

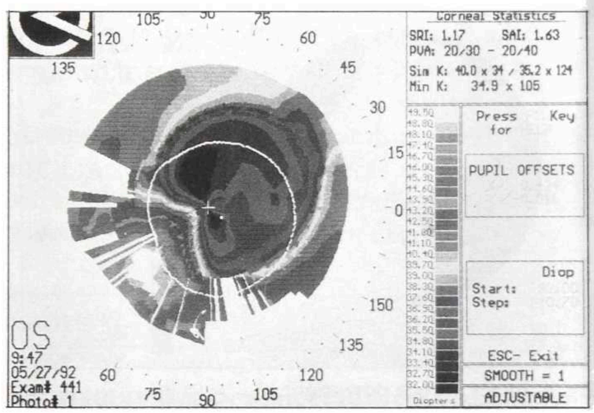


Fig. 10. Same cornea in downright position.

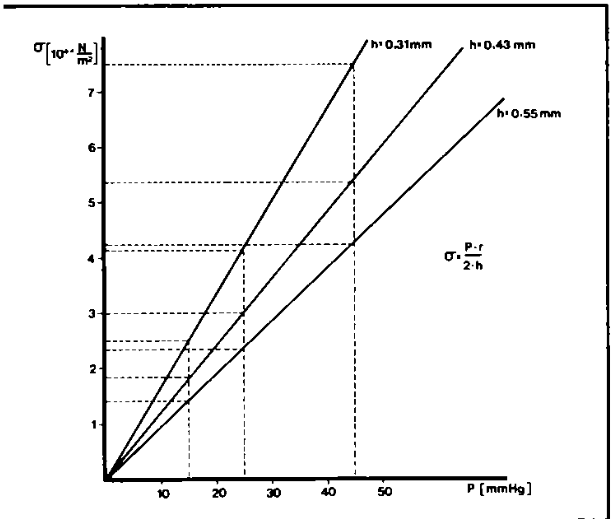
Discussion

The major variable affecting long-term refractive stability after RK is the slow wound healing of the unsutured, not well adapted avascular incisions. We know from histological findings that even 7 years after surgery an active wound healing at these incisions can be found. Bowman's Membrane and the peripheral circular running collagen fibres are still fractured.

Other forces also tend to flatten the central cornea. Due to the pressure of the eyelides with each blink and daily changes of the intraocular pressure in liring and upright positions, the weakened cornea is exposed to a permanent stretching stress. This stress at a tissue with weak stability and prolonged wound healing causes in 20% of the cases a permanent progressive hyperopia.

This finding can be brought into line with the Laplace equation (Fig. 11). The intraocular pressure causes a counter-acting tangential stress inside the cornea. This stress depends not only on the intraocular pressure, but also on the corneal radius and the corneal thickness. This stress stands for the tension the corneal stroma is exposed to. By elevating the intraocular pressure, by flattening the corneal radius and by decreasing the corneal thickness, this tension will be decreased.

Long-term studies about corneal stability must show if the ablated cornea, in particular higher



ig. 11 Laplace equation

legrees of ablation, with decreased elasticity s able to withstand the physiological intra-ocular pressure in order to guarantee a stable efraction.

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