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Purpose: To understand the ablation process and to establish quantitative data about the treatment of eyes with the new solid-state laser system LaserSoft of Katana Technologies GmbH.

Methods: Pig eyes were irradiated with a new frequency shifted diode pumped solid-state laser using a computer controlled fast scanning. The system Lasersoft runs at a repetition rate of 1 kHz with a small spot size of about 0.25 mm at the target. A sequential frequency conversion with nonlinear crystals shifts the wavelenght of the laser radiation into the range between 208-210 nm. The cw (continuous wave)-diode pumping leads to very stable shot-to-shot and long-term stability of the UV output. The resonator structure as well as the beam delivery ensure an emission of the laser radiation with a true Gaussian beam, providing an excellent UV light spot distribution on the cornea, without the need for beam-forming elements in the beam path. The ablation pattern utilized in LaserSoft with accurate overlap of true gaussian spots ensures an extremely homogenous corneal surface. The eye-tracker has a latency of 1 ms and controls the centration of the ablation at very high repetition rates.
The preoperative and postoperative 3D shapes of the eyes were measured using a contactless optical scan method (Fries Technologies GmbH, Germany). The ablation depth was calculated from pachymetric values taken before and immediately after the ablation procedure with the ultrasonic pachymeter (DGH Technology, Inc). The corneal maps have been taken using a topographic system TMS-2N (Tomey Inc.).

Successively nine human eyes were treated with photorefractive keratectomy. Four eyes had myopia, 3 eyes had compound myopic astigmatism and 2 eyes had compound hyperopic astigmatism. The follow up was 1 month for 5 eyes and 3 months for 4 eyes. The mean outcome measures were UCVA, BCVA, corneal topography and corneal transparency.

Results: The experimental ablation depths for different values of corrections of myopia and PTK correlate extremely well with the calculated depth taking into account the measured ablation depth for single shot experiments (Table 1). We achieved the necessary steepening for the treatment of hyperopia and flattening for myopia (Figures 1-4).

Sample	Treatment/OZ/TZ	Max depth predicted (µm)	Pachy after removal of epithelium (µm)	Pachy after treatment (µm)	Difference (µm)	Deviation (%)
Pig 1	Sph -10/6,5/8,5	148	740	600	140	-5,7
Pig 2	Sph -8/7/9	144	735	594	141	-2,1
Pig 3	PTK 100/4	100	770	680	90	-10,0

Table 1.

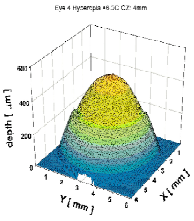

Fig.1 3D picture of a porcine eye after ablation for a treatment of hyperopia of +6D with ablation zone of 4 mm.

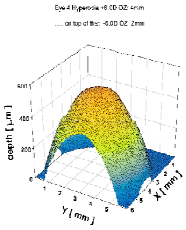

Fig.2 3D picture of an additional treatment of myopia -6D with ablation zone of 2 mm on the top of the previous hyperopic ablation showed in fig.1.This would correspond to a removal of a steep central island with diameter of 2 mm and optical power of +6D.

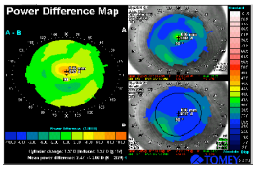

Fig.3 The power difference map of the hyperopic treatment of +6D with ablation zone of 4 mm. The map shows the difference of 8D. The post ablation corneal topography (top right) shows a regular central steepening.

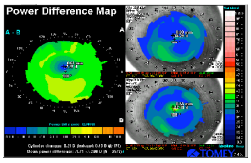

Fig.4 The difference map of the myopic treatment of -6D with ablation zone of 2 mm put on the previously created central steepening. The small central flattening of 8D is evident. The corneal topography after ablation (top right) shows a regular central pattern.

The clinical results showed high efficacy and safety. No eye lost lines of the BCVA and all eyes improved their UCVA. 100% of eyes were within ± 1D and 89% were within ± 0,5D of spherical equivalent refraction. (Table 2 and Figures 5-7).

EYE	Pre UCVA	Pre BCVA	Pre SPH	Pre CYL	Pre AXIS	Pre Sph.Eq.	1 month UCVA	1 month BCVA	1 month SPH	1 month CYL	1 month SE	3 months UCVA	3 months BCVA	3 months SPH	3 months CYL	3 months SE
1	0,02	0,80	-7,00	-1,00	160	-7,50	0,90	0,90	0,00	-0,75	-0,38	0,80	0,90	-0,50	-0,75	-0,88
2	0,02	1,00	-7,00	-1,25	90	-7,63	1,10	1,10	0,00	0,00	0,00	1,00	1,00	0,00	0,00	0,00
3	0,40	1,00	1,00	1,00	180	1,50	1,00	1,00	-0,50	0,00	-0,50	1,00	1,00	0,00	0,00	0,00
4	0,40	1,00	1,00	0,75	180	1,38	1,10	1,10	0,00	0,00	0,00	1,00	1,00	0,00	0,00	0,00
5	0,40	1,00	-1,75	0,00	0	-1,75	1,10	1,10	0,00	0,00	0,00					
6	0,50	1,00	-1,25	0,00	0	-1,25	1,10	1,10	0,00	0,00	0,00					
7	0,20	1,00	-1,25	-1,00	10	-1,75	1,10	1,10	0,00	0,00	0,00					
8	0,30	1,00	-1,50	0,00	0	-1,50	1,00	1,10	-0,50	0,00	0,00					
9	0,04	1,00	-2,75	0,00	0	-2,75	0,90	1,00	-0,50	-0,50	-0,75					

Table 2.

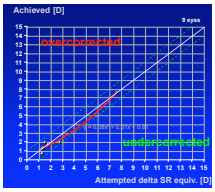

Fig.5 Attempted versus achieved corrections

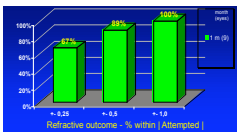

Fig.8 Spherical equivalent refractive outcome at 1 month

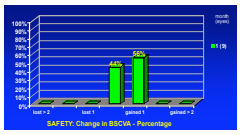

Fig.9 Change in BSCVA at 1 month

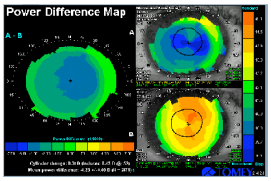

Fig.8 Corneal topography of myopic ablation

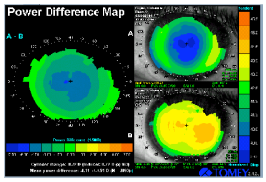

Fig.9 Corneal topography of compound myopic astigmatism ablation

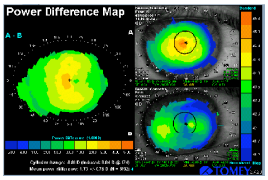

Fig.10 Corneal topography of compound hyperopic astigmatism ablation.

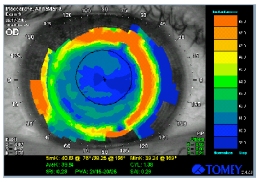

Fig.11 Corneal topography after the treatment of myopia of -7D. The wide ablation zone could be appreciated.

The corneal maps showed a nice regular pattern with a wide ablation zones (Figures 8-11). The surface quality of the treated corneas were exceptionally good. The complete rehepithalisation was achieved between the third and fifth day from the treatment. No corneal haze was observed during the whole follow-up (Figure 12).

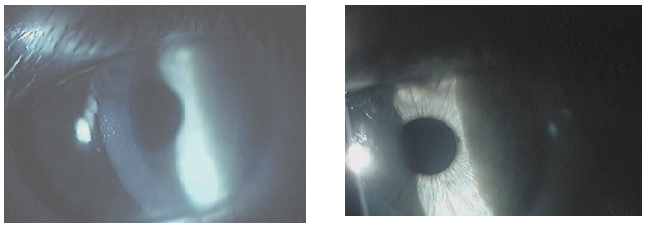

Fig.12 Corneal surface and transparency on the fifth day after the PRK (left) and after 3 months (right).

Conclusions: LaserSoft is a very promessing new surgery system with parameters well suited for customized laser ablation. The small true gaussian spot produces a very smooth and clear cornea during and after surgery.
Due to the high repetition rate (1kHz) the energy per pulse is lower then in excimer treatments. This leads to an ablation with strongly reduced stress waves. Experimental results and clinical data of patient treatments confirm high efficacy and safety of the refractive procedure performed with this device.

References: 1. Customized Corneal Ablation.The quest for supervision.Edited by Mc Rae SM Kruger RR, Applegate Ra. SLACK Inc. 2001.
2. Krueger RR, Seiler T, Gruchman T, Mrochen M, Berlin MS : Stress wave amplitudes during laser surgery of the cornea. Ophthalmol. 2001;108,6:1070.