NEW INSTRUMENT

Pulsed Electron Avalanche Knife (PEAK-fc) for Dissection of Retinal Tissue

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Objective: To evaluate the effectiveness and precision of tractionless retinal tissue dissection by the advanced version of the pulsed electron avalanche knife for fine cutting (PEAK-fc; Carl Zeiss Meditec, Jena, Germany).

Methods: Porcine retina (in vivo) and human retina (in vitro) were incised with the PEAK-fc using various pulse parameters. The globes were then processed for light microscopy. Evaluation of all specimens focused on depth of the retinal cuts and on the degree of collateral damage.

Results: Retinal cuts performed both in vivo on porcine eyes and on human donor eyes showed very sharp edges with only little collateral damage. With probes of 600 µm in length, the optimal pulse parameters for precise and reproducible cutting of the retina were an amplitude of 350 to 380 V, a repetition rate of 300 Hz, and 30 "minipulses" per pulse of 100-microsecond duration. With increasing voltage, cuts also affected the retinal pigment epithelium and the choroid, followed by intravitreal bleeding during in vivo application.

Conclusion: We demonstrated that PEAK-fc is capable of precisely cutting retinal tissue in vivo and in vitro using optimal pulse parameters. Further in vivo studies will be necessary to determine the efficacy of this new tractionless cutting device in vitreoretinal surgery.

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OUR UNDERSTANDING OF the pathogenesis and pathologic abnormalities of several vitreoretinal diseases has increased during the last years. Surgical trauma has been identified as a possible cause for proliferative vitreoretinal diseases.[1-3] Therefore, we need an improved, more precise surgical cutting instrument that limits collateral damage.

During the last 15 years, several researchers have attempted to develop tractionless vitreoretinal surgery with various types of lasers.[4-15] Some of these attempts have failed to achieve widespread acceptance because of the problems associated either with deep collateral damage induced in the surrounding tissue (carbon dioxide laser, Ho:YAG laser)[4,5] or with the adverse effects from using radiation in the eye (xenon chloride excimer laser).[6] The Er:YAG laser[7-10] and argon fluorine excimer laser[11,12] intraocular systems have been successfully tried in both animal and human surgery, including attempts at transection and ablation of epiretinal and subretinal membranes, segmentation of the vitreous base, and capsulotomy.[10,13] Despite the demonstrated advantages of precise dissection of ocular tissue in liquid media, both of these systems have failed to achieve widespread acceptance in practice because of their prohibitively high cost, large size, and relatively slow pace.[10,12,13]

The pulsed electron avalanche knife (PEAK; Carl Zeiss Meditec, Jena, Germany) has been recently introduced to perform precise, "cold" dissection of tissue in liquid medium without inducing tractional forces.[16,17] The PEAK uses short (100-nanosecond) electric pulses rather than laser photons to create plasma microstreamers in front of a pointed intraocular probe. Overheating water with a plasma-mediated discharge causes explosive vaporization of the liquid that results in ablation or dissection of the adjacent tissue. Because PEAK uses very short pulses, and because the electric discharge is confined to a very small volume (the electrode diameter is 25 µm), the interaction results in mechanical fragmentation of tissue without thermal damage.[16,17] Because vaporization and subsequent cooling are so rapid that the heat does not diffuse to the surrounding tissue by more than about 10 µm during the pulse, the PEAK technique is referred to as cold cutting.

During extensive testing of this device in vitro and in vivo, we found the following limitations to its applicability. Individual pulses applied to the surface of tissue by a pointed electrode produce a series of perforations, which do not always merge into a continuous cut. Applying the higher energy required in surgery on tougher tissue results in substantial collateral damage during expansion and collapse of the cavitation bubbles.[16-18] The instrument cannot dissect tough tissue such as sclera, cornea, and skin. Because of the small size of the pointed microelectrode, this probe cannot coagulate tissue.

Based on this experience, Palanker and colleagues developed a new version of PEAK that addresses all these limitations.[19] The problem of the noncontinuous cut was solved by changing the geometry of the probe from the inlaid disk (pointed, nonpenetrating electrode) to the exposed cylinder (penetrating electrode). The elongated shape of the electrode allows for dissection with its edges rather than just with its apex, leaving no connections between the 2 edges of the cut. Strong cavitation is avoided by extending the pulse duration and applying a burst of "minipulses" instead of a single submicrosecond pulse.

Changing the mechanism of interaction from mechanical fragmentation to rapid overheating and ionization extends the applicability of PEAK to tougher tissues. This is achieved by changing the waveform from a single 100-nanosecond pulse of high voltage to a longer burst of pulses (100 microsecond) and lower voltage. A thin layer of pulsed plasma is formed around elongated microelectrode in conductive fluid.[19] Changing the duration of the pulsed waveform minimizes both the cavitation-related and the heat diffusion–related damage. This tool can now dissect even such tough tissues as cartilage and skin. The "hot" coagulation mode, as opposed to the cold cutting mode, can also be achieved on an elongated electrode because of a sufficiently large exposed area.

In a pilot study, this advanced version of PEAK, called PEAK-fc for "fine cutting" (Carl Zeiss Meditec), was tested in vivo in pig eyes to optimize the parameters required for efficient and controlled cutting of retinal tissue: voltage, pulse repetition rate, and pulse duration and structure (number of minipulses/pulse). Tissue specificity and selectivity and the extent of collateral damage were assessed for various pulse parameters and surgical techniques. Results derived from the in vivo animal model were transferred to an in vitro study in human donor eyes.

METHODS

The PEAK has been substantially redesigned. In contrast with the first version of PEAK,[16,17] the advanced PEAK-fc operates with much lower voltages (300-500 V) and much longer pulses of about 100 µs. The latter consist of a burst of several minipulses. The cutting part of the PEAK-fc probe is a protruding Tungsten wire with a diameter of 50 µm (**Figure 1**). The wire extends from the glass insulator by 0.3 mm (only used in the animal model) or 0.6 mm. The glass insulator itself has an outer diameter of 0.6 mm and is enclosed by a 20-gauge stainless steel return electrode.

The PEAK-fc provides integrated fiber optics for bright intraocular illumination. This facilitates bimanual procedures in vitreoretinal surgery with a lower risk of unintended tissue damage because of improved ergonomics. Additionally, a coagulation mode has been integrated.

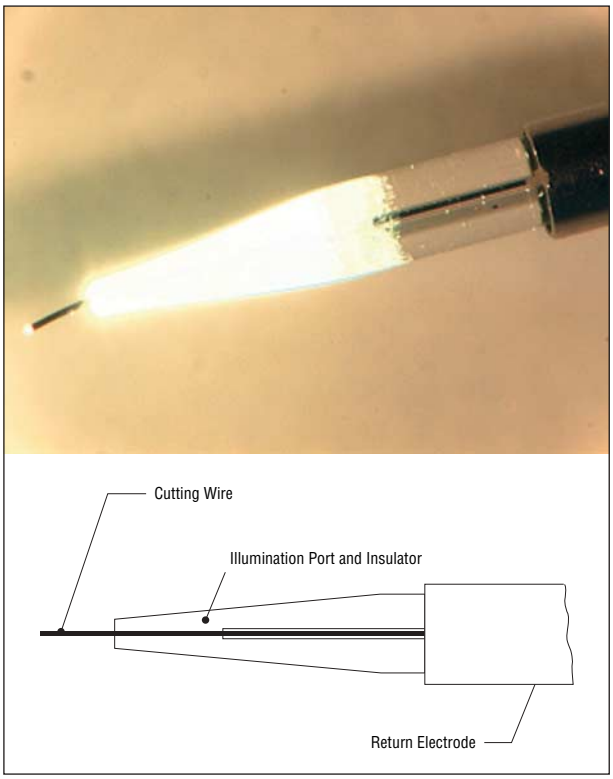

Figure 1. Intraocular pulsed electron avalanche knife–fine cutting (PEAK-fc) probe. The PEAK-fc operates with a 0.3- or 0.6-mm protruding Tungsten wire of 50 µm in diameter. It has a 0.6-mm glass insulator and a 20-gauge stainless steel return electrode. The PEAK-fc provides integrated fiber optics for bright illumination, facilitating bimanual vitreoretinal surgery.

Our study clinically and histologically evaluated the characteristics of the cut obtained by the PEAK-fc using different parameters: voltages from 300 V to 600 V, pulse repetition rates of 80 Hz to 860 Hz, 20 to 40 minipulses per pulse, and pulse durations of 7 to 100 µs.

SURGICAL APPROACH

In Vivo Approach

Four adult pigs were immobilized and anesthetized by administering ketamine (35 mg/kg) and xylazine (5 mg/kg) intramuscularly at 10 to 15 minutes before surgery. Pupils were dilated using a topical application of 2.5% phenylephrine and 1% cyclopentolate.

At first, we performed a standard 3-port pars plana core vitrectomy using a commonly available vitrectomy machine (Megatron, Geuder, Germany). Posterior vitreous detachment was induced by suction with the vitrectomy probe over the optic nerve head. We introduced the PEAK-fc probe via the sclerotomy and made several 3- to 5-mm retinal cuts using different PEAK-fc parameters in each eye. The PEAK-fc probe was moved along the surface of the retina with a velocity of approximately 1 mm per second.

We tested the coagulation mode by intentionally damaging arterial branches of different sizes. Eyes were enucleated immediately after surgery and fixed in 10% formaldehyde. All animal experiments were performed in accordance to the "Statement for the Use of Animals in Ophthalmic and Vision Research" from the Association for Research in Vision and Ophthalmology (Rockville, Md).

Table 1. PEAK-fc Retinal Cuts In Vitro Using Human Postmortem Donor Eyes

	Donor				Clinical Observation		Histologic Analysis	
Case	Age, y	Time Since Death, h	Tissue	Amplitude, V	Collateral Damage	Bubbles	Depth	Collateral Damage, µm
1	36	23	Retina	500	Edema, much	Medium	Choroid	>50
2	74	24	Retina	500	Edema, medium	Medium	Sclera	>50
3	56	19	Retina	450	Edema, little	Medium	Choroid	>50
4	22	34	Retina	450	Edema, medium	Few	Choroid	26-50
5	49	22	Retina	420	Edema, little	Medium	RPE	26-50
6	21	34	Retina, detached	420	Edema, little	Few	Retina	26-50
7	36	23	Retina	400	Edema, little	Medium	Retina	26-50
8	49	22	Retina	400	Edema, little	Few	RPE	0-25
9	21	34	Retina	380	Edema, little	Few	RPE	0-25
10	33	23	Retina, detached	380	Edema, little	Few	Retina	0-25
11	24	18	Retina	380	Edema, little	Few	Retina	0-25
12	56	19	Retina	350	Edema, little	Few	Retina	0-25
13	74	24	Retina, detached	350	Edema, little	Few	Retina	0-25
14	22	34	Retina	330	Edema, little	Few	Retina (partial)	0-25
15	24	18	Retina	330	Edema, little	Few	Retina	0-25
16	33	23	Retina	300	Edema, little	Few	Retina (partial)	0-25

Abbreviations: PEAK-fc, pulsed electron avalanche knife for fine cutting; RPE, retinal pigment epithelium.

Table 2. PEAK-fc Retinal Cuts In Vivo in a Pig Animal Model

			PEAK-fc Parameter				Clinical Observation			Histologic Analysis	
Case	Tissue	Probe, µm	Amplitude, V	Repetition Rate, Hz	Pulse Duration, µs	Minipulses per Burst, No.	Complications	Edema	Bubbles	Depth	Collateral Damage, µm
1	Retina	600	600	100	100	20	Bleeding	Much	Medium	Sclera, 26-50 µm	>50
2	Retina	600	500	100	100	20	Bleeding	Much	Medium	Sclera, 0-25 µm	>50
3	Retina	600	480	130	100	40	Bleeding	Medium	Medium	Choroid	26-50
4	Retina	600	430	150	100	30	None	Little	Few	RPE defect	26-50
5	Retina	600	400	150	100	40	None	Little	Few	Retina	0-25
6	Retina	600	400	100	100	40	None	Little	Few	RPE defect	0-25
7	Retina	300	400	150	100	30	Residual vitreous	Little	Few	Partial retina	0-25
8	Retina	300	400	300	100	30	None	Little	Few	Retina	0-25
8	Retina	300	380	300	100	30	None	Little	Few	Partial retina	0-25
9	Retina	600	380	300	100	30	None	Little	Few	Retina	0-25
10	Retina	600	380	80	75	30	None	Little	Few	Retina	0-25
11	Retina	600	380	860	7	40	None	No effect	Few	No effect	None
12	Retina	600	360	150	100	30	None	None	Few	Retina	0-25
13	Retina	600	350	330	100	40	None	Little	Few	Retina	0-25
14	Retina	600	300	300	100	40	None	Little	Few	Partial retina	0-25

Abbreviations: PEAK-fc, pulsed electron avalanche knife for fine cutting; RPE, retinal pigment epithelium.

Human Donor Eyes

Sixteen eyes from 8 donors aged between 21 and 74 years were provided by the eye bank at Ludwig-Maximilians-University, Munich, Germany (**Table 1**). Only eyes from donors with informed consent for research purposes were included. All eyes were preserved in a moist chamber at 4°C within 34 hours postmortem. All experiments were performed in accordance to the Declaration of Helsinki.

After removal of the corneoscleral disc and the iris lens diaphragm, the cornea was secured for conservation, and the iris and the lens were discarded. Then, we performed an open-sky vitrectomy (Megatron), including induction of a posterior vitreous detachment as described earlier in the article.

Subsequently, we made 2 linear incisions of about 3 to 5 mm in length with the PEAK-fc probe in all donor eyes. Incisions were made perpendicular to the papillo-foveal axis. We tested different voltage levels (300-500 V; Table 1) in the areas of detached and attached retinas. Eyes were fixed in formaldehyde fixative immediately after surgery.

HISTOLOGIC ANALYSIS

Porcine and human globes were dissected horizontally into 2 equal hemispheres. For light microscopy, specimens were placed in 10% formaldehyde, dehydrated, and embedded in paraffin. Semithin sections (8 µm) were stained with hematoxylin-

eosin. We assessed characteristics of the PEAK-fc incisions such as depth and the area of collateral damage.

RESULTS

IN VIVO ANIMAL MODEL

In an in vivo porcine pilot study, we assessed the impact of variable PEAK-fc parameters, such as voltage, pulse repetition rate, pulse duration, frequency of minipulses, and probe length on retinal morphology (**Table 2**).

Depth of the PEAK-fc incisions and visible collateral damage showed a direct proportional correlation to voltage, pulse repetition rate, pulse duration, and frequency of minipulses (Table 2), with higher levels of these parameters resulting in deeper cuts and increased collateral damage of ocular structures.

Changes of voltage had the most influence on penetration into retinal structures: With voltages lower than 400 V, only neuroretinal structures were dissected in almost all specimens (**Figure 2**A), whereas voltages higher than 450 V always led to damage of underlying structures such as the retinal pigment epithelium (RPE; Figure 2B) or the choroid (Figure 2C). If subretinal structures were affected during surgery, hemorrhages occurred during the in vivo experiments.

Slight alterations of the pulse repetition rate, pulse duration, and frequency of minipulses showed only little effect on the depth of the cut obtained and the extent of clinically visible collateral damage. Only major variations of these parameters resulted in changes in the incision characteristics of the PEAK-fc (Table 2).

Penetration of the PEAK-fc probe into the tissue depended on the probe length and its distance from the retina. Penetration of the 0.6-mm probe seemed to be deeper in comparison with cuts by the 0.3-mm probe, provided the 0.3-mm probe was not conducted deeper than the level of the retinal surface. With the shorter probe (0.3 mm), it was not possible to cut the retina under visual control, as opposed to experience with the 0.6-mm probe.

Histologic analysis revealed that, beside incision depth, the extent of collateral damage within the retina showed a direct proportional correlation to voltage: the higher the voltage used, the more pronounced the collateral damage with associated retinal edema (Table 2; Figure 2). Changes in pulse repetition rate, pulse duration, frequency of minipulses, and probe length showed little effect on collateral damage.

From the clinical and histological results, we judged that the optimal PEAK-fc parameters for dissection of retinal tissue are the 0.6-mm probe along with voltages of 350V to 380V, a pulse repetition rate of 300 Hz, a pulse duration of 100 microseconds, and 30 minipulses per pulse. With these parameters, all retinal samples showed precise cuts with little collateral damage within the retina, thereby dissecting the whole neuroretinal layer and avoiding damage to the underlying RPE and choroids. Clinically, only faint retinal whitening could be observed after using these parameters.

Formation of gas bubbles similar to those seen during conventional diathermy has been observed at all studied parameters. Reducing the voltage decreased the

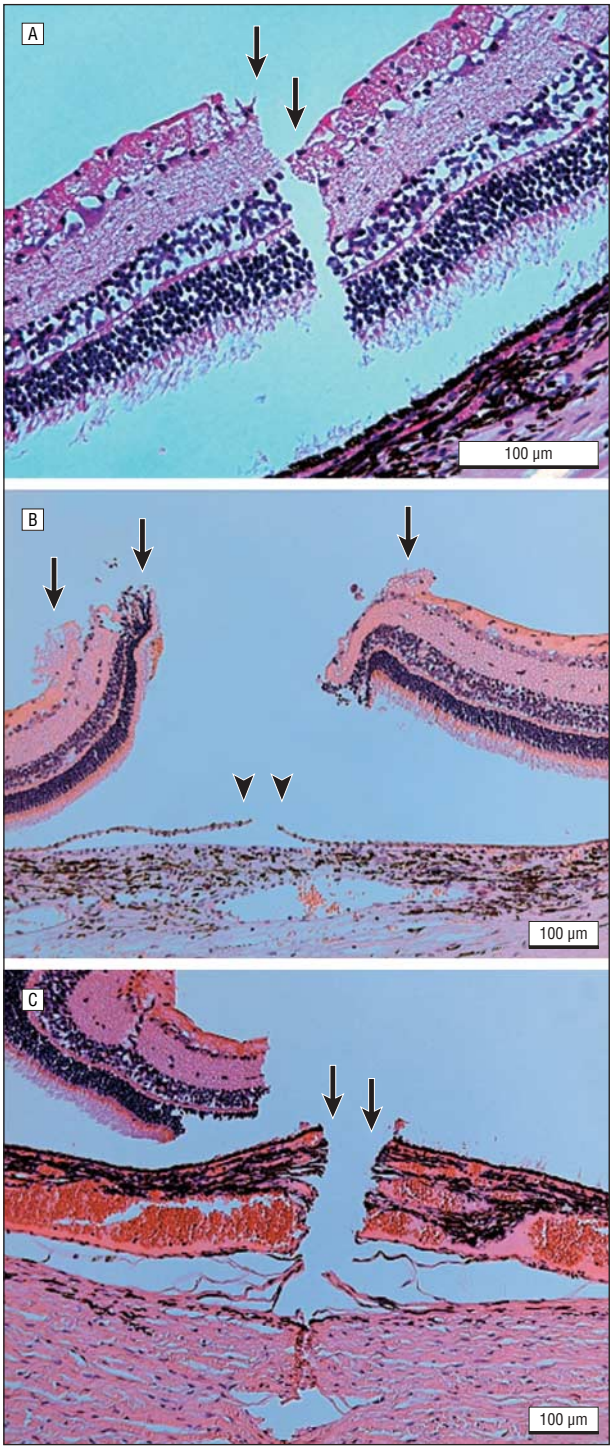

Figure 2. Histologic sections of the pulsed electron avalanche knife–fine cutting (PEAK-fc) cuts in pig retinas in vivo. A, Section of a full-thickness cut in a pig retina produced at an amplitude of 380 V, a pulse repetition rate of 300 Hz, a pulse duration of 100 µs, and a scanning rate of 1 mm per second with 30 "minipulses" per pulse. All neuroretinal structures are dissected without any damage to the retinal pigment epithelial (RPE) layer. The incision walls are clearly demarcated (arrows), and no signs of collateral coagulation damage can be observed (original magnification ×200). B, Full-thickness cut and RPE damage (arrowheads) produced with 430 V. Unsharp incision edges and loosening of neuroretinal structures indicate the increase in collateral damage (arrows; original magnification ×100). C, Histologic section of a cut in a pig retina produced at 600 V. The RPE and choroid are destroyed (arrows), leading to intraoperative bleeding (original magnification ×100).

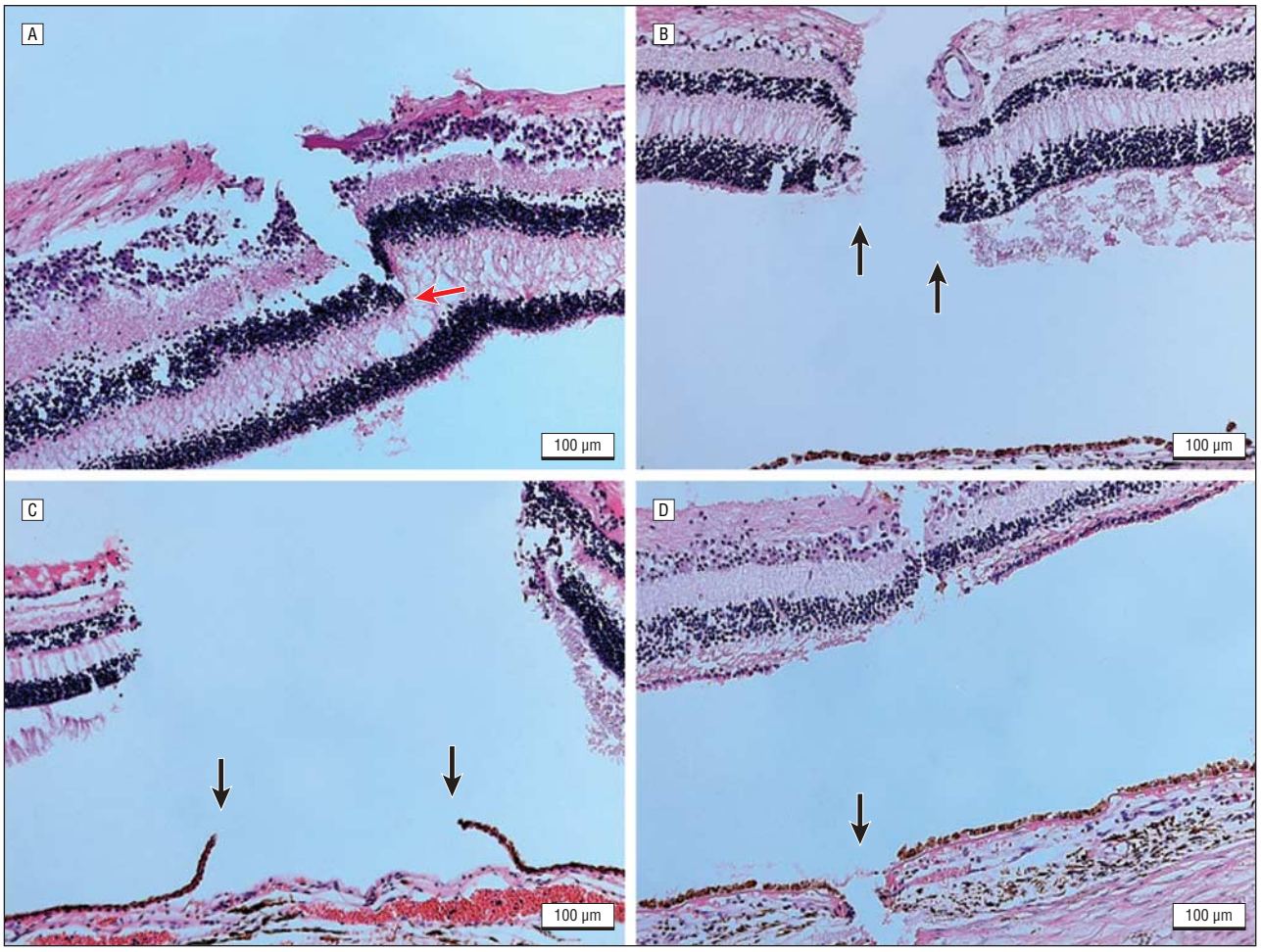

Figure 3. Histologic sections of the pulsed electron avalanche knife–fine cutting (PEAK-fc) cuts in human postmortem retinas. Cutting depth PEAK-fc cuts were performed after open-sky vitrectomy and induction of posterior vitreous detachment. All incisions were performed with a pulse repetition rate of 300 Hz, a pulse duration of 100 microseconds, and 30 "minipulses" per pulse. The 0.6-mm probe was used. A, Voltage of 300 V resulted in an incomplete dissection of the neuroretinal layers. Arrow indicates the boundary. B, A full-thickness cut in a human retina produced at 350 V. With an increase of voltage to greater than 400 V, PEAK-fc was cutting beyond the neuroretinal layers and damaging the RPE (arrows in C), choriocapillaris, and choroid (arrow in D). C and D, Histologic sections produced at 420 V and 500 V, respectively.

amount of bubbles but could not eliminate them completely. Nevertheless, using the optimized parameters, we could perform controlled retinal cuts despite the generation of gas bubbles.

Unlike the first model of PEAK, the PEAK-fc has integrated a coagulation mode. To test this mode, we artificially damaged arterial branches. All injured arterial branches were coagulated successfully, and bleeding stopped immediately.

IN VITRO HUMAN MODEL

To prove the efficiency and safety of PEAK-fc in human tissue, we tested the device in vitro using human postmortem donor eyes. After open-sky vitrectomy and induction of posterior vitreous detachment in 16 donor eyes, we made incisions with the PEAK-fc. For the in vitro studies in human donor eyes, we used only parameters that had been proven to be efficient in the animal models. Accordingly, voltage was varied from 300 to 500 V, pulse repetition rate was set at 300 Hz, pulse duration was 100 µs, and 30 minipulses were set per pulse (Table 1). With respect to the results obtained in vivo, where changing voltages was the most effective variable, we altered only the level of voltage in the human eyes while keeping all other parameters the same. Additionally, we used only the 0.6-mm probe, offering safe cutting under visual control, for the in vitro studies.

CLINICAL OBSERVATIONS

Macroscopically, only slight whitening of the retina without any loss of tissue was observed. In some cases, even careful manual separation of the dissected retina was necessary to demonstrate complete dissection. Lack of traction during cutting was evident from the clinical observations.

As in the in vivo experiments, the formation of gas bubbles occurred. The amount of bubbles was low, so they did not interfere with surgical experiments.

HISTOLOGIC ANALYSIS

Light microscopic analysis (Table 1; **Figure 3**B, C, and D and **Figure 4**) of all retinal specimens confirmed the

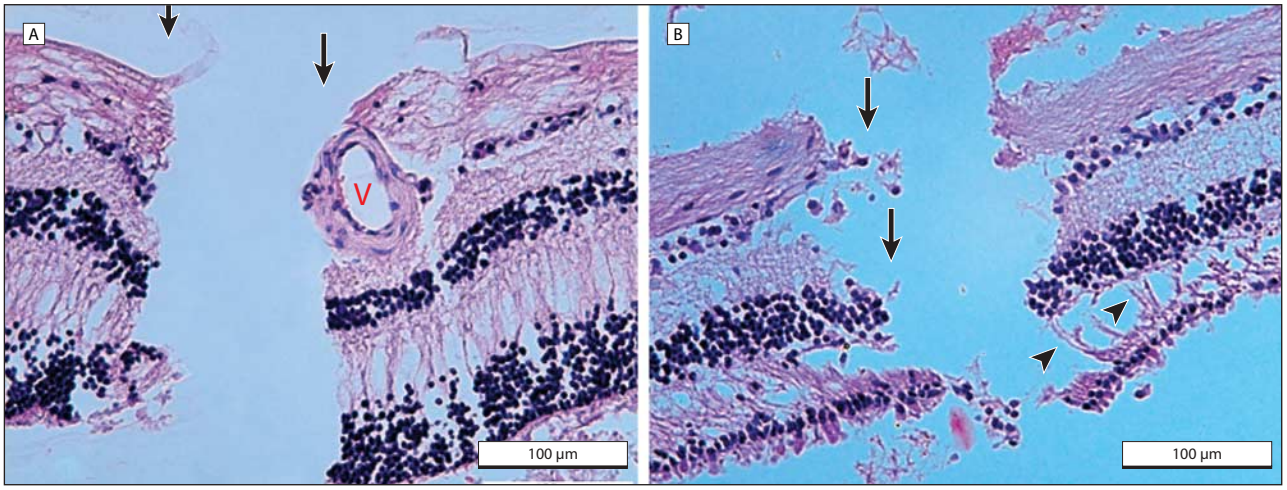

Figure 4. Collateral damage of pulsed electron avalanche knife–fine cutting (PEAK-fc) cuts in human postmortem retinas depends on the level of voltage. A, Cut in a human retina produced at an amplitude of 350 V, a pulse repetition rate of 300 Hz, a pulse duration of 100 microseconds, and a scanning rate of 1 mm per second and 30 "minipulses" per pulse. The incision edges are clearly delineated (arrows). The retina is well organized and shows no coagulation damage. A vessel (V) on the retinal surface remained undamaged, indicating that the energy level sufficient for cutting the retina does not harm retinal vessel walls. When we used higher voltages, the zone of collateral damage increased to 100 µm. B, Ill-defined incision edges (arrows) and collateral damage (arrowheads), especially edema, of a retina dissected with 450 V.

clinical observation that neuroretinal layers were completely dissected using voltage levels from 350 to 500 V. Along with an increase of voltage higher than 400 V, the cuts exceeded the level of the RPE and affected the underlying RPE (Figure 3C), choriocapillaris, and choroid (Figure 3D). Using voltages lower than 380 V, no effect on the structures below the RPE could be detected in any specimen (Figure 3A and B). However, because this was a postmortem study, partial faint detachment of the retina as often seen in autopsy eyes might have prevented damage to deeper ocular structures such as the choriocapillaris and the choroid.

The width of the collateral damage zone varied between 0 and 100 µm with a proportional increase in the damage zone related to voltage level (Figure 4A and B). Below 400 V, the incision edges were sharp and revealed well-preserved retinal layers (Figure 3A and B; Figure 4A). The PEAK-fc cuts immediately next to retinal vessels showed no effect on the vessel itself. Histological examination (Figure 4A) revealed no signs of vessel damage.

COMMENT

In the present study, the PEAK-fc, the advanced version of PEAK, allowed for effective and reproducible cutting of retinal tissue. We demonstrated that the penetration depth of PEAK-fc cuts and the extent of collateral damage mainly depends on voltage, the probe length, and the distance of the probe to the retina.

We identified the following PEAK-fc parameters as safe for intraocular use: voltages of 350 to 380 V, pulse repetition rates of up to 300 Hz, pulse durations of 100 microseconds, and 30 minipulses per pulse. In contrast with laser systems (Er:YAG, carbon dioxide, and Ho:YAG lasers), which either revealed a variable ablation depth and lower reproducibility[20] or induced deep collateral damage in the surrounding tissue,[4,5] these PEAK-fc parameters allowed efficient, constant, and reliable retinal dissection, avoiding damage of structures deeper than the neuroretinal layer and showing little collateral damage of the retina. Using the listed parameters, no retinal detachment occurred intraoperatively and almost no signs of collateral damage could be observed. In the majority of cases, only faint retinal whitening was noted. This slight whitening and the opening of the cut due to tissue tension made the cut sufficiently visible, therefore avoiding "invisible cutting," which might of course be dangerous.

Because the cutting depth depends on the distance between the PEAK-fc probe and the retina, a constant distance must be maintained during tissue dissection. In our experiments, the probe was conducted along the retinal surface by gently touching the retina to avoid uncontrolled deeper penetration. It turned out that the 0.6-mm probe was more suitable for the described surgical maneuvers in comparison with the 0.3-mm probe, which could hardly be visualized during dissection of retinal tissue. With respect to this observation, we state that the 0.3-mm probe leads to insufficient penetration compared with the 0.6-mm probe. We therefore decided to use the 0.6-mm probe for our in vitro experiments, and we recommend this probe for future clinical trials.

Recently, the 3-dimensional damage zone induced by the first model of PEAK was accurately measured in vitro and in vivo by staining the damaged tissue with propidium iodide.[18] These experiments demonstrated that tissue damage induced by PEAK was dominated by the effects of cavitation bubbles. The size of the damage zone could reach 300 µm depending on the voltage and number of pulses.

The PEAK-fc was introduced for more precise cutting of retinal tissue by rapid vaporization and ionization, rather than mechanical fragmentation of retinal tissue. Although the PEAK operated with single pulses of 100 nanoseconds in duration and voltages of 2000 to

5000 V,[16,17] the PEAK-fc offers much lower voltages (300-500 V) and longer pulses of about 100 microseconds, each of them consisting of a burst of several minipulses. Also, the PEAK probe was an inlaid disk, but the PEAK-fc operates with a protruding wire of 0.3 mm or 0.6 mm in length. Furthermore, a coagulation mode was added.

In contrast with the previous version of this device with limited cutting depth and cavitation-dominated collateral damage, the PEAK-fc provides a sharp and rapid dissection of retinal tissue, causing very little cavitation damage. By using optimal pulse parameters for dissection of the retina, collateral coagulation damage from the PEAK-fc could be reduced to minimal changes, hardly detectable in light microscopy. However, there is no surgical device that does not produce any collateral damage: at least 1 layer of cells at the edges will be damaged just because those cells are cut. With optimal settings, the PEAK-fc seems to produce precise cutting with collateral damage that is well acceptable for vitreoretinal surgery.

In contrast with the PEAK-fc, the use of conventional intraocular scissors may induce unintended tractional forces on the retina, causing mechanical trauma. These traction forces can be avoided and damage can be limited when using the PEAK-fc. Therefore, this device may be a promising tool for tractionless preparation of delicate ocular structures, such as the peeling of fibrovascular epiretinal membranes, eg, in proliferative vitreoretinopathy or in proliferative diabetic retinopathy. A combination of precise cutting and excellent illumination with an integrated light source allows for bimanual surgical approaches, for example, for tangential ablation of epiretinal membranes. Clinical studies must be performed to confirm the value of this new device in clinical practice.

A major adverse effect of using the PEAK-fc is the formation of gas bubbles that potentially impair the surgeon's view of the retina. The amount of gas bubbles generated by PEAK-fc can be compared with gas development in conventional intraocular diathermy. By optimizing the pulse parameters, particularly by reducing voltage and providing effective and safe retinal cutting as described earlier in the article, gas bubbles could be reduced to an acceptable degree.

In summary, the PEAK-fc is a new cutting device for intraocular surgery with an integrated light source, allowing bimanual surgery and potentially making vitreoretinal surgery more precise and safer. A limitation of the current study is that the observations obtained in the animal model and in vitro human experiments do not completely mimic the intraoperative situation in patients undergoing vitreoretinal surgery. Therefore, with respect to our in vitro human and in vivo animal experiments, a multicenter trial has been initiated to evaluate the intraoperative properties of the PEAK-fc in anterior segment and in vitreoretinal surgery. With ongoing development of this device, a wider range of indications for its application can be expected.

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