# Pulsed electron avalanche knife for capsulotomy in congenital and mature cataract

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The pulsed electron avalanche knife (PEAK-fc, Carl Zeiss Meditec) is an electrosurgical cutting device that allows precise "cold" and traction-free tissue dissection. We describe its applicability and safety for anterior capsulotomy in a child with congenital cataract and an adult patient with mature cataract. The PEAK-fc was set at a voltage of 600 V and a pulse repetition rate of 80 Hz. Anterior capsulotomies were successfully and safely performed in both cases, with the edges of capsulotomies appearing sharp and showing only limited collateral damage. The PEAK-fc appears to be a helpful cutting device for complicated cases of cataract surgery, especially for mature and congenital cataracts.

*J Cataract Refract Surg 2006; 32:1085–1088 © 2006 ASCRS and ESCRS*

The pulsed electron avalanche knife (PEAK-fc, Carl Zeiss Meditec) was recently introduced for "cold" and traction-free dissection of tissue in liquid medium.[1–4] This new electrosurgical device works by induction of plasma generated microsecond pulses of high electric fields. Because PEAK-fc uses pulses with a duration of about 100 ms, the heat diffusion to the surrounding tissue is limited to about 10 mm, thereby inducing little thermal collateral damage. Consequently, the PEAK-fc technique is referred to as *cold* cutting.[1–4] The cutting part of the PEAK-fc probe is a protruding tungsten wire with a diameter of 50 µm (Figure 1). The wire used in this study extends from the glass insulator (length 0.6 mm).

We recently demonstrated the multifunctional applicability of PEAK-fc in vitreoretinal surgery.[5,6] It was successfully used for a variety of surgical maneuvers commonly encountered in patients having vitreoretinal surgery. Based on these promising experiences, we decided to evaluate the applicability of this new microsurgical tool for anterior segment surgery. The safety and efficacy of PEAK-fc in pediatric and adult patients having cataract surgery were evaluated.

## SURGICAL TECHNIQUE

After preoperative dilation of the pupil, the conjunctival sac was flushed with 10 mL povidone–iodine 10% rinsing solution. For cataract surgery of the mature cataract, a superior sclerocorneal incision was then created using a diamond blade followed by a 2.75 mm steel keratome (Alcon). Two 1.2 mm clear corneal incisions were performed with a 15-degree keratome (Alcon), and the anterior chamber was expanded with ophthalmic viscosurgical device (OVD) (sodium hyaluronate, Healon). Trypan blue (Vision Blue, DORC) was used to enhance visualization of the anterior lens capsule, as described in the literature.[7,8]

For capsulotomy, the PEAK-fc probe was slowly moved along the capsule in a circular manner (6.0 mm diameter), with a velocity of approximately 1 mm/s to avoid tractional forces and pressure on the lens capsule. The PEAK-fc parameters were set as follows: pulse repetition rate, 80 Hz;

Accepted for publication January 27, 2006.

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Presented in part at the XXIII Congress of the European Society of Cataract & Refractive Surgeons, Lisbon, Portugal, September 2005.

Daniel Palanker has a patent-related financial interest in PEAK. No other author has a financial or proprietary interest in any material or method mentioned.

Part of this project (Stanford University) was provided by the NIH R01 EY01288 grant and by the Whitaker Foundation grant RG-03-0042.

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0886-3350/06/$-see front matter
doi:10.1016/j.jcrs.2006.03.020

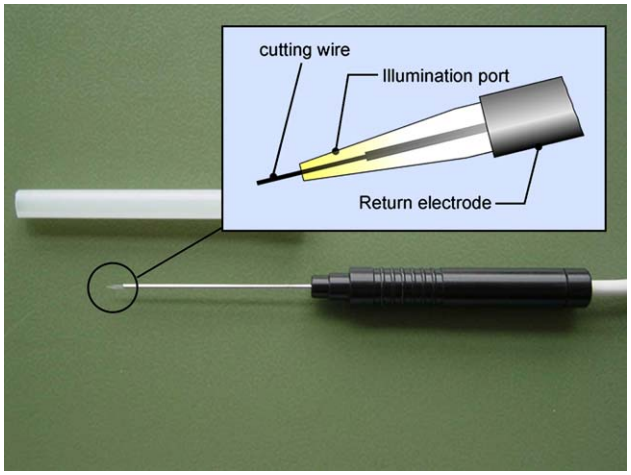



**Figure 1.** Diagram of PEAK-fc probe. The cutting part of the PEAK-fc probe is a protruding Tungsten wire with a diameter of 50 μm. The wire used in this study extends from the glass insulator 0.6 mm in length.

number of minipulses per pulse, 60; and pulse duration, 100 μs. Voltage varied within a range of 600 V. The PEAK-fc was initially set at the values that had been determined in animal and in vitro studies as safe and efficient for dissection with only minimal collateral damage.[5] Parameters were increased until the desirable tissue effect was observed.

After hydrodissection, cataract extraction was performed using the divide-and-conquer technique.[9] The Megatron S3 (Geuder) phacoemulsification unit was used, with an ultrasound power set at 100% and a phaco tip angled at 30 degrees.

For congenital cataract extraction, anterior capsulotomy with PEAK-fc was performed as described earlier. However, cataract surgery differed with respect to the access and extraction technique. Only two 1.2 mm clear corneal incisions were created using a 15-degree keratome, and the congenital cataract was extracted by bimanual lens aspiration under general anesthesia. After hydrodissection with prolapse of the entire lens or at least half of the lens out of the capsular bag, lens extraction was performed using the Geuder Megatron S3 irrigation/aspiration mode, followed by polishing of the posterior capsule. After injection of an OVD into the capsular bag and anterior chamber, 1 of the clear corneal incisions was enlarged to 2.0 mm and the intraocular lens (IOL) (AcriSmart, AcriTec) was inserted with a shooter. Bimanual irrigation/aspiration was performed to remove all OVD. Finally, stromal hydration of the corneal incisions was performed to ensure sufficient wound closure. The IOL power was extrapolated to the age of 15 years.

All maneuvers were recorded on videotape to document the efficacy and possible complications.

*Case Reports*

We selected 2 patients with congenital and mature cataract because in these cases, the proven benefits of PEAK-fc, such as tractionless cutting, might contribute to a safer surgical procedure. Exclusion criteria were history of glaucoma, visual acuity less than 20/800 in the fellow eye, or a medical history requiring systemic anticoagulation. Written informed consent was obtained concerning the intraoperative use of PEAK-fc from the patient and the infant's parents, respectively.

*Case 1.* A 45-year-old man with mature cataract presented with a history of ocular trauma to his left eye 6 months before his first visit to our clinic (Figure 2, *A*). Visual acuity already had deteriorated to hand movement. Slitlamp examination revealed a white mature cataract and a distinct phacodonesis; intraocular pressure was 17 mm Hg. Ultrasound examination was performed to exclude intraocular abnormalities.

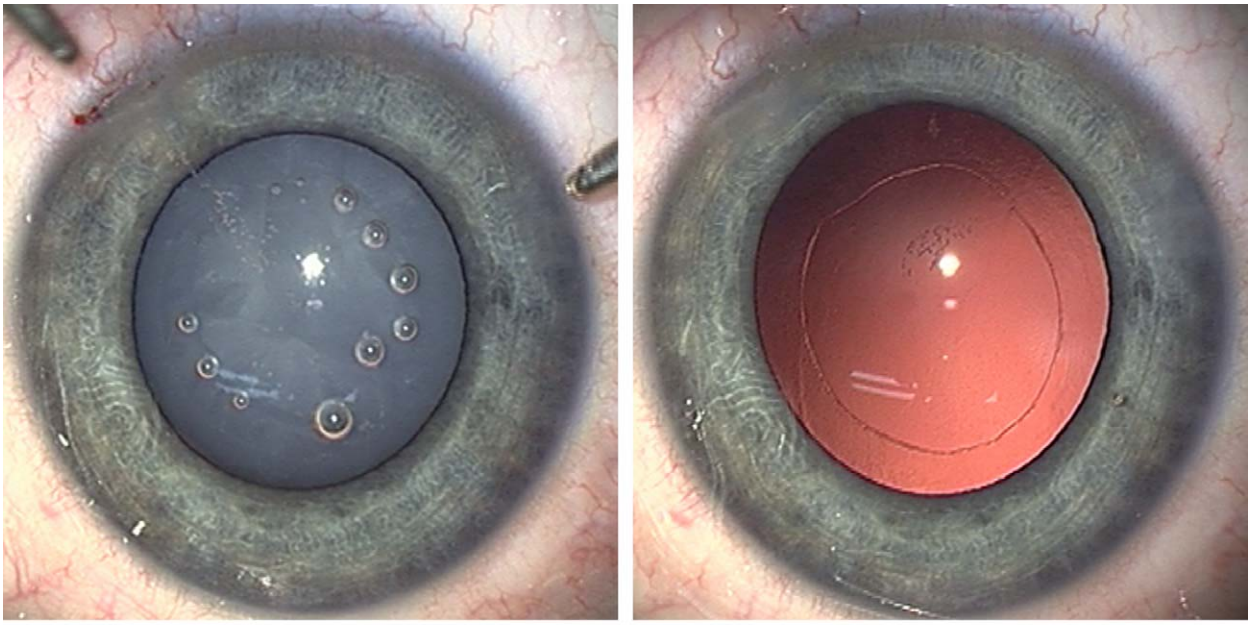
*Case 2.* A 2-year-old girl with congenital cataract in the left eye presented to our clinic for the first time at 1 year of age. At that time, her left eye showed incipient cataract formation. Therefore, amblyopia therapy was performed for 1 year. As cataract formation continued to increase, cataract surgery was performed at 2 years of age.

*Results.* Anterior capsulotomy was successfully performed in both the mature and congenital cataract. Identical PEAK-fc parameters were used in the 2 cases: voltage of 600 V, pulse repetition rate of 80 Hz, 60 minipulses per pulse, and pulse duration of 100 μs. Slow movement of the probe along the capsule in a circular manner with a velocity of approximately 1 mm/s appeared to be most crucial for a successful surgical procedure. The PEAK-fc cuts showed sharp edges with hardly visible whitening, indicating negligible collateral damage (Figure 2, *B*). No major intraoperative complications occurred. Formation of gas bubbles similar to those seen during conventional diathermy was observed and slightly impaired vision during surgery. However, for the PEAK-fc parameters used, the amount of bubbles was reduced to a minimum and controlled cuts could be performed despite the generation of gas bubbles in both cases.

Ophthalmological examinations including visual acuity testing, slitlamp examination (clarity of cornea, flare and cells in the anterior chamber), intraocular pressure, and fundus biomicroscopy showed regular ophthalmological findings during the follow-up period of 3 months.

## DISCUSSION

In this study, we report an initial clinical experience with the new cold-cutting device, PEAK-fc, in anterior segment surgery. We successfully performed a capsulotomy in both a congenital and a mature cataract.



A B

**Figure 2.** *A:* Patient presenting with mature cataract. Anterior capsulotomy with PEAK-fc at a voltage level of 600 V and repetition rate of 80 Hz was performed. *B*: Sharp edges of the capsulotomy indicate little collateral damage.

Continuous curvilinear capsulorhexis (CCC), first described by Neuhann and Gimbel,[10,11] is currently the preferred technique to achieve a circular and stable anterior capsulotomy. However, especially in cases of mature and congenital cataract,[12,13] the risk for peripheral extension of the cut (radial rips of CCC) is markedly increased. In the pediatric eye, this is due to specific characteristics such as high elasticity of the capsule and increased posterior pressure.[13] In the adult eye, conditions such as white cataract may pose certain challenges to the surgeon when performing CCC and imply risks concerning the surgical outcome due to the lack of the red fundus reflex or liquefied cortex in cortical mature cataracts. In contrast to CCC, which usually exerts a certain degree of traction on the capsule, PEAK-fc dissects tissue without any traction, thus preventing unintended tears. In the cases presented, we demonstrated that PEAK-fc allows the surgeon to perform traction-free and controlled capsulotomies in a safe and quick way, thereby avoiding potential complications such as the risk for radial rips. Cuts with PEAK-fc showed almost no thermal damage in the cutting zone.

Another technique for creation of anterior capsulotomy in eyes with poor or missing red fundus reflex is the high-frequency capsulotomy (HFC).[14–16] In contrast to PEAK-fc, HFC has been associated with a higher risk for capsule tears and intraoperative and postoperative complications than CCC.[17–20] Histological examination of HFC cuts revealed thermal damage,[21] decreasing the biomechanical stability of the anterior capsule opening.[17–20]

A mechanized (vitrector-cut) anterior capsulotomy technique (vitrectorhexis) combined with IOL implantation in pediatric cataract surgery was first described in the 1990s.[12] In a retrospective analysis of 208 eyes, the incidence of radial tears was reported to be as high as 7.7%.[22] In addition, this technique requires a long learning curve to achieve best possible results and limit complications.[22] In contrast, PEAK-fc was easy to handle and did not require any long learning curve in applications for cataract surgery.

Recently, the Fugo plasma blade was introduced for capsulotomies with resistant-free incision of the anterior lens capsule.[13,22] Similar to PEAK-fc, the Fugo blade uses plasma technology to create the cut. However, in contrast to our experience with PEAK-fc, a very high percentage of radial tears (5 of 8 cases) during hydrosdissection, lens aspiration, or IOL implantation has been associated with this technique.[22] The Fugo plasma blade, therefore, might have failed to achieve a widespread acceptance although it is capable of precise dissection of ocular tissue.

One disadvantage of PEAK-fc is the formation of gas bubbles interfering with the surgeon's view of the operating field. The amount of gas bubbles generated by PEAK-fc is comparable to that with conventional intraocular diathermy. However, in the 2 cases presented, the development of gas did not impair vision to a degree making surgery

uncontrollable. We point out that PEAK-fc is a new technique that is still in development. An advanced version that will produce markedly less bubbles is currently under construction and preclinical evaluation (personal communication).

The PEAK-fc was successfully used for complicated cases of anterior capsulotomy. It allowed surgical cutting in a very precise manner, resulting in capsulotomies with induction of only minimal collateral damage at the edges of the cut. However, additional studies enrolling larger patient series will be required to confirm these results and accurately determine the role of this new instrument in cataract surgery.

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