Laser-phakopuncture in the treatment of soft cataracts

M. M. KRASNOV
State Institute of Ophthalmology, Moscow, U.S.S.R.

The use of lasers in medicine is a fairly recent development. Clinical studies have usually made use of the thermal (coagulating) effect of laser irradiation. The application of lasers in ophthalmology has so far been confined mainly to lesions of the fundus, such as retinal detachment and diabetic retinopathy. Other (non-thermal) effects have more recently been investigated and have been employed for the first time in clinical ophthalmology (Krasnov, 1972).

In contemporary surgery, published papers show that there is interest in the possibility of using a laser beam instead of a knife. This is seen in neurosurgery, dermatology, and otolaryngology. In biology the same applies (laser microsurgery of the cell).

The transparency of the ocular media makes the use of lasers especially promising. In some diseases the thermal action is exactly what is needed to serve the aim of the treatment, for example to achieve coagulation of the newly formed blood vessels in diabetic retinopathy. For many other purposes, however, the burn to the ocular structures is contra-indicated, and it is the mechanical, cutting effect that is required. An interesting way of solving this problem is the use of Q-switched (or modulated) pulses of laser energy. Their main characteristic is their extremely short duration of only a few nanoseconds (10^-8 s and less).

We started to work along these lines, having consulted the Nobel laureate, A. M. Prokhorov, who confirmed the theoretical validity of the underlying idea.

The anterior segment of the eye presents considerable scope for the use of the laser for purposes previously achieved by surgery: this "laser microsurgery" of the anterior segment of the eye is virtually a new field of exploration.

Since 1970 the author has had much experience in the laser treatment of glaucoma. The procedure of Q-switched laser gonipuncture, laser iridectomy, and laser cyclodalysis have been advanced and developed for clinical use in different forms of glaucoma (Krasnov, 1973; Krasnov, Saprykin, Doronin, Nikolskaya, Akopyan, and Mamedov, 1973). The laser was also successfully employed to fix an intraocular lens to the iris (extrapupillary iris-lens: Krasnov and Orlova, 1969).

In the course of this work a number of basic problems had to be solved concerning the principles and effects inherent in the interaction of a laser beam with the ocular tissue at the target point. Among them were the study of the optimum characteristics of the laser impulses (duration, output, energy, etc.) in different clinical situations, and of channelling powerful laser beams into the eye, dosage, safety requirements, etc. Experimental studies on animal eyes were carried out in preparation for the clinical work.

A new Q-switched laser unit was designed (Krasnov, 1972), mainly for the use in the anterior segment of the eye. The present communication is confined to the subject of cataract treatment.

The laser has already been successfully tried for the perforation of the secondary membranes in the pupillary region (Eroshevsky, Panfilov, and Semenov, 1971; Krasnov and others, 1973; Massin and Gernet, 1973), but no reports have been traced by the author on the use of the laser in non-membranous cataracts.

The basic idea of the present investigation stemmed from data obtained from some of our studies, which seemed to support the possibility of breaking the lens capsule by a Q-switched laser pulse. The application of such a method is, by its very principle, limited to so-called "soft" cataracts, in which a conventional discission procedure might have been the method of choice. It should be pointed out that the procedure of discission once held a prominent place in the surgery of soft cataracts, but that the operation later lost much of its popularity, mainly because it involved the risk of complications such as phakoanaphylactic uveitis and phakolytic glaucoma. The availability of treatment to control these complications has greatly increased since that time.

The above considerations constituted a basis for the experimental treatment of cataract with the laser.

First, experiments were carried out on the eyes of thirty chinchilla rabbits to investigate the foundations of the method. Q-switched ruby and neodymium lasers were used with the output energy of a single pulse (measured at the target point) of up to 0.3 J and a pulse duration of about 20 nanoseconds. It was easy to demonstrate the rupture of the lens capsule (as a rule, with the first pulse).

Strong pulses of laser energy may be harmful to the
inner structures of the eye: this particularly concerns
the neodymium lasers. Certain precautions are there-
fore needed to prevent retinal damage, one of the most
important being very short focusing.

Our experimental data will be summarized in a
separate communication. The main conclusion was
the feasibility of clinical trials with human subjects.

From 1972 onwards, the procedure of Q-switched
laser phakopuncture was tried on human eyes. In
the first place ten eyes with senile cataract were
treated, and in none was the capsule ruptured. This
revealed the important fact that the anterior capsule
of the human lens is more resistant to laser irradiation
than that of the rabbit lens. Eventually all the eyes
thus treated were subjected to a conventional cataract
extraction; it was found that there had been no
damage to the visual function, and the procedure was
then tried for the treatment of soft cataract.

Laser phakopuncture was carried out on the eyes
of a series of nine children, whose ages ranged from
4 to 12 years. The cataract was congenital in six
cases and traumatic in two, and in one the underlying
tissue remained uncertain (? uveitis). Only topical
anaesthesia (for instance, 1–2 drops of 0·5–1 per cent.
pontocaine) was required.

As with the adults (see above) the capsule could not
be ruptured as easily as in our experiments on animal
eyes. More sophisticated ways had therefore to be
found. Nature sometimes affords an easy solution
whenever there are dark (pigmented) deposits on the
capsule: these are potential absorbents of light
energy, and the capsule is, as a rule, easily torn at such
points by an incident laser pulse. If the capsule is
transparent throughout its entire surface, it is some-
times possible to puncture it by delivering the pulse
at the pupillary border. The pigment granules
accumulated in this region serve as photoacceptors,
but they, naturally, must be in contact with the
capsule. Some injury to the pupillary margin is thus
unavoidable, but there is virtually no harm in this.
The lesion can, of course, be conveniently localized
under the upper lid.

In another method which proved to be reliable, the
procedure was divided into two stages:

(1) The iris was pre-treated with the laser in a
similar way to that used in cases of retinal detachment,
_i.e._ by producing a burn in the iris tissue which
caused an iridocapsular adhesion. The posterior
synechiae thus formed are always pigmented and
present convenient target-points for a subsequent
laser phakopuncture.

A conventional argon laser can be employed for
this pretreatment procedure. The pupil should be
made conveniently narrow by the use of a suitable
miotic, and should be kept constricted for several
days afterwards to enhance the formation of the
synechiae.

(2) For the second stage, on the contrary, full
mydriasis is required. The posterior synechiae are
either ruptured or become exposed, thus providing
the pigmented target-points of light absorption.
Conventional (non-modulated) lasers can sometimes
be employed for this second-stage procedure also.

With the use of the techniques described, laser
capsulotomy was eventually produced in all our
cases. Mydriasis needs to be maintained continuously
for a period of several months afterwards to prevent
the puncture site from becoming closed by the iris.

A successful Q-switched laser-phakopuncture starts
a slow process of liquefaction and resorption of the lens
substance. As a rule, there is no massive herniation
of the lens material into the anterior chamber
because the hole in the capsule is too small. On the
contrary, we observed a tendency to gradual obliteration
of the defect by proliferation of the
capsular epithelium. Closure of the capsular rupture
is an indication to repeat the laser “incision”.

Complete reabsorption of the lens substance in
our patients took several months (up to approximate-
ly one year). Signs of a very mild inflammatory
response could sometimes be detected, but subsided
quickly after local treatment with steroid drops. There
were no other complications.

The most important result of our investigations is
the possibility of achieving aphakia without surgery.
Q-switched laser-phakopuncture should of course
never be attempted in the case of cataracts with a
hard nucleus or with signs of tissue proliferation
(for instance, after long-standing uveal inflammation).

The anatomical results in our cases were, on the
whole, better than the functional ones. In spite of
complete reabsorption of the lens substance, full visual
acuity was achieved in only two cases out of nine,
although there were no clinical signs of retinal
damage due to laser irradiation. It therefore seems
probable that some of the eyes had been amblyopic;
this is often the case with congenital cataracts, and is
often responsible for the poor visual results of surgical
treatment.

**Summary**

A new method of treating soft cataracts by laser
irradiation is described (“laser-phakopuncture”).
Rupture of the lens capsule can be produced by a
strong laser pulse focused on the anterior surface of
the lens. This is followed by gradual reabsorption
of the lens substance (in much the same manner as
with a conventional discission procedure). Pigment
deposits on the capsule are usually necessary to
ensure sufficient absorption of light energy at the
target point. The laser beam can also be employed in
a preliminary procedure to produce such pigmented
spots, and to prepare the eye for a subsequent laser-
phakopuncture.
The method was first investigated experimentally on animal eyes. The so-called Q-switched lasers proved to be most effective in producing a tear in the capsule. It was then tried clinically in nine juvenile patients and reabsorption of the lens substance was the eventual result in all cases, although full visual acuity was achieved in only two of them.

The use of lasers offers a completely new approach to the treatment of cataract without surgery.

References


——— (1973) *Amer. J. Ophthal.*, 75, 674

