LASIK: Keratomileusis Eventually Comes of Age?

CHAD K ROSTRON
St George’s Hospital, London, UK

INTRODUCTION

Laser in situ keratomileusis (LASIK) was born in 1990 [1] and nurtured in the caring hands of the current generation of keratorefractive surgeons. Rapidly heralded as the latest panacea for all or any optical defect, LASIK has already been evaluated by ophthalmologists world-wide and its true niche is becoming established as it is subsumed into mainstream ophthalmology.

LASIK could not have come into existence without the previous development of keratomileusis, first described by José Barraquer in 1949 [2]. The more ponderous evolution of keratomileusis itself speaks of a bygone era, before electronic communications and commercial interests injected increasing impetus into ophthalmic research and development. Keratomileusis — derived from the Greek for ‘cornea’ and ‘chiselling’ — was the first effective refractive surgical procedure described and, indeed, represents the initiation of keratorefractive surgery itself. Barraquer devised the first microkeratome with which to resect corneal lamellar buttons. By incorporating cryo elements into a watchmaker’s lathe he was able to grind the isolated corneal lamellae to alter their refractive power, in order to correct both myopia and hypermetropia.

In his initial work with corneal tissue resected from the patient’s eye (autoplastic keratomileusis) Barraquer was able to correct a range of spherical refractive errors, up to around −15 D of myopia and +8 D of hypermetropia. The limitations in the range of refractive error correctable were not defined by the limitations of the equipment but, on the contrary, by the more fundamental limitation of how much change in corneal profile could be achieved with the raw material of the patient’s cornea alone. To overcome this, Barraquer used donor corneal tissue excised by microkeratome from a donor eye (homoplastic keratomileusis) and the additional thickness of tissue derived allowed the refractive range to be extended. Because of the more complex corneal profile required for hyperopic keratomileusis, the procedure had a smaller range than myopic keratomileusis (where the optical zone is effective over a greater proportion of the lamellar button).

In those pre-intraocular implant days, the correction of aphakia was a pressing need, but many aphakic refractions were beyond the range of hyperopic keratomileusis. Barraquer’s response was keratophakia – a pre-lathed donor tissue button to implant beneath an unlathed superficial lamellar keratectomy — extending the range of hyperopic correction achievable to around +20 D.

Despite the fact that both homoplastic keratomileusis and keratophakia allowed the lathing of the corneal tissue to be separated from the rest of the operation, these procedures remained complex, the equipment expensive and training in the technique difficult. Keratomileusis was pioneered in England by Derek Ainslie [3], but for 30 years it was carried out by only a handful of ophthalmologists world-wide and it remained an exotic ophthalmic curiosity.

EPIKERATOPHAKIA DEVELOPS FROM KERATOMILEUSIS

TP Werblin conceived of epikeratophakia in 1979, while pondering on the raised burial chambers found above ground level in the cemeteries of New Orleans. The potential of this idea was immediately appreciated and developed by Herb Kaufman [4]. The technology to carry out epikeratophakia had been in
The concept of the incomplete superficial lamellar flap on a hinge, originally described by Barraquer [13], was adopted by Pallikaris, who named the technique 'LASK' [1]. This small technical advance, combined with a simultaneous push by the laser and micro-instrument manufacturers, produced an unprecedented growth curve in LASK, changing it from concept to cure almost overnight.

**LASK: THE EARLY DAYS**

The path which LASK was set to follow was that of a useless microlaminate system combined with excimer laser systems in their youthful stages of development. With PRK having already made a significant head start in the keratorefractive market place, LASK initially had a difficult way to tread, directly in the footsteps of its elder sibling. Thus LASK was seen as a solution for the cases that PRK could not reach [15-17] - the higher levels of myopic correction where significant haze and regression were being encountered [18,19]. There seems no doubt that LASK does indeed offer relative freedom from axial scarring and regression effects in comparison to PRK [20,21], but the extent to which this is bound up with the excimer laser delivery systems themselves rather than the difference in operative techniques only became apparent as the two procedures evolved.

**LASK and PRK for myopia correction**

Where then does LASK now stand in the family of keratorefractive techniques, in particular in relation to PRK? On the face of it one would expect that comparisons could readily be made between two operations capable of hewing identical conditions, and now results of a few direct comparative studies are becoming available. Where the two techniques have been directly compared, LASK has been shown to give superior results for a number of criteria [22-24]. However, one stumbling block to obtaining a simple comparison of the two procedures is the ability to offer LASK patients re-treatment within a few months of the original treatment. At 3 months postoperatively many cases of PRK are barely half way to reaching a final stable refraction, yet virtually all LASK patients at this point will have reached a stable endpoint [22]. If one waits until 12 months for an analysis, direct comparisons can be made. This is an important point for patients who have had their refractive surgery performed elsewhere and who desire to have the surgery reviewed and perhaps refurnished.

**Optical Zone size and shape**

With a short time of observation, it became apparent that results were being achieved with the resultant postoperative optical zone size and shape being inadequate [25,30]. By achieving even energy delivery beams, laser manufacturers have been able to improve the optical zone size and shape obtained by the development of adaptive control systems, to achieve more uniform and accurate optical results.

Because hyperopic LASIK ablation over a zone larger than the optical zone can lead to significant astigmatism, it is important to recognize the importance of utilizing a robust and accurate optical zone sizing system.
complete superficial lamellar described by Barraquer girls, who named the tech-

nical advance, push by the laser and aturers, produced an

ve in LASIK, changing it at

ight.

s to follow was that of a

a system combined with

their youthful stages of

ving already made a sig-

keratorefractive market

is difficult way to treat,

lder sibling. Thus LASIK

cases that PKR could

their levels of myopic con-

aze and regression were

There seems no doubt

rate freedom from

n effects in comparison to

which this is bound up

ery systems themselves

ative techniques as the two procedures

OPTICAL CORRECTION

ew stand in the family of

particular in relation to

would expect that com-

between two opera-

identical conditions, and

comparative studies are

the two techniques have

LASIK has been shown to

a number of criteria

bbling block to obtain-

the two procedures is the

is re-treatment within a

ment. At 3 months

is of PKR are barely half

tection, yet virtually

will have reached a

ews until 12 months for

an analysis, direct comparisons can be made for

patients who have had a single treatment, but this
denies patients the major benefit of LASIK, in that

any deviant refractive outcome can be quickly re-
treated. The problems of analysis are further com-
pounded by the speed of evolution of eximer laser

s, such that in the space of time necessary to

recruit and follow-up a reasonable cohort of patients,

ances in software or hardware will have made

any assessment that of yesterday's technology.

LASIK has now found a place for correction not

only of the higher degrees of myopia, but also for

the small errors previously treated by radial keratotomy or

PKR [25]. Two recently reported prospective compar-

ative studies of PRK and LASIK in low to moderate
degrees of myopia have clearly shown the benefit

of LASIK for this group, with faster visual rehabilita-

and better rates of restoration of normal acuity [26,27].

A further excellent prospective study compared the

results of simultaneous and consecutive bilateral

LASIK [38]. There was no significant difference in out-

comes between the two groups, with the unexplained

exception of more frequent epithelial in-growth in the

simultaneously treated group.

OPTICAL ZONE SIZE AND HYPEROPIC TREATMENT

Within a short time of evaluation of myopic PRK it

became apparent that the optical zone diameters that

were achievable with the early laser systems were

inadequate [29,30]. Because of the limitations of

achieving even energy density over a broad eximer

beam, laser manufacturers have moved to various

scanning systems whereby large area ablations can be

achieved by smaller beams [31]. This has been assist-

ed by the development of associated tracking systems

to ensure accurate placement of the treatment.

Because hyperopic eximer laser PRK requires

ablation over a zone larger than that in which the opti-
cal correction is obtained, the development of hyper-
opic treatment has lagged behind that of myopic

PKR. Early results confirmed the ability to treat low

levels of hypermetropia with PKR, but there was a

greater tendency to problems with regression and

loss of best-corrected acuity compared with similar
degrees of myopic treatment [32-34]. LASIK again

seems to outperform PRK for hyperopic treatment,

although there are only early reports available

[35,36]. Initially, the actual laser ablation parameters

being used in both PKR and LASIK were identical,

and even today some LASIK surgeons are still using

the same hardware and software programs inter-

changeably for the two procedures. By using laser

treatment profiles for hyperopic ablation that are

specifically tailored for LASIK there is potential for

further improvement in the range and quality of

results.

CONCLUSION

Today's laser systems can offer refractive corrections

for both myopia and myopic astigmatism that are

limited in their range of effect only by the physical

constraints of the minimal residual corneal thickness

after treatment (up to ~10 to ~15 D). For hyperme-
tropia and hyperopic astigmatism, treatments are

improving but at present are only reliable for the

lower degrees (up to around ±5 D).

Because of intrinsic biological variability it seems

unlikely that any keratorefractive system will ever

be able to achieve perfect precision in every case,

and LASIK's relative ease of speedy secondary

adjustment is a clear benefit in this respect. In addi-

tion, the virtually painless postoperative period

and rapid visual rehabilitation make the procedure

extremely favourable from the patient's perspective.

The view that LASIK is PKR performed properly is

one now shared by many surgeons.


