The Comanagement of Radidal Keratotomy

Senior Project

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Radial keratotomy has definitely become a household name in recent years. This procedure which everyone seems to be talking about is the biggest thing to happen since contact lenses were introduced to replace glasses. Now people want to be rid of glasses as well as contact lenses. With this procedure people expect and hope for perfect vision without the help of any of the conventional methods known to correct for refractive error. Radial keratotomy is not the first technique to be made available to correct for refractive error. Surgical procedures to correct for Ametropia have been around, in theory at least, since early in the 19th century.

The ancient Chinese began by suggesting the use of heavy sandbags to correct for myopia. The recommendation was to place bags of sand over closed eyelids during the sleeping hours with the expectation that this would flatten the cornea and in turn reduce the refractive error. This technique did not catch on due to the fact that the flattening effect of the sandbags probably did not last very long. Sometime early in the 19th century Dr. Ball fabricated a different method to correct for myopia. He designed an instrument similar to a clamp which was placed over the eyes again to flatten the cornea. This technique was not successful for the same reasons the Chinese were unable to correct myopia with the use of sandbags. Following these early unsuccessful attempts to eliminate the need for glasses came several surgical techniques that proved to have a little more promise. Keratomileusis, keratophakia, epikeratophakia and stromal thermokeratoplasty are a few of these procedures.

Keratomileusis:

This method was introduced around 1960 to correct for large refractive errors. Both myopia and hyperopia were successfully corrected by this technique. This surgical procedure involved excising a wedge of the anterior section of the cornea. This slice of cornea was then frozen and altered to reflect the new power desired to correct for the

specific refractive error necessary. Cryolathing was the method used to alter the curvature of the corneal section, the stromal side of the wedge was made flatter for myopic errors and steeper for hyperopic errors. The exact amount needed was calculated using a computer software program with predetermined corneal curvature data. Following the cryolathing the now altered corneal graft was reattached to the patients cornea.

Keratomileusis was a very complex technique needing extremely sophisticated machinery to ensure satisfactory results. It presented with many complications such as perforation of the delicate corneal wedge during the altering step of the procedure, overcorrection and undercorrection due to inaccurate computer calculations, growth of epithelium on the cryolathed surface of the wedge resulting in a change in curvature and finally irregular astigmatism was induced occasionally during the reattachment phase. The foremost reason people were excited about this technique was the fact that it gave surgeons the ability to correct for high refractive errors, both hyperopic and myopic. Nevertheless, keratomileusis did not become a surgical option to correct Ametropia due to its complexity and many adverse effects.

Keratophakia:

The difference between this technique and all other refractive surgery procedures is that this method was not introduced initially with the idea of eliminating the need for glasses. It was intended to be used to compensate for aphakic prescriptions induced following cataract extraction. This procedure began by preparing a pre-selected batch of donor corneal lenticules. These corneal wedges were cryolathed to different specifications and stored for use during the procedure. Due to the limited supply of donor cornea the use of synthetic materials to make the lenticules was attempted. Some of the materials tested were plexiglass, cellulose acetate, flint glass and polyethylene membranes, but none were met with much success due to the fact that they blocked the flow of water through the

corneal layers. The only successful man-made materials were high water content hydrogel contact lens material and polysulfone plastic. The advantage of synthetic materials was that they could be produced in large numbers in all possible parameters without worrying about a shortage in donor tissue.

Keratophakia involved making a lamellar section in the host cornea using an instrument called a microkeratome. The donor or synthetic lenticular, in the desired power, is then placed in the space created. The final stage is suturing the host cornea back over the donor corneal wedge. This procedure was only successful in correcting hyperopic refractive errors, and the improvement in visual acuity was not significant enough to declare this technique a success. The introduction of intraocular lenses for correction of aphakia also helped make keratophakia a less needed surgical procedure.

Epikeratophakia:

This procedure is a clone of keratomileusis and keratophakia. Epikeratophakia is based on these techniques with a simpler and safer methodology. Donor or synthetic corneal wedges are again pre-prepared and freeze dried until needed. The host cornea is numbed with an anesthetic and then the surgeon marks the visual axis. Small epithelial defects are induced using cocaine at a specified distance on either side of the marked visual axis point. The appropriate lenticule is then selected, rehydrated and sutured over the surface of the patients cornea. Shortly after the surgical procedure the epithelium rejuvenates and grows a uniform layer over the graft cornea.

Epikeratophakia was more successful than any of the other lamellar surgical procedures for several reasons: this technique was safer since actual invasion of the cornea was not needed, the procedure was reversible, appeared to be fairly simple and did not require sophisticated equipment. The disadvantages of this technique include neovascularization

of the corneal graft, chronic epithelial detachments and infections. Epikeratophakia is again not a common surgical procedure to correct Ametropia but it is occasionally utilized for aphakes and high myopes.

Stromal Thermokeratoplasty:

This procedure involved the use of heat to shrink the stromal cells which in turns flattened the cornea and compensated for myopic refractive errors. Initially it was used to flatten the cornea of keratoconics in order to fit them with contact lenses more efficiently, but slowly it evolved into a refractive surgical procedure which appeared to have promising results. Several years after the introduction of stromal thermokeratoplasty it was revealed that thinning of the epithelial layers, changes in Bowman's membrane, stromal melting and recurrent corneal erosions were very common side effects. The use of heat to correct for refractive error is no longer recommended as a refractive surgical procedure.

None of the above mentioned techniques are commonly used today to correct for refractive errors and eliminate the need for glasses or contact lenses. The interest in these procedures is mainly historical in nature. Refractive surgeons have not totally abandoned these methods, but they are definitely not as popular as radial keratotomy or excimer laser photorefractive keratectomy. Refractive surgical procedures need to meet fairly rigorous standards of safety and effectiveness due to the fact that they are competing with devices such as spectacles and contact lenses which are known to be fairly effective in treating refractive errors. Safety, reversibility, simplicity, and cost-effectiveness are a few of the attributes of the ideal refractive surgical procedure.

There appears not to be one single technique which meets the ideal safety requirements, and this does result in some controversy when it comes to actually recommending these techniques to patients. The most severe complications of radial keratotomy are considered

globe rupture and endophthalmitis. Both of these side effects are very rare but they do occur. The controversy exists due to the fact that there are many less serious side effects which do reflect negatively on the results of radial keratotomy. These side effects may not be sight threatening but they are very aggravating for the patient. These side effects will be discussed in a later section of this paper. The complications of photorefractive keratectomy are not fully understood at this point, but it appears that globe rupture and endophthalmitis are not a serious threat.

Reversibility is another criterion which is not met by any of the available surgical procedures. The effects of radial keratotomy and photorefractive keratectomy can not be reversed, but they can be adjusted to ensure optimum correction. For radial keratotomy the surgeon increases the number or depth of the incisions to enhance the results. Retreatment of eyes which undergo excimer laser photorefractive keratectomy has also proven relatively successful in adjusting the refractive outcome.

The complexity of a given technique definitely affects how successful it is and in turn how popular it becomes among surgeons. The most desirable procedures are those with the least amount of complexity and fewest steps. Keratomileusis is one of the most complex refractive surgical procedure, it involves many steps which allows for a large margin of error. Naturally, myopic keratomileusis is not a very popular refractive surgical procedure. Radial keratotomy and laser photorefractive keratectomy are fairly easy procedures to learn and master. They involve only a number of steps and therefore complications during the procedures are not common for experienced surgeons.

Cost-effectiveness is very important even though it may appear to have no bearing on patient safety. Refractive surgical procedures need to be cost-effective since this reflects upon the price charged to the patient. If the technique costs outrageous amounts of

money, which are not yet covered by any insurance company, patients may prefer to remain with glasses and contact lenses which are considered relatively cost-effective. The average contact lens wearer will spend between 600 and 700 dollars a year on optical devices. This price includes contact lenses, solutions and a back-up pair of spectacles. An ideal surgical procedure is a method which provides equivalent vision to that obtained with contact lenses while maintaining a low enough cost to make it worth while after a few years. The equipment needed for photorefractive keratectomy may be more expensive then that needed for radial keratotomy, but radial keratotomy requires more of the surgeons time and therefore the prices of the two procedures may be comparable.

Radial keratotomy may not be an ideal surgical technique, but at this point it is the best of the approved procedures in the United States. Our job as Optometrists is to help our patients decide objectively whether radial keratotomy is right for them. Objectivity stems from knowledge and therefore we need to become extremely educated about radial keratotomy as well as excimer laser technology, their contraindications and possible side effects. Only then can we attempt to enlighten those who depend upon us, our patients.

Percentage of Various
Refractive Procedures Performed

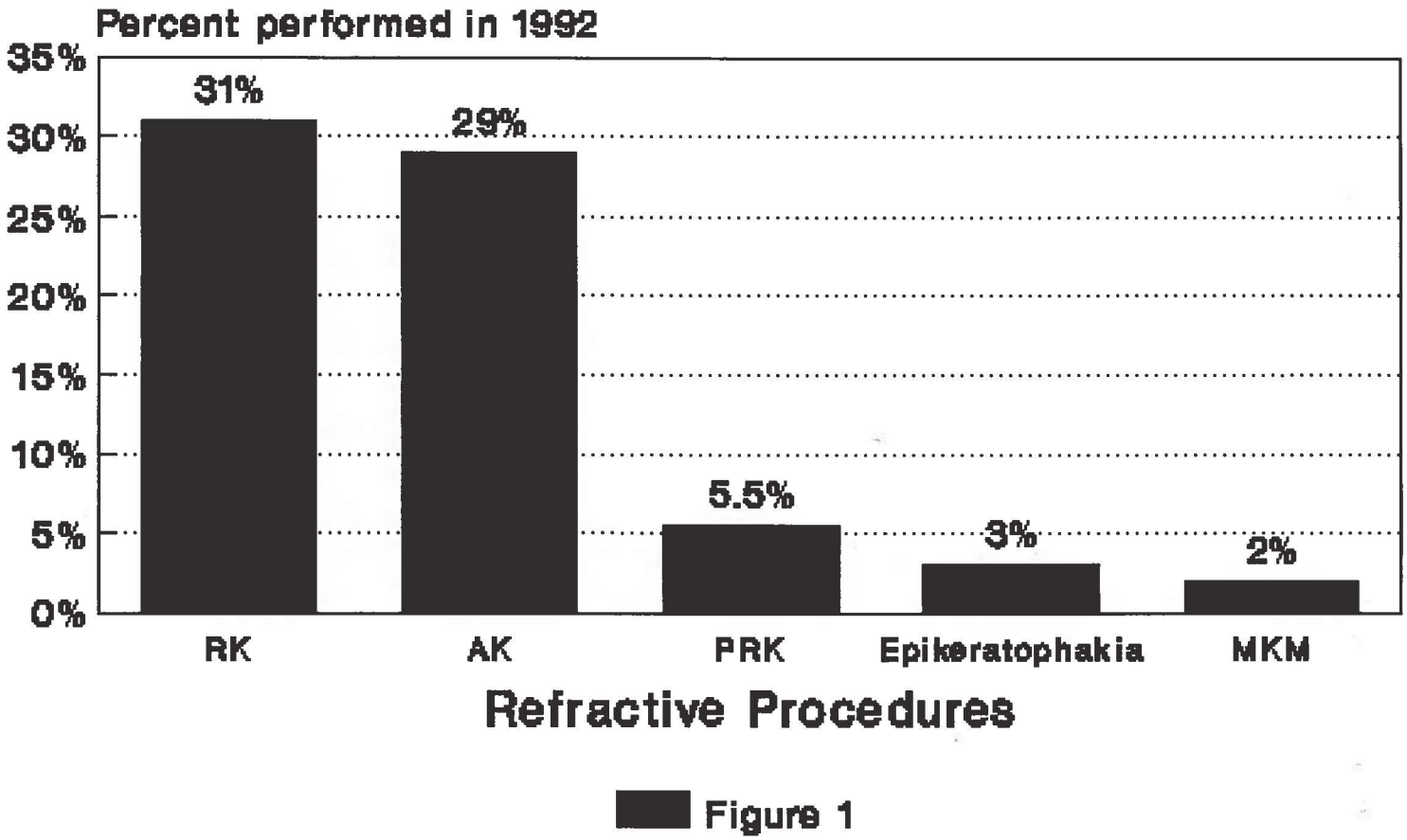

Figure 1

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Number of RK Performed
Monthly by Survey Respondents

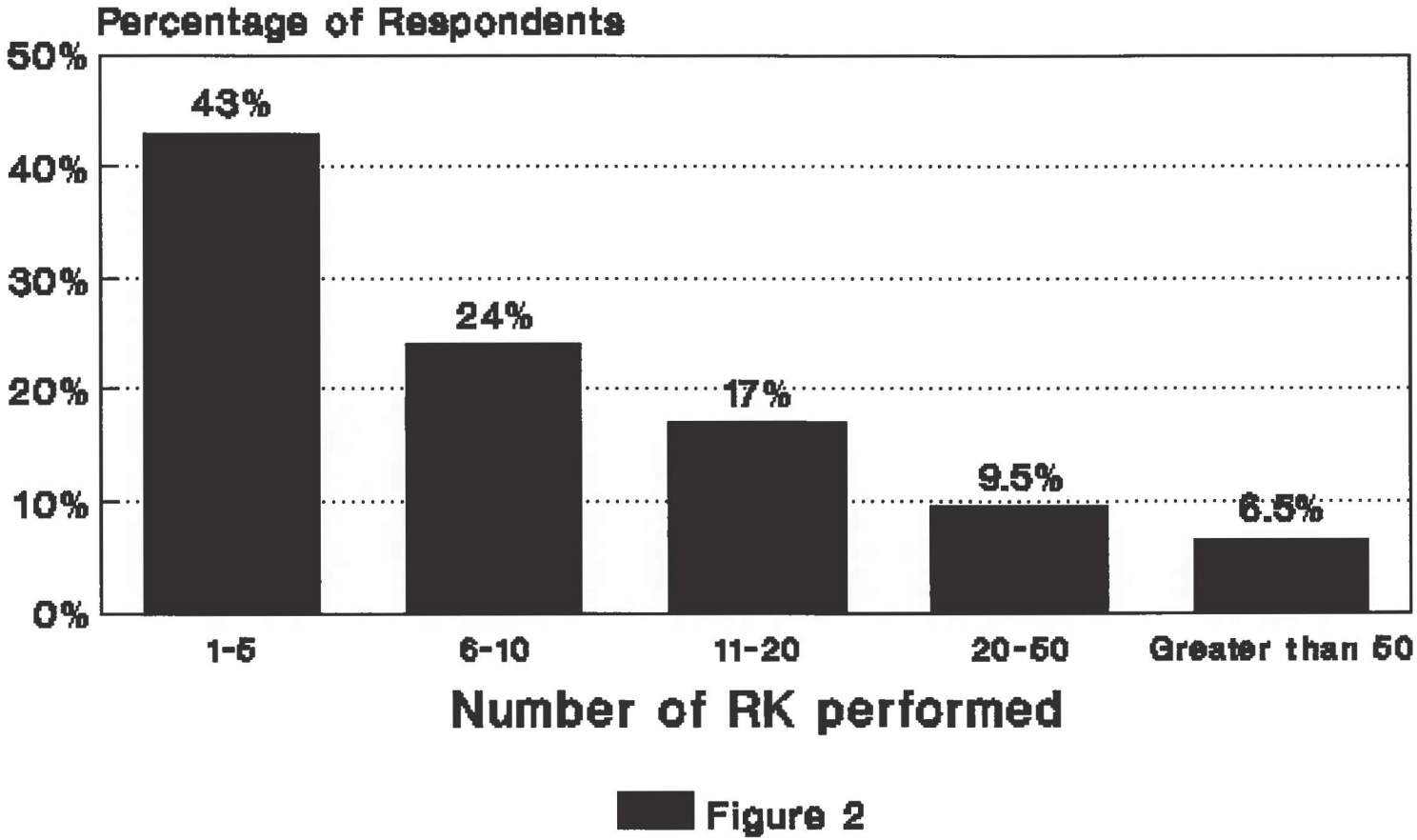

Figure 2

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Radial Keratotomy:

The Surgical Technique:

The procedure begins by anesthetizing the eye, depending on the surgeons preference retrobulbar or local anesthesia is utilized. Most surgeons prefer to use local anesthesia with two drops of proparicane or tetracaine. Occasionally intravenous sedation is needed if the patient appears over-anxious. A shield is then placed over the non-operative eye to stabilize fixation. The surgical zone is cleaned with iodine solution and then draped with sterile sheets and all personnel must scrub and wear sterile clothing. A lid speculum is used to stabilize the upper and lower lids of the operative eye while the superior and inferior limbal conjunctiva is marked. Following these preliminary preparations the patient is encouraged to remain calm and fixate directly on the center of the microscope while the visual axis is determined and the corneal surface is marked. An optic zone marker of pre-determined dimensions is then centered around the visual axis and the cornea is again marked. The third and final imprint which prepares the cornea for surgery is the 8-blade radial incision marker. It is very uncommon today to find a surgeon who performs more than eight incision radial keratotomy. Phacymetry is the next step in this procedure, it is extremely crucial and needs to be performed very accurately to avoid serious consequences. The thickness of the cornea is measured at five different positions and the thinnest measurement is then used for calibration of the blade. The calibration of the diamond knife is checked and rechecked for accuracy before the surgery can begin. The final step before the incisions are made is the stabilization of the globe with forceps at the pre-marked superior and inferior limbal conjunctiva. The incisions are then made following along the markings proceeding from the optic zone out towards the limbus. The surgical technicians must continue to instill tetracaine drops throughout the procedure to maintain anesthesia. Following the completion of the surgery the cornea is hydrated using saline and three drops are instilled; an antibiotic drop such as Ciloxan, a mild mydriatic such as

Number of Incisions Used
By Surgeons Surveyed in 1992

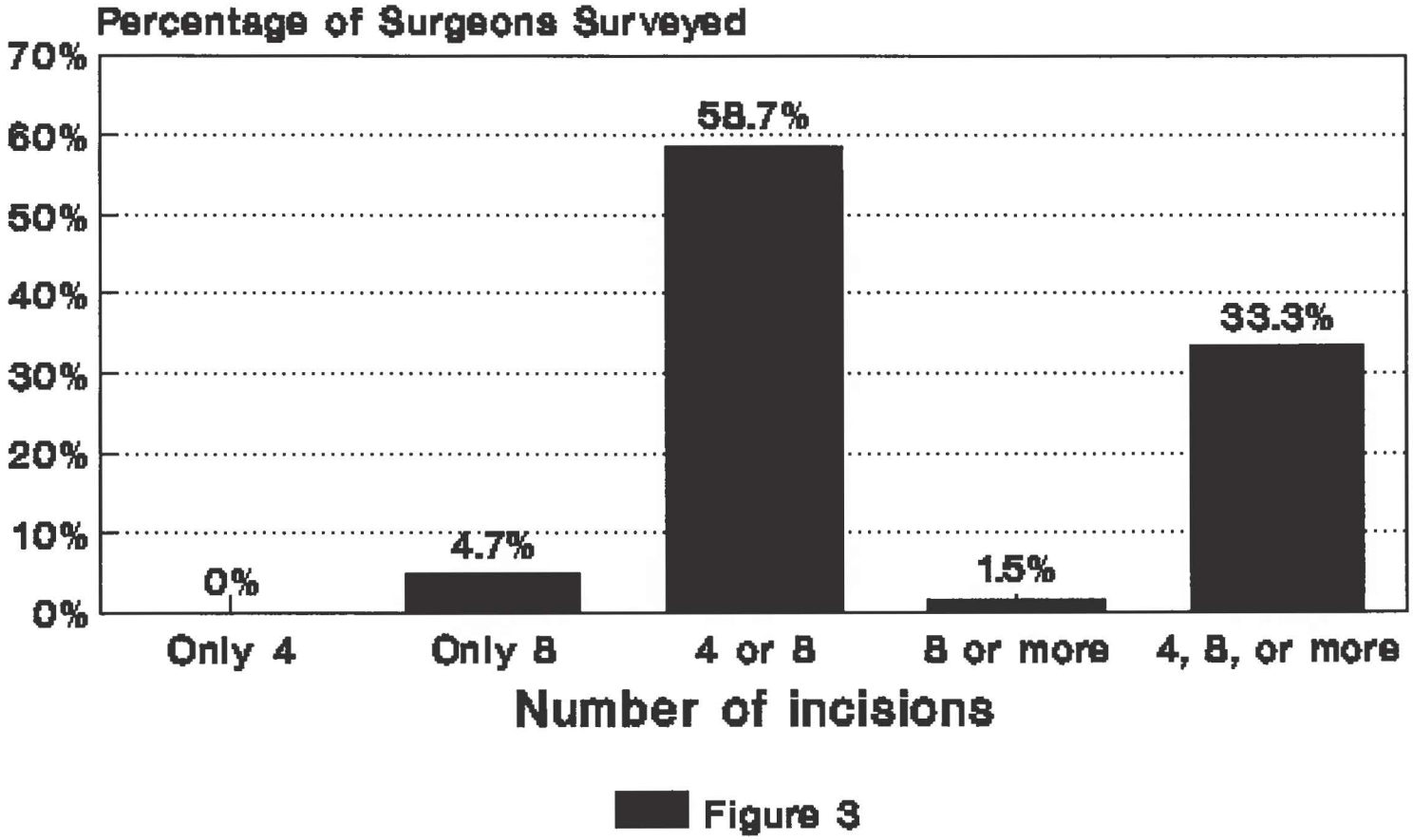

Figure 3

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Neosinephrine and an anti-inflammatory such as Voltaren. The eye is then patched or a bandage contact lens is fit and the patient is discharged.

It is apparent that radial keratotomy is not a very complex procedure to master, most surgeons are fairly competent when it comes to the actual surgical technique. The selection of the appropriate candidate and insuring that all the preliminary measurements are accurate is far more difficult than making a straight incision. I believe as this technique becomes more popular we as Optometrists will be relied upon entirely for the selection of the appropriate RK candidates as well as the pre-operative and post-operative care of these patients.

Who is a candidate?

The most difficult job of any eyecare practitioner involved with RK surgery is the determination of who is and who is not a candidate for the procedure. Optometrists need to be very familiar with the criteria used to select the patients who may benefit from this surgical technique if they intend to play an active role in the co-management of these patients.

Most surgeons consider age before recommending radial keratotomy to their patients. The ideal age considered for this procedure is usually between 18 and 40. Patients younger than 18 are usually considered a risk due to the fact that their myopia may not have stabilized and therefore may progress following the surgery, while patients over 40 are discouraged since the advent of presbyopia will require them to wear glasses for near with or without RK. It is important to realize that this age range is not exclusive and that each patient should be considered individually depending upon their desires and expectations.

Average Age of RK Patients

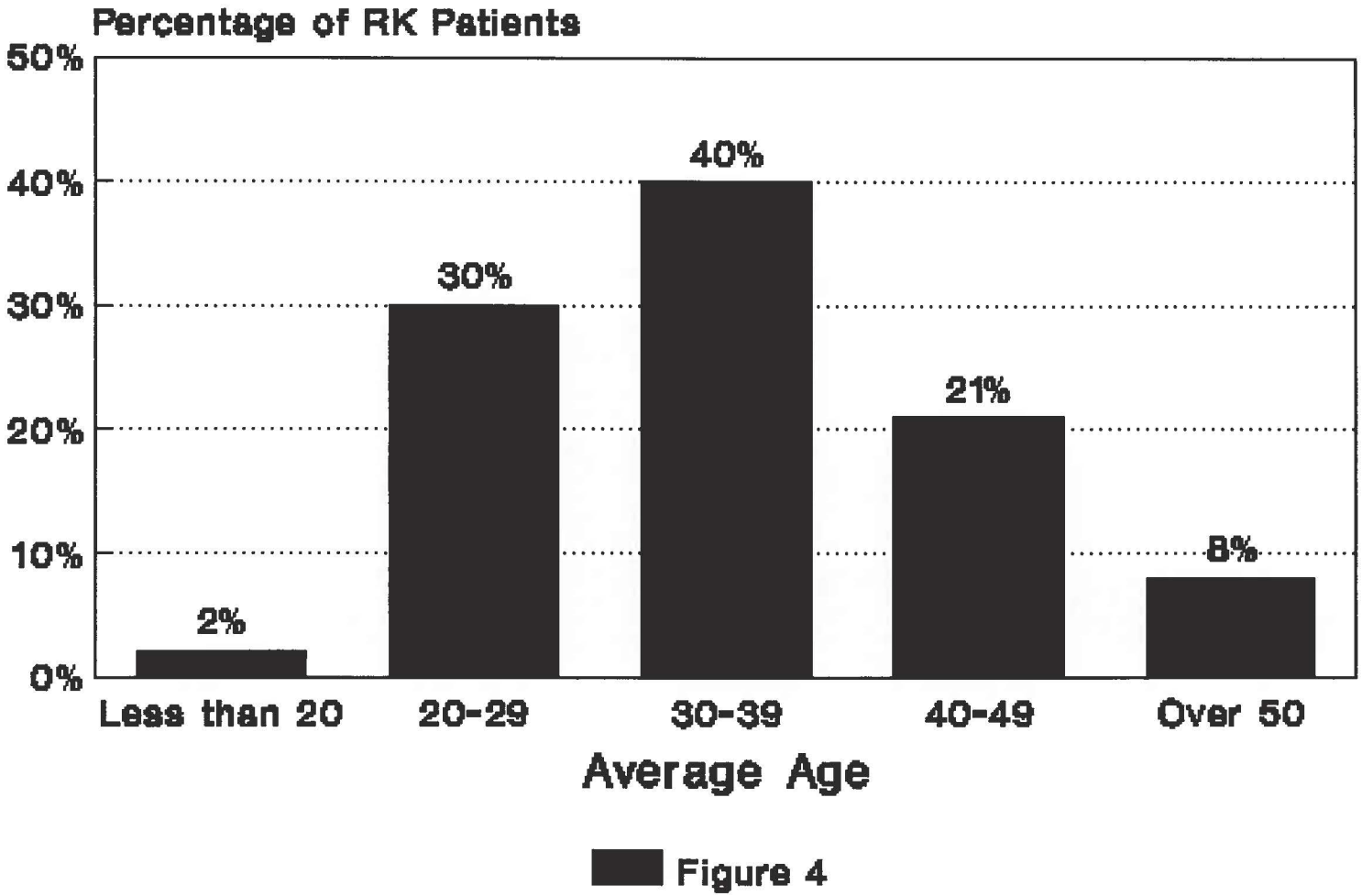

Figure 4

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The level of the refractive error is another important factor taken into consideration while determining the appropriate candidates. Myopia levels lower than 1.50 D or higher than 6.00 D are usually not considered for radial keratotomy. The results of this procedure become less predictable as you steer away from this range. Astigmatism up to 4.00 D is usually considered the limit for keratorefractive surgery. Not only are the degrees of myopia and astigmatism taken into consideration, but the spherical equivalent also needs to be plano or myopic.

The third factor taken into consideration should be the presence of any progressive eye disease. Any patient with proliferative diabetic retinopathy, cataracts, chronic uveitis or any other disease predicted to affect the patients vision in the future should be discouraged from undergoing radial keratotomy. Corneal diseases and dystrophies are definitely considered a contraindication to this surgical technique. Questionable or shifting corneal topographies should also be considered a contraindication. Some systemic diseases such as diabetes are also risk factors when it comes to keratorefractive surgery. Decreased healing and the possibility of retinal disease are reasons enough to discourage a diabetic from undergoing radial keratotomy.

The expectations of the patients should also be investigated and discussed before making a referral. Radial keratotomy should never be introduced as the answer to everything and any patient who expects a miracle needs to be aware of the reality before pursuing it further. Dissatisfied patients are inevitably those who had unattainable expectations which were obviously not fulfilled following surgery. Perfect uncompromised vision without glasses or contact lenses is just not a realistic expectation and patients need to be aware of that. Most people have 20/25-20/40 resultant visual acuity with some distortion, but if patients do not expect perfection they may not be disappointed with that outcome. When presenting radial keratotomy the eye doctor needs to be optimistic but realistic. Before

Expected Visual Acuity
Three Years Following RK Surgery

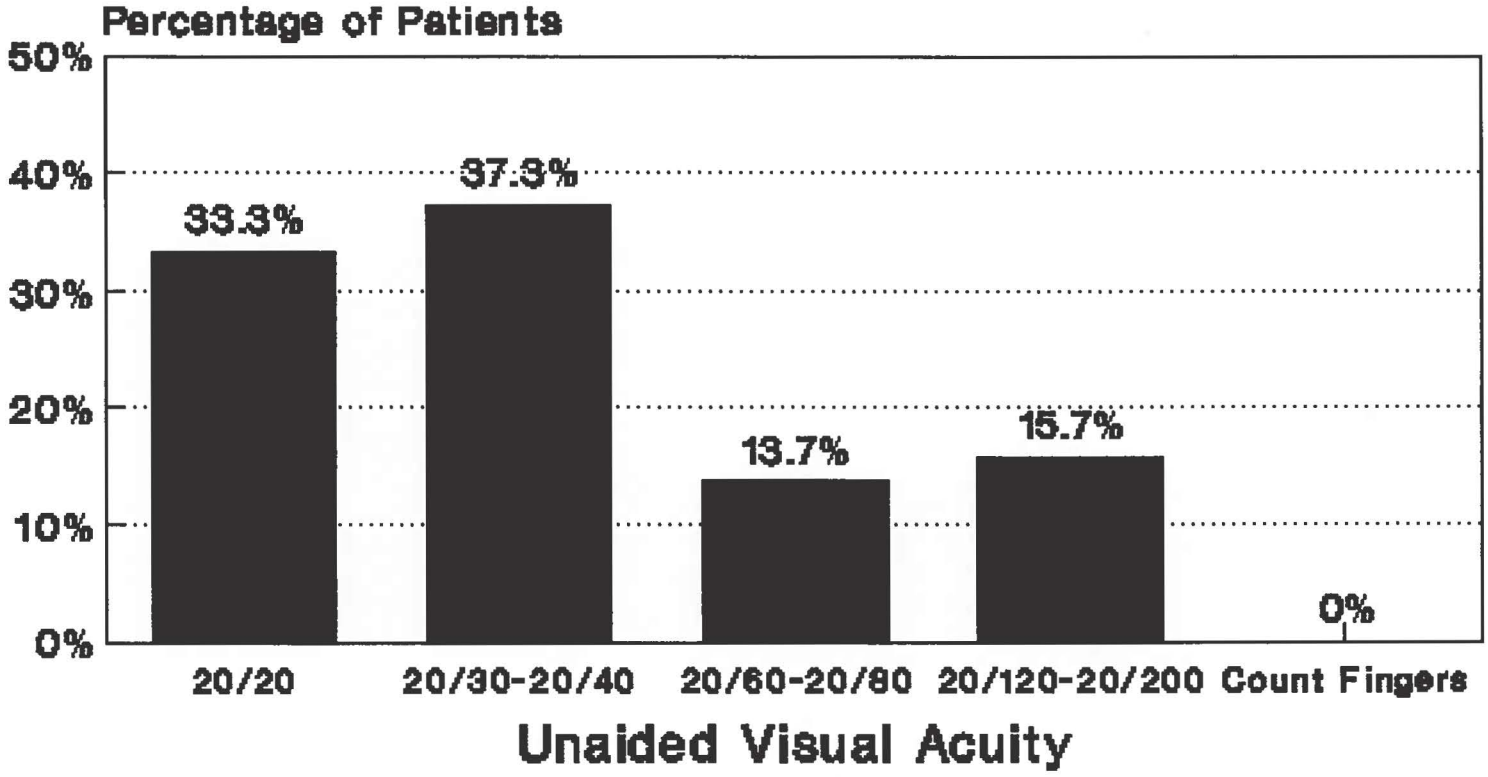

Figure 5

recommending the surgery the patient should be aware of all risks and the most likely outcome.

Preoperative Evaluation:

After it has been decided that a specific individual is a good radial keratotomy candidate very specific information needs to be gathered during the preoperative evaluation. This information is utilized for further evaluation of the patient and for pre-surgical calculations by the surgeon.

A. History:

A frank discussion of patient expectations to reveal any unrealistic hopes or occupational motives is encouraged. The patient is questioned about stability of vision. It is preferred that the vision has remained unchanged for two years but one year is also acceptable. The medical history is also important to reveal the presence of any connective tissue or collagen diseases which could retard the healing process. All questions or concerns should be addressed at this point and before proceeding any further into the evaluation.

B. Visual Acuity:

Visual acuity with and without correction are measured. The acuity without correction is needed since following surgery you will be monitoring uncorrected acuity to determine the level of success of the procedure. Best corrected acuity should be 20/40 or better, if not the etiology needs to be investigated before referral.

C. Pupil Evaluation:

The size of the pupil in normal illumination levels should be measured to determine the minimum optic zone size possible without increasing the probability of post-operative glare.

D. Refraction:

The refraction is probably the most important preoperative measurement. Hard contact lens use, including gas permeable lenses, should be discontinued three weeks prior to the refraction. These lenses can alter the thickness and shape of the cornea which may influence the refractive error measured. Soft contact lenses need only be removed three days prior to the preoperative evaluation. A manifest subjective refraction is performed and then compared to a cycloplegic refraction to avoid over-minusing the patient.

E. Keratometry and Topography:

An accurate evaluation of the corneal contour is needed to reveal topographies outside normal limits. Patients with extremely flat corneas may not have a good result following RK while patients with extremely steep corneas may have keratoconus which is a contraindication to radial keratotomy. Topography may also help reveal irregular astigmatism which may make the surgery very difficult.

F. Slit Lamp Evaluation:

A complete evaluation of the anterior segment is performed to reveal any corneal pathology. A history of herpes keratitis is definitely a contraindication to surgery. A check of the clarity of the crystalline lens is also needed to rule out the possibility of cataract formation in the near future. The intraocular pressure should also be measured to identify any questionable pressure rises following surgery.

E. Dilated Fundus Exam:

An evaluation of the retina is performed to reveal any retinal disease or peripheral degenerations. Most myopes have some form of peripheral retinal pathology and this should be noted for future monitoring.

All information gathered during the preoperative evaluation must be extremely accurate to avoid any sight threatening mistakes. Even after all precautions are taken to insure the accuracy of all measurements and following a precise surgical procedure the results are still unpredictable. There are many unanswered questions surrounding radial keratotomy and therefore the results are almost always somewhat of a surprise.

Complications of Radial Keratotomy:

Any surgical procedure is associated with some risk and radial keratotomy is no exception. There are a multitude of possible complications and some are more serious than others. Most of the complications commonly associated with radial keratotomy are not sight threatening but that does not mean that they do not affect the patients vision to some degree.

A. Instability of Vision:

Fluctuations in vision is one of the most common side effects of radial keratotomy. As the patient sleeps the cornea swells due to increased level of water absorption. During the day there is a gradual decline in the thickness of the cornea which results in a change in the vision. The refractive error shifts towards hyperopia as the thickness of the cornea decreases during the day. Most of the change occurs upon awakening, but a residual effect remains throughout the day and this seems to be the most annoying to the patient.

B. Overcorrection and Undercorrection:

These complications are directly related to an error during the actual procedure. Overcorrection is usually the result of too many incisions or incisions which are too deep, the opposite is true of undercorrection. Overcorrection is usually considered more serious since in most situations undercorrection can be treated using enhancement techniques. Voltaren is occasionally used to compensate for overcorrection..

C. Progressive Hyperopia:

A shift towards hyperopia over time is probably the complication most annoying to refractive surgeons. The result of the surgery may seem close to perfection at first but then slowly regress into a major refractive catastrophe. It is known that as a person ages it is in their favor to be slightly myopic, this is not true of a large majority of RK patients. As they age the cornea continues to flatten resulting in an increase in hyperopia. The occurrence of this hyperopic shift rises the smaller the optic zone and the greater the number of incisions. The biggest problem is that we are not talking about a minuscule shift, it has been reported that a hyperopic shift of up to 13.50 D is possible. The problem of overcorrection is very difficult to treat, but some surgeons may go back and suture half of the incisions while attempting to leave the patient slightly myopic in the end. There is no real preventative method since it is not known exactly why progressive hyperopia occurs, but the incidence seems to decrease dramatically if only four or eight incision radial keratotomy is performed.

D. Glare:

Glare seems to be the side effect which patients complain about the most. The starburst effect occurs due to distorted light reflection off of the radial incisions. As the optic zone size decreases the effective glare tends to increase. It is reported that almost all RK patients complain of glare initially, but within six months less than 25% of patients continue to complain of the so called starburst effect.

E. Micro and Macroperforations:

These complications are secondary to incisions which go too deep and traverse the whole thickness of the cornea. Microperforations are very small and usually need no treatment. Macroperforations, on the other hand, are larger and more serious occasionally resulting

Complications of RK Surgery
As Reported by Surgeons in 1992

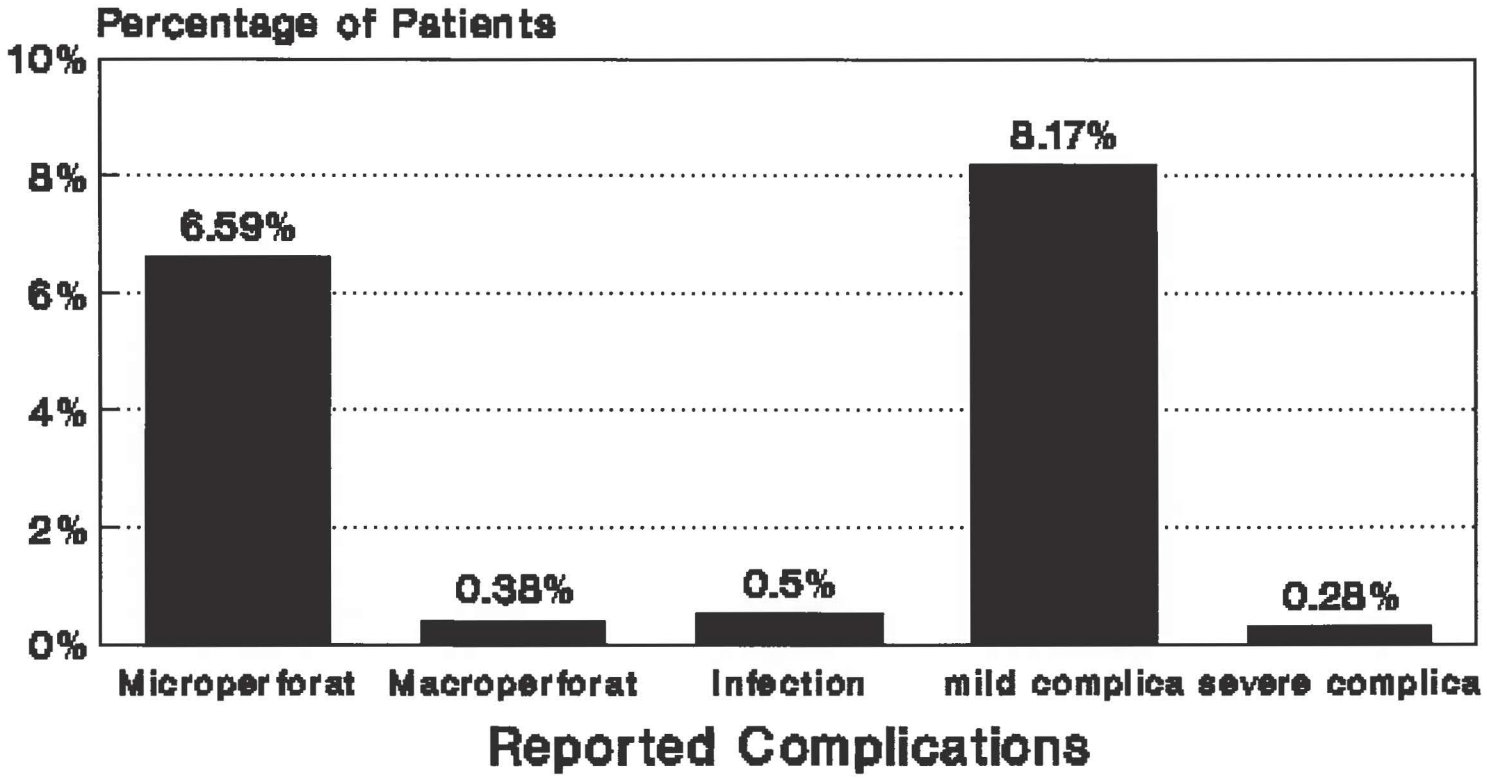

Figure 6

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in the loss of the anterior chamber. Two or three sutures are usually enough to halt aqueous flow and seal the perforation. Micro and macroperforations are not very common, but never the less they do occur and may be very serious.

F. Endophthalmitis:

This is one of the least common complications, but definitely the most serious. It occurs secondary to bacterial invasion through macroperforations. The bacteria enters through the open wound and results in a massive and sight threatening infection of the globe.

The above discussion of complications is not all inclusive, but the other reported side effects are of such low incidence that it is highly unlikely that we as Optometrists will ever come across a patient who exhibits one of them during the postoperative care period.

Postoperative Care:

One Day Post-op:

The RK patient needs to be seen 24 hours following the procedure to ensure all is well and proceeding as would be expected. A brief history is acquired from the patient to reveal any discomfort or unexpected symptoms. Most patients express difficulty sleeping and some general eye pain. Uncorrected visual acuity is measured at this point and retinoscopy is attempted. Perfect vision is not expected at this point and the patient should be comforted if it is not. A thorough slit lamp evaluation is performed and all the incisions are evaluated for leakage. If the depth of the anterior chamber is not normal a bandage contact lens may be used to prevent further leakage of aqueous. Assuming all appears fairly normal the patient should be placed on a steroid-antibiotic combination drop, QID and asked to return in one week. Very few restrictions are placed on the patient other than rest for the first 24 hours while wearing a metal shield on the operative eye. Lifting is restricted to about 15 pounds for the first few days to avoid any strain on the patient. The patient is

asked not to shower for the first day to avoid infecting the eye and also to avoid scuba diving for about one month. Protective eye wear should also be worn during any type of physical activity to protect the eye.

One Week Post-op:

At one week post-op it is expected that the patient be more comfortable with relatively stable vision. Again a thorough history is taken followed by unaided visual acuities. A subjective refraction is attempted, preferably under cycloplegia, to determine the refractive status of the patient at this point. Keratometry or topography is performed for an insight into how the corneal contour changed after surgery. The slit lamp evaluation should reveal complete wound closure and re-epithelialization of all incisions. Further tests are performed at the discretion of the doctor and depend upon the signs observed. All eye drops are discontinued at this time and the patient is asked to return four weeks later for further evaluation.

One Month Post-op:

Assuming everything appears as expected at the one week post-operative visit the patient need not return for approximately four weeks. A brief history is taken to ensure patient comfort and satisfaction, followed by a measurement of unaided acuities. A subjective refraction is again attempted to reveal any shifts in the refractive error, while topography is performed to test the stability of the corneal contour. At this point in the post-operative schedule the doctor and patient may decide to pursue enhancement procedures or other methods to relieve possible symptoms. It is recommended by most that any contact lens fittings be delayed until the three month follow-up to ensure full healing has taken place and the cornea has reached a stable topography.

Three Month Post-op:

This is usually the final scheduled follow-up for RK patients. At this point the patient's vision should have reached it's optimum and the patient should be able to accurately express their satisfaction or dissatisfaction with the procedure. Following an accurate history, acuities are again recorded as well as keratometry, slit lamp exam, subjective refraction and fundus evaluation. If needed contact lens fitting may be considered at this point. Post RK contact lens fitting is fairly complicated without the assistance of a corneal topographer. An accurate corneal map is needed for a better visualization of the varied curves in order to better design a lens to fit most of the cornea. The most likely design is usually a flat lens to fit the central cornea with steep secondary curves to fit the periphery of the cornea.

Radial keratotomy is definitely not a threat to Optometry. Also it is unlikely that this surgical technique will replace the need for glasses or contact lenses. This procedure and other refractive surgical techniques are an advancement in eyecare and Ophthalmology and Optometry alike can benefit from this milestone. Even with the advent of PRK radial keratotomy is here to stay. It is believed at this point that Excimer PRK will most likely benefit those myopes who lie outside the acceptable range for radial keratotomy. Therefore the desired technique for most patients may remain diamond blade keratotomy. Optometrists need to find their place in this process or they will be left out. No one is better qualified to give patients a truthful and objective viewpoint on the surgery and the possible benefits and side effects then Optometrists. Pre-operative work-ups, as well as, post-operative care should be performed entirely by Optometrists. Extremely crucial pre-RK information should not be delegated to technicians but rather should be collected by the patient's Optometrist. Post-RK contact lens fittings and other post-surgical procedures can only be performed by a competent Optometrist. As a result of all of this it is necessary

for Optometry to remain educated on RK and continue to be abreast of all advancements in the growing field of refractive surgery.

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