CALCULATED EFFECTS OF RIGID BACK SURFACE ASPHERIC CONTACT LENSES

A SENIOR PROJECT PRESENTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF OPTOMETRY

by

HOLBROOK RILES, JR.

FERRIS STATE COLLEGE OF OPTOMETRY

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Introduction

The majority of rigid contact lens patients are fitted with bicurved and multicurved spherical lenses. Some practitioners have used aspheric back surface lenses. Theoretically, back surface aspheric rigid lenses can solve a variety of problems. The eccentricity can be ordered to fit that of the cornea, possibly resulting in better centration. Since there is a continuous change in radius from the apex to the edge of an aspheric lens, flare is significantly reduced.[1] Aspheric lenses have been used to correct presbyopes, which result in a less complicated lens design as opposed to segmented lenses. Such designs are being used more with the introduction of gas permeable materials.[1,4,5]

There are two categories of aspheric contact lenses being used clinically.[2] The first, conic sections, are the end results of cutting a cone at varying angles to its base. (i.e. parallel to perpendicular) The e-value discribes the rate of flattening of a conic section as well as its relationship to a circle. The following are the main standards of eccentristic measurement.[2,5]

A) circle . . . . . . e-value 0.0

B) ellipse . . . . . e-value . . . . . < 1.0

C) parabola . . . . . e-value 1.0

D) hyperbola . . . . e-value . . . . . > 1.0

The e-values considered for this study ranged from 0.60 to 1.10.

The second category of aspheric contact lenses, referred to as non-conic, will usually have a spherical or toric central zone with a conic section periphery. The non-conic section will not be considered in this study.

To date very little has been published to illustrate changes in the fit resulting from varying clinically significant contact lens parameters. This project will provide the results of the latter in graphical form.

Key Words

1) Aspheric lenses
2) e-value (eccentricity value)
3) z-value
4) Apical radius
5) Central clearance
6) Center to touch

METHODS

A computer program, devised by Gerald Lowther, O.D., Ph.D. and Michael Keating, Ph.D., was utilized to obtain the values used to develop the calculated changes in various parameters as illustrated by the resulting graphs.[1]

Parameter changes used were in keeping with changes that would be reasonable with an average patient. (i.e. corneal radius 7.8mm, corneal e-value 0.5) Contact lens values were meant to coincide with those most frequently used when fitting rigid aspheric back surface contact lenses. (i.e. e-value 0.6 to 1.5, apical radius 6.6 to 7.8mm)

Refer to references for specific equations.

RESULTS

Figure 1 shows the relationship between increasing the eccentricity and the calculated effects on the z-value. The graph illustrates an increase in the z-value as we increase the e-value of a 7.8mm apical radius/9mm OAD rigid aspheric contact lens. If the apical radius is held constant, the fluorscein pattern would gradually manifest a larger area of edge stand off as the e-value is progressively changed from 0.7 to 1.5. The relationship is shown to be a linear one.

The determination of the central clearance of aspheric contact lenses with apical radii of 7.0mm to 7.5mm, are made as the e-value of the contact lens is increased from 0.8 to 1.5. The results are illustrated in figure 2. Keeping the corneal radius and e-value constant at 7.8mm and 0.5, respectively, we find an expected decrease in central clearance as we fit our imaginary cornea with 7.0 to 7.5mm aspheric contact lenses. In studying Figure 2, there appears a significant difference between fitting a 7.0mm lens with e-values of 0.8 and 1.5 respectively, as opposed to a 7.5mm lens with e-values of 0.8 and 1.5. The resulting fluorscein pattern would most likely exhibit excessive central pooling to minimal pooling with the 7.0mm and 7.5mm aspheric lenses, respectively, using a 0.8 e-value.

The term "center to touch," describes the distance from the axis determining the lens apex to the peripheral point in which contact is made between the lens and the corneal surface. Figure 3 uses contact lenses of apical radii 7.1 to 7.8mm and changes the e-value from 0.6 to 1.5. Each lens is mathematically fitted on a cornea with a radius of 7.8mm and eccentricity of 0.5. The data consistently demonstrates a decrease in the center to touch distance as we increase the eccentricity value.

Once again the center to touch distance is plotted in Figure 4. The theoretical corneal parameters are identical to those of Figure 3, while the lens apical radius is varied from 6.6mm to 7.7mm. Five contact lens eccentricity values are used. (0.7 to 1.5 in 0.2 increments) There is a marked linear reduction in the center to touch measurement as we fit from steep to flat apical radius while simultaneously using lenses of increasing eccentricity. The most noticeable fitting difference appears with the lenses of 6.6mm and 7.7mm apical readius using the e-value of 0.7, vs. the 6.6mm and 7.7mm lenses using a 1.5 e-value.

The e-value in a spherical contact lens of parameters 7.8mm apical radius, 9.0mm OAD is zero. Therefore, the sagittal depth remains constant as illustrated in Figure 5. On the other hand, by increasing the e-values of an aspheric contact lens of the same parameters as the aforementioned spherical lens, a reduction in the sagittal depth occurs. The latter is consistent with the findings of Figure 2, which shows a decrease in the central clearance resulting from increasing the e-value of all aspheric rigid lenses.

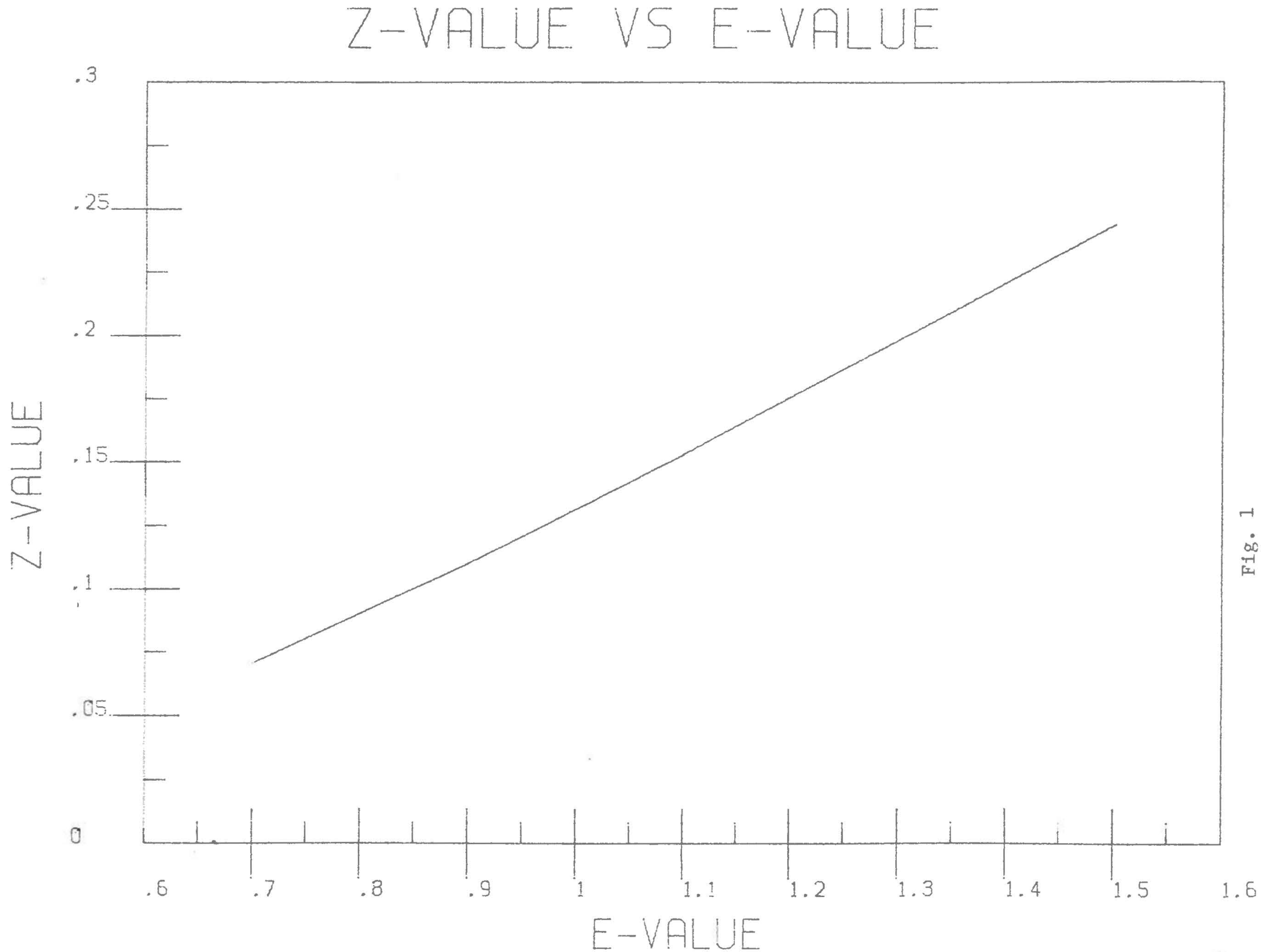

Z-VALUE VS E-VALUE
.3
.25
.2
.15
.1
.05
0
Z-VALUE
.6
.7
.8
.9
1
1.1
1.2
1.3
1.4
1.5
1.6
E-VALUE

Fig. 1

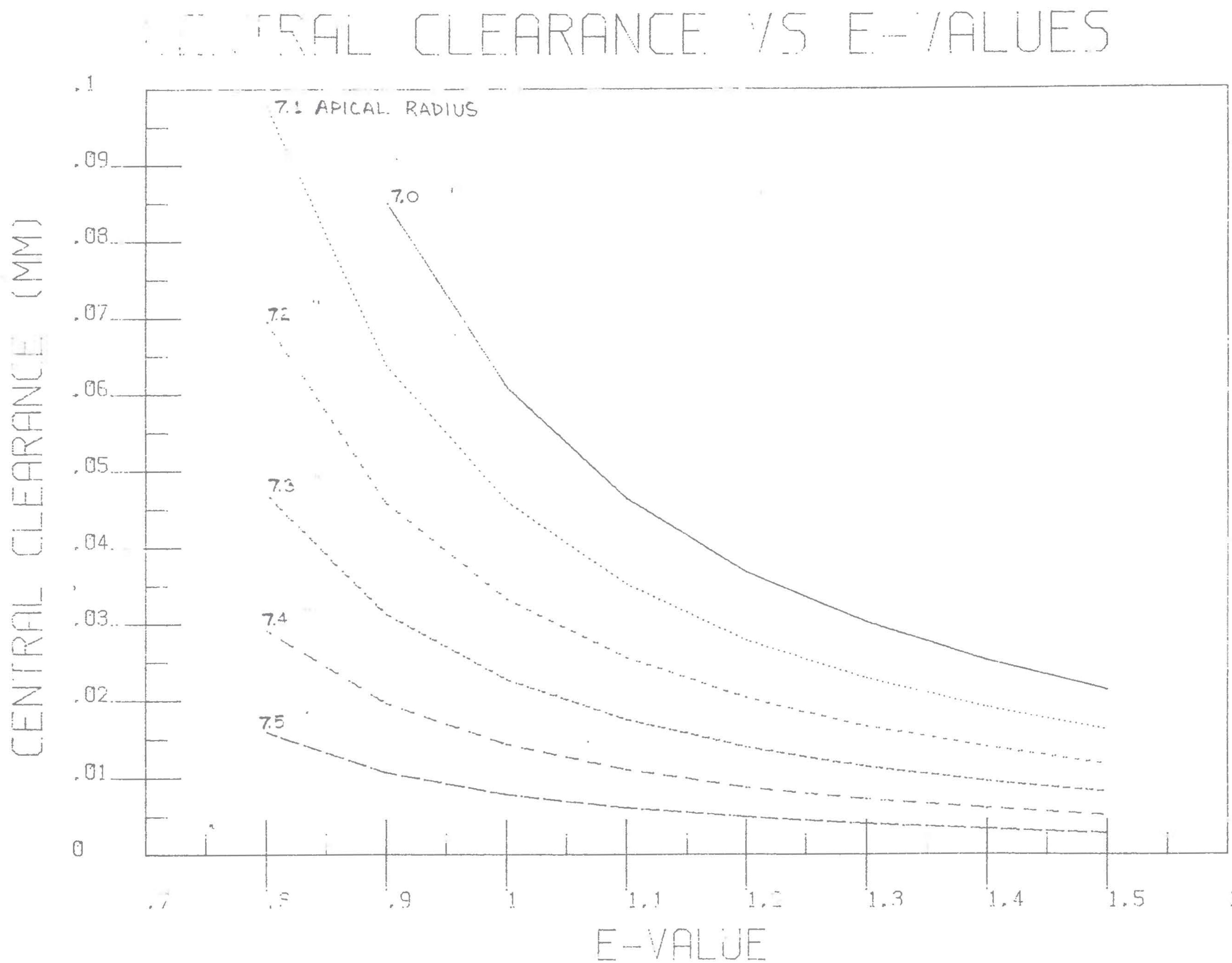
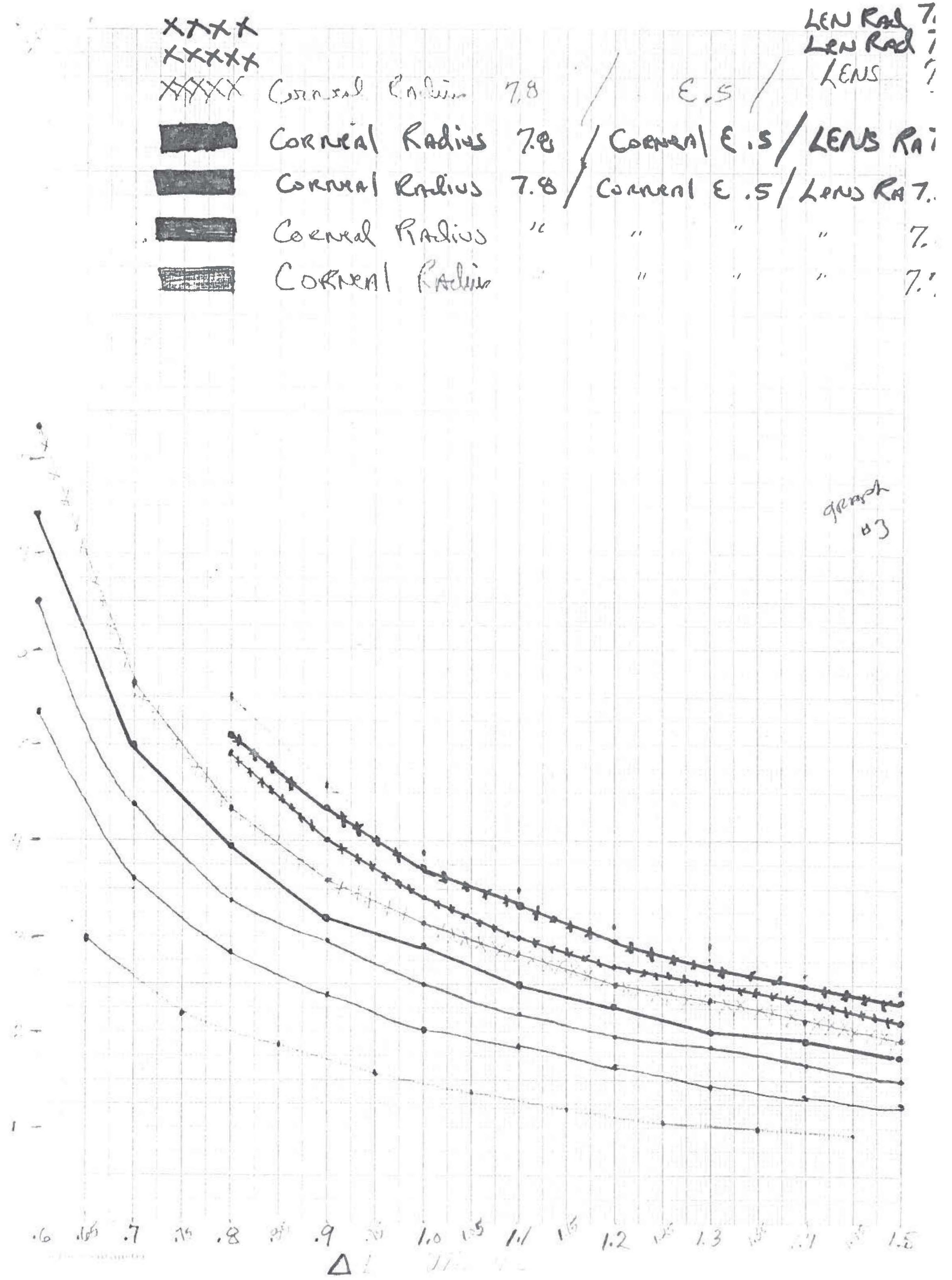

CLEARANCE VS E-VALUES
CENTRAL CLEARANCE (MM)
E-VALUE
7.1 APICAL RADIUS
7.0
7.2
7.3
7.4
7.5
.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
.9
1
1.1
1.3
1.4
1.5
1.6

Fig 2


Corneal Radius 7.8 / E .5 / LENS 7
Corneal Radius 7.8 / Corneal E .5 / LENS Ra
Corneal Radius 7.8 / Corneal E .5 / Lens Ra 7.
Corneal Radius " " " " 7.
Corneal Radius " " " 7.
LEN Rad 7.
Len Rad
.6 .65 .7 .75 .8 .85 .9 .95 1.0 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.45 1.5
Δ
graph #3

CENTER TO TOUCH (MM) VS APICAL RADIUS

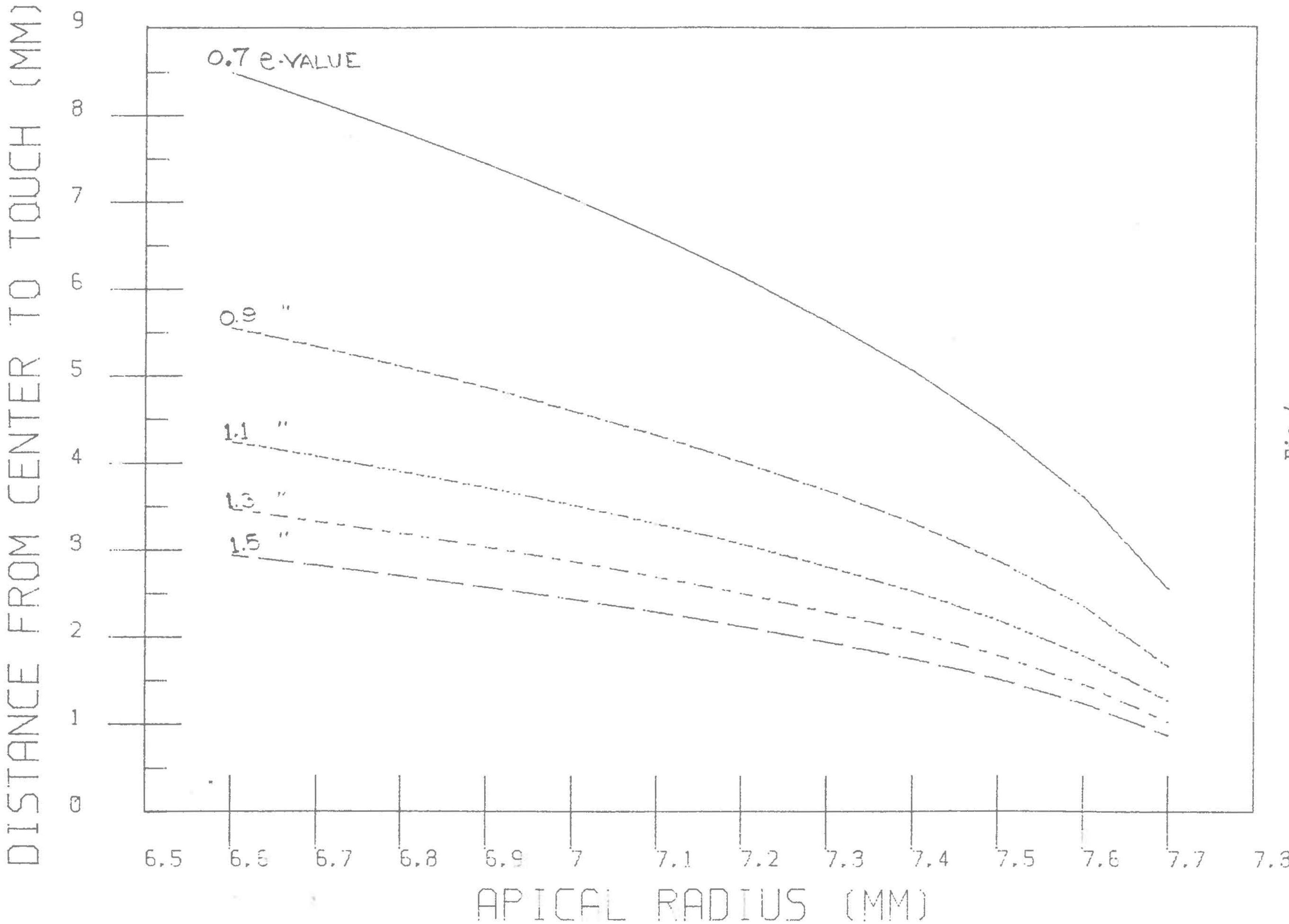


Fig 4

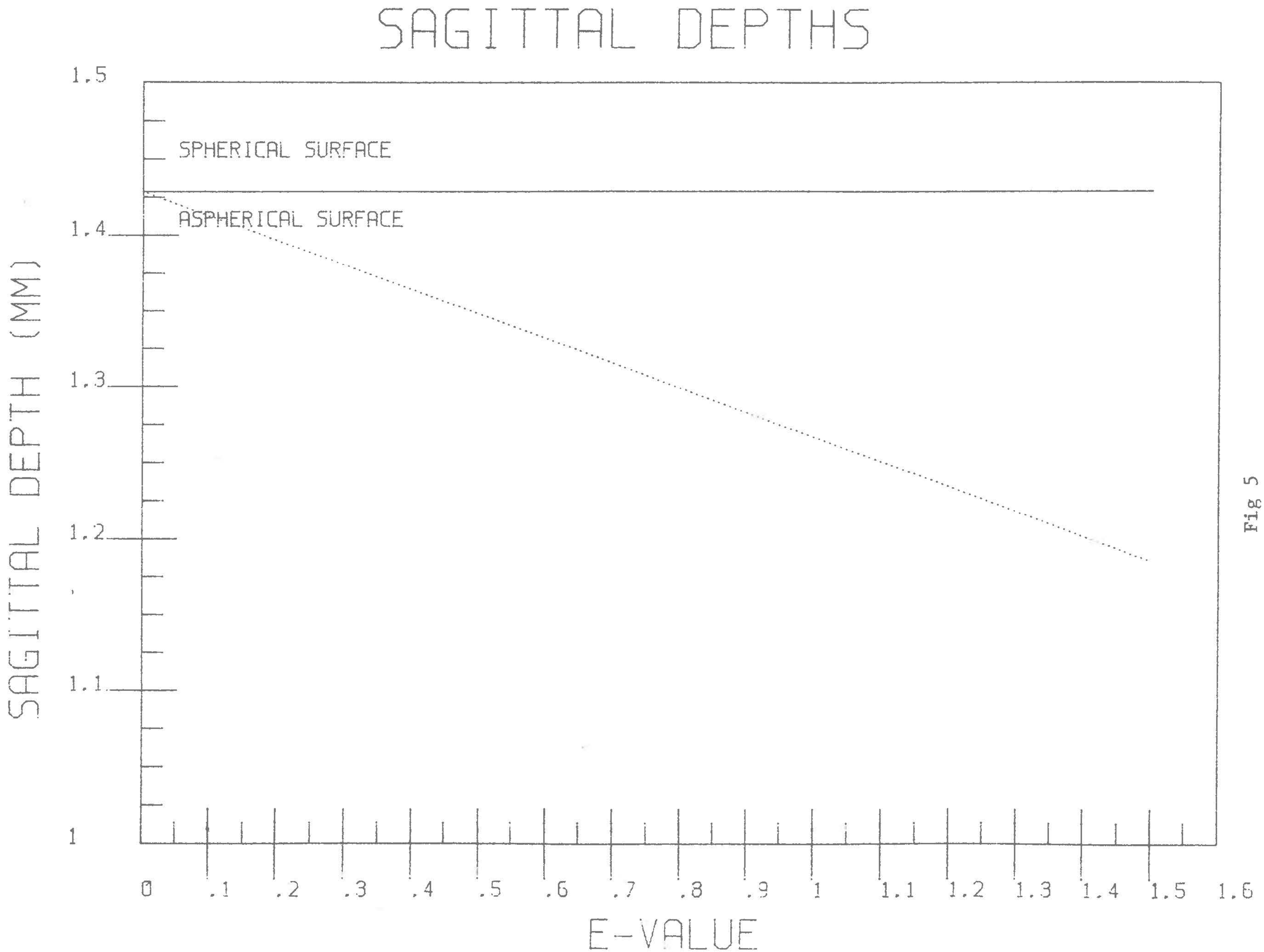

SAGITTAL DEPTHS
SPHERICAL SURFACE
ASPHERICAL SURFACE
SAGITTAL DEPTH (MM)
1.5
1.4
1.3
1.2
1.1
1
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
1.1
1.2
1.3
1.4
1.5
1.6
E-VALUE

Fig 5

10

DISCUSSION

The purpose of this study was to provide information to the optometric community regarding the calculated fitting relationship of rigid back surface aspheric contact lenses. The resulting graphs illustrated in Figures 1 through 5, and accompanying narrative should provide some assistance with respect to anticipating and solving aspheric fitting problems. Granted, if certain parameters are known, other essential information can be extrapolated.

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