AN ANALYSIS OF POSTERIOR SURFACE ASPHERIC RGP'S USING COMPUTER-ASSISTED VIDEOGRAPHY

A SENIOR RESEARCH PROJECT BY:

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ABSTRACT:

Posterior surface aspheric rigid lenses are being used more and more to enhance fitting and to provide a multifocal option to presbyopic contact lens wearers. These lenses have very complex posterior geometries and therefore are difficult to manufacture and polish as well as verify. Computer lathes and new polishing techniques are making the lenses more reproducable and computer-assisted videography may be the next step in lens verification and quality control. This study is going to use the EyeSys Corneal Analysis System to analyze and present many different aspheric designs, calculate their eccentricities, and contrast and compare color map representations of each lens design.

INTRODUCTION

Aspheric rigid corneal lenses have been used clinically to obtain a better lens to cornea fitting relationship and for the correction of presbyopia. The posterior curvature of aspheric rigid lenses flatten gradually from the apex to the edge. The base curve of an aspheric lens is the steepest point on the posterior surface. It is at the lens apex and is specified as the posterior apical radius. The amount or degree of flattening from the apex to the edge is the lens eccentricity (e value).

Not all aspheric designs are the same. Some lenses are modeled after conic sections. They have a mathematical definition and flatten at a constant rate from apex to edge. These lenses may be specified by their posterior apical radius and a single e value. Depending on the e value, these lenses are either ellipsoids, paraboloids, or hyperboloids.(Table 1)

Aspheric designs not modeled after conic sections have variable rates of flattening and can not be specified by a single e value. These include sphere/asphere geometries which have a spherical optic zone of a certain chord diameter and an aspheric periphery. Biaspheric lens designs incorporate an aspheric optic zone of a certain eccentricity and an aspheric periphery of a different eccentricity. Posterior surface aspherics may also have a variable eccentricity which gradually changes from apex to edge.

Lenses with low e values are used to improve fitting to the aspheric cornea which has an e value reported to be .50. These lenses are especially helpful in the fitting of moderately toric corneas and, in some cases, keratoconus. Because these lenses more closely approximate the cornea and have a junctionless back surface, they can be fit with less localized bearing. Some clinicians have experienced an increase in patient comfort because of this.

Posterior surface aspherics with e values in the neighborhood of .80 or greater are used as multifocal lenses. Since the posterior surface flattens greatly within the optical zone, it induces a progressive addition effect. Lenses with high e values must be fit with a posterior apical radius much steeper than the flattest corneal keratometric reading. This is done to decrease edge lift, improve lens bearing and fit, and control lens movement.

The lathing of aspheric lenses had been very difficult in terms of accuracy and reproducability. With the advent of computerized lathes, new manufacturing methods, and increasing ability to polish these lenses, accuracy and reproducability have been greatly increased.

Clinicians have also had a difficult time verifying these lenses. Measuring central lens power and the posterior apical radius was easy enough but the eccentricity was very difficult to assess. Interferometry has been used for this purpose as well as for assessing surface quality. DeFazio and Lowther modified a radiuscope with a tilting stage to measure curvatures at peripheral points on the posterior surface. Any point peripherally on an aspheric surface is toric. It has two separate radii of curvature. These are termed the sagittal radius and tangential radius. The tangential radius is also known as the meridional radius and is always longer than the sagittal or transmeridional radius. (Figure 1) DeFazio and Lowther used sagittal radii values for certain points and calculated eccentricity using the equation:

$$e=\sqrt{\frac{Rs^2 - Ro^2}{y^2}}$$

e = eccentricity

R_s = sagittal radius

R_o = posterior apical radius

y = distance of measured point from apex or ½ the chord diameter

This method is good for calculating e values for peripheral points but does not give one a feeling for the whole surface geometry.

With the advent of computer-assisted videography systems, we now have a new and potentially much better way to analyze and verify posterior aspheric surfaces. Computer-assisted videography systems have been used primarily for corneal curvature analysis, diagnosis of corneal disorders such as keratoconus, and as a tool in contact lens fitting. When used on a contact lens surface, these systems can provide accurate curvature data for a multitude of points. Multiple videographic map displays give a clinician a good understanding of the posterior surface geometries of different aspheric lenses.

PROCEDURES

In this study we used the EyeSys Corneal Analysis System to compare and contrast a manufactured button of known eccentricity (.57), four multifocal aspheric rigid lens designs, three single vision aspheric rigid lens designs, and one spherical lens design.

POSTERIOR APICAL RADIUS	LENS DESIGN
8.15 mm	aspheric button
7.90 mm	VFL
7.90 mm	VFL 2
7.90 mm	VFL 3
7.20 mm	APA
8.30 mm	Quantum
7.90 mm	Envision
7.90 mm	spherical Fluorocon
7.90 mm	Ellip-See-Con

Each of these lenses were analyzed by the EyeSys Corneal Analysis System, a computer-assisted videokeratoscope. The Corneal Analysis System has the capability of measuring concave as well as convex surfaces. Calibration data stored within the computer must first be reversed to obtain accurate data. Each contact lens was affixed to the contact lens mounting unit supplied by EyeSys which was then attached to the positioning chinrest. After careful centering, an eight ring Placido's disc was projected onto the posterior surface. The Corneal Analysis System has a large depth of focus, so to ensure accurate and repeatable results a systematic focusing procedure was used. The focusing joystick was pushed forward enough to blur the reflected mires. The joystick was then pulled back until the mires first became clear. The reflected mires were then photographed by the videokeratoscope and analyzed by the processing unit. This method produced accurate repeatable results for chord diameters up to eight millimeters.

We obtained data from the contact lens map printout which provided us with the posterior apical radius value, peripheral curvature values, and average curvature data for certain distances from the apex. (Figure 2) These radius values are the sagittal radii. Using this data we calculated e values for each lens. We also used the color map printout to provide a topographical presentation of each posterior surface. Each printout was standardized by assigning the darkest maroon color a value .01 mm steeper than the posterior apical radius and each successive color change .05mm flatter. This provides a means by which we can compare the color maps for each lens.

RESULTS

The data in Figures 3 - 11 show the differences in the color map topography printouts. The aspheric button is an ellipsoid which was measured by interferometry and sent to us with a known e value of .57. The color map printout shows a posterior geometry which flattens from apex to edge at a continual rate. It's e values as calculated in this study are shown in Table 2. Note that the e values decreased slightly in the periphery. This may be due to imperfect lathing and polishing techniques or a slight error in the EysSys' ability to measure more peripheral radii.

There is great similarity between all four multifocal lenses. The APA lens is in a 7.20 mm posterior apical radius but by making each color represent a change in curvature of .05 mm, we are able to compare surface geometry of different base curves. All four multifocal lenses show a great amount of flattening beginning at a point one millimeter from the apex. This is to ensure that a sufficient add power can be made within the useful optical zone. Eccentricity values have been calculated for these multifocal lenses in Table 2. All four lenses continue to flatten in the extreme periphery, as shown by the e values, although not at as great a rate as centrally. These lenses, because of their rapid flattening, must be fit 2-4 diopters steeper than the flattest corneal curvature.

Compare the multifocal lenses to the control sphere, the Quantum, and the Envision. The color map of the control sphere shows no pattern of peripheral flattening as expected. Intermediate and peripheral curves of the spherical lens are not depicted in the color map nor in the eccentricity calculations. The Quantum and Envision are single vision aspherics and are made with essentially the same design. They show minimal flattening centrally in the optic zone. Both lenses begin to flatten gradually at a point approximately 3.5mm from the apex. The lenses do not flatten a great deal in the periphery compared to the multifocal lenses. Their eccentricities are calculated in Table 2. The Envision is a biaspheric design and the Quantum is a Sphere/aspheric design. Both are very similar to a spherical lens with a well blended peripheral curve system. Because of this, they should be trial fit initially on K.

The Ellip-See-Con is an example of an ellipsoid. The color map printout shows a posterior geometry which flattens from apex to edge at a continual rate. A single e value can be used to describe ellipsoids. The Ellip-See-Con is approximately .65 according to the Conforma Contact Lens Fitting Guide. It's eccentricity as calculated in this study is shown in Table 2. Our calculations show that the Ellip-See-Con varies slightly from a perfect ellipsoid. Lenses with e values such as the Ellip-See-Con are single vision lenses and will need to be fit around one diopter steeper than K.

DISCUSSION

We have used the EyeSys Corneal Analysis System to analyze and present eight seperate posterior surfaces. All aspheric surfaces are not the same and only few can be described by a single e value. By combining multiple e values, which were calculated using DeFazio and Lowther's formula, with computerized color map printouts, we have shown the differences in a spherical posterior surface, an ellipsoidal surface such as the Ellip-See-Con, a spher/aspheric geometry such as the Quantum, the biaspheric geometry of the Envision, and surfaces with variable eccentricities such as the VFL 3 and APA.

Aspheric designs are extremely complicated and therefore they are difficult to manufacture, polish, and verify. The advent of computer-assisted videography systems should provide practitioners with a greater understanding of aspheric surfaces and a better way to verify these lenses. They should also be beneficial to the manufacturers in quality control and development of new and better designs.

TABLE 1 LENS SHAPE VS. E VALUE

LENS SHAPE	e VALUE
SPHERICAL	$e = 0$
ELLIPSOIDAL	$0 < e < 1$
PARABOIDAL	$e = 1$
HYPERBOLOIDAL	$e > 1$

(Table 2) ECCENTRICITY CALCULATIONS

LENS	Ro	Y	Rs	e
VFL I	7.90mm	1mm	7.93mm	.69
		2mm	8.04mm	.75
		3mm	8.20mm	.73
		4mm	8.29mm	.63
VFL II	7.90mm	1mm	7.95mm	.89
		2mm	8.09mm	.87
		3mm	8.22mm	.76
		4mm	8.30mm	.64
VFL III	7.90mm	1mm	7.96mm	.98
		2mm	8.11mm	.92
		3mm	8.24mm	.78
		4mm	8.38mm	.70
APA	7.18mm	1mm	7.23mm	.85
		2mm	7.35mm	.79
		3mm	7.53mm	.76
		4mm	7.77mm	.74
SPHERE	7.89mm	1mm	7.88mm	.00
		2mm	7.86mm	.00
		3mm	7.86mm	.00
		4mm	7.87mm	.00
ENVISION	7.91mm	1mm	7.90mm	.00
		2mm	7.90mm	.00
		3mm	7.90mm	.00
		4mm	7.99mm	.28
QUANTUM	8.32mm	1mm	8.29mm	.00
		2mm	8.28mm	.00
		3mm	8.31mm	.00
		4mm	8.38mm	.25
ELLIP-SEE-CON	7.90mm	1mm	7.93mm	.69
		2mm	7.99mm	.60
		3mm	8.07mm	.55
		4mm	8.12mm	.47
BUTTON	8.14mm	1mm	8.16mm	.57
		2mm	8.22mm	.57
		3mm	8.29mm	.52
		4mm	8.39mm	.51

FIGURE LEGENDS

FIG. 1 At pt. Z: AB is the tangential radius
CD is the steeper sagittal radius

FIG. 2 Contact Lens Map

FIG. 3 BUTTON color map

FIG. 4 VFL color map

FIG. 5 VFL 2 color map

FIG. 6 VFL 3 color map

FIG. 7 APA color map

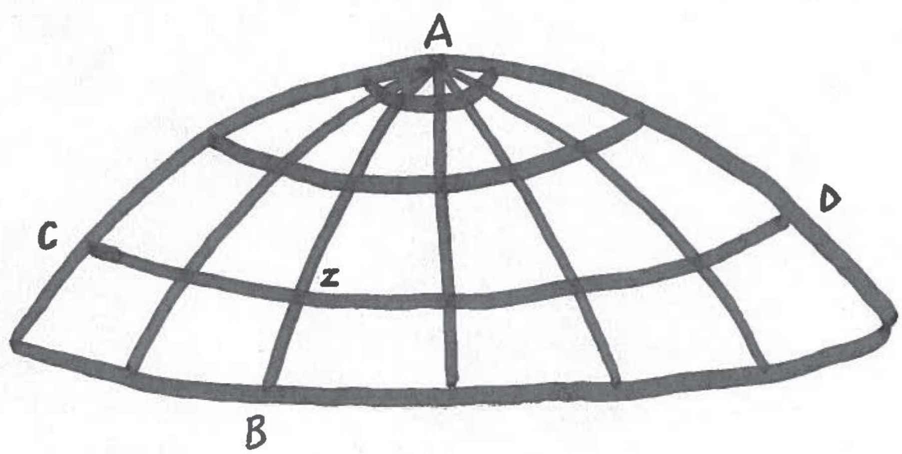
FIG. 8 CONTROL SPHERE color map

FIG. 9 QUANTUM color map

FIG. 10 ENVISION color map

FIG. 11 ELLIP-SEE-CON color map

Fig. 1



At pt. Z: AB is the tangential radius
CD is the steeper sagittal radius

ASPHERIC VFL III 7.90 OD

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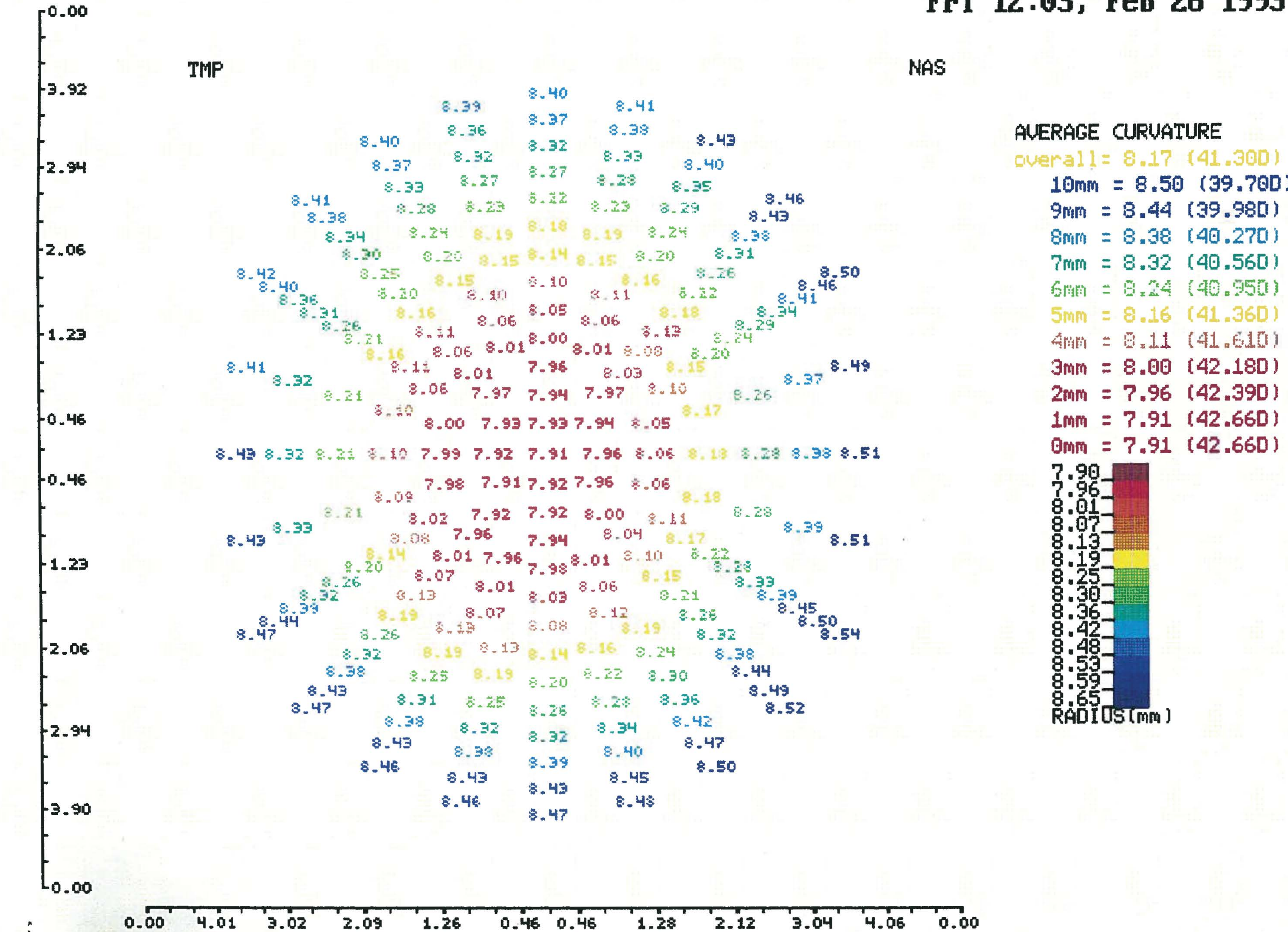
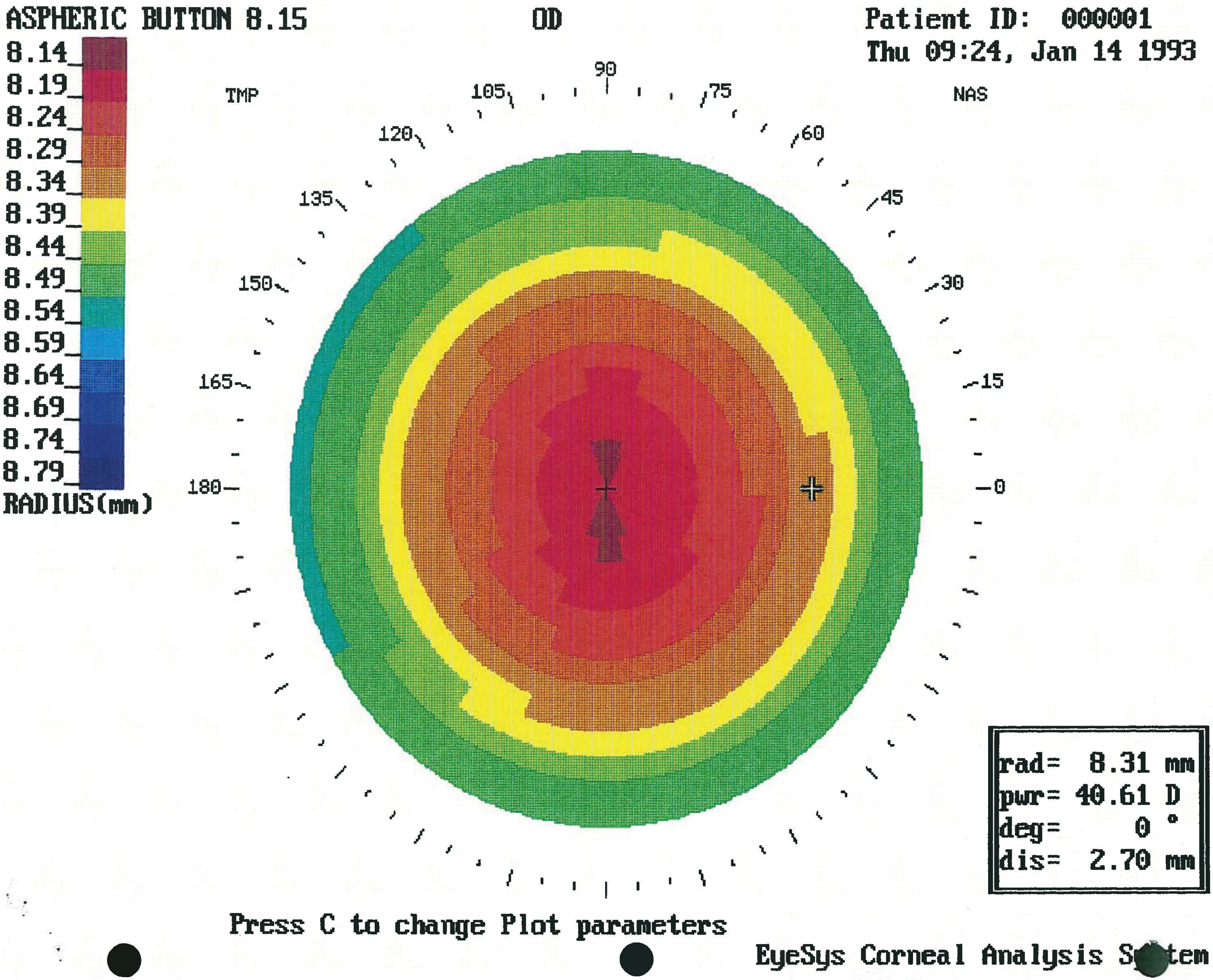
Fri 12:03, Feb 26 1993



EyeSys Corneal Analysis System


ASPHERIC BUTTON 8.15
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8.14
8.19
8.24
8.29
8.34
8.39
8.44
8.49
8.54
8.59
8.64
8.69
8.74
8.79
RADIUS(mm)
TMP
NAS
90
105
75
120
60
135
45
150
30
165
15
180
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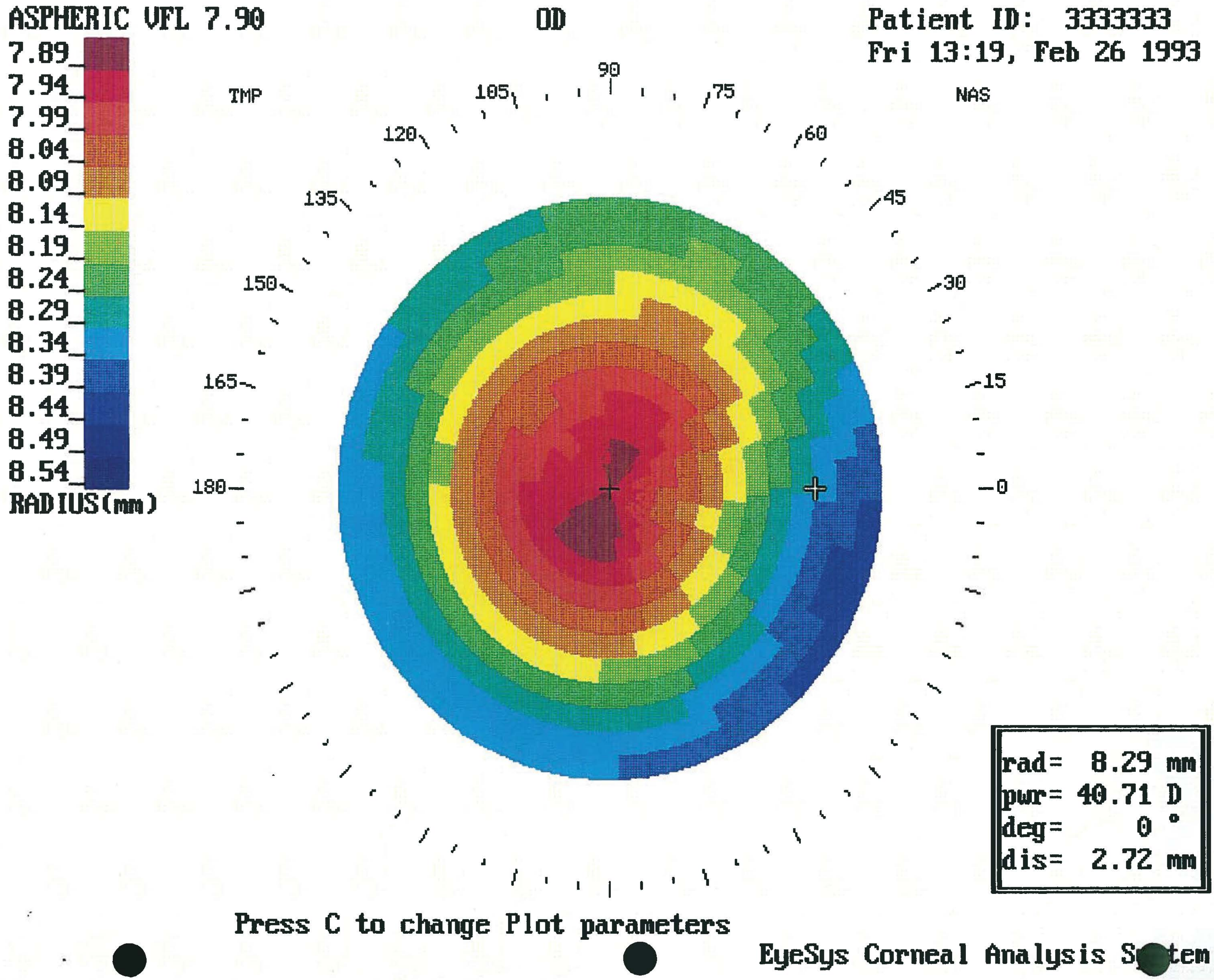
pwr= 40.61 D
deg= 0 °
dis= 2.70 mm
Press C to change Plot parameters
EyeSys Corneal Analysis System



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7.94
7.99
8.04
8.09
8.14
8.19
8.24
8.29
8.34
8.39
8.44
8.49
8.54
RADIUS(mm)
TMP
NAS
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105
75
120
60
135
45
150
30
165
15
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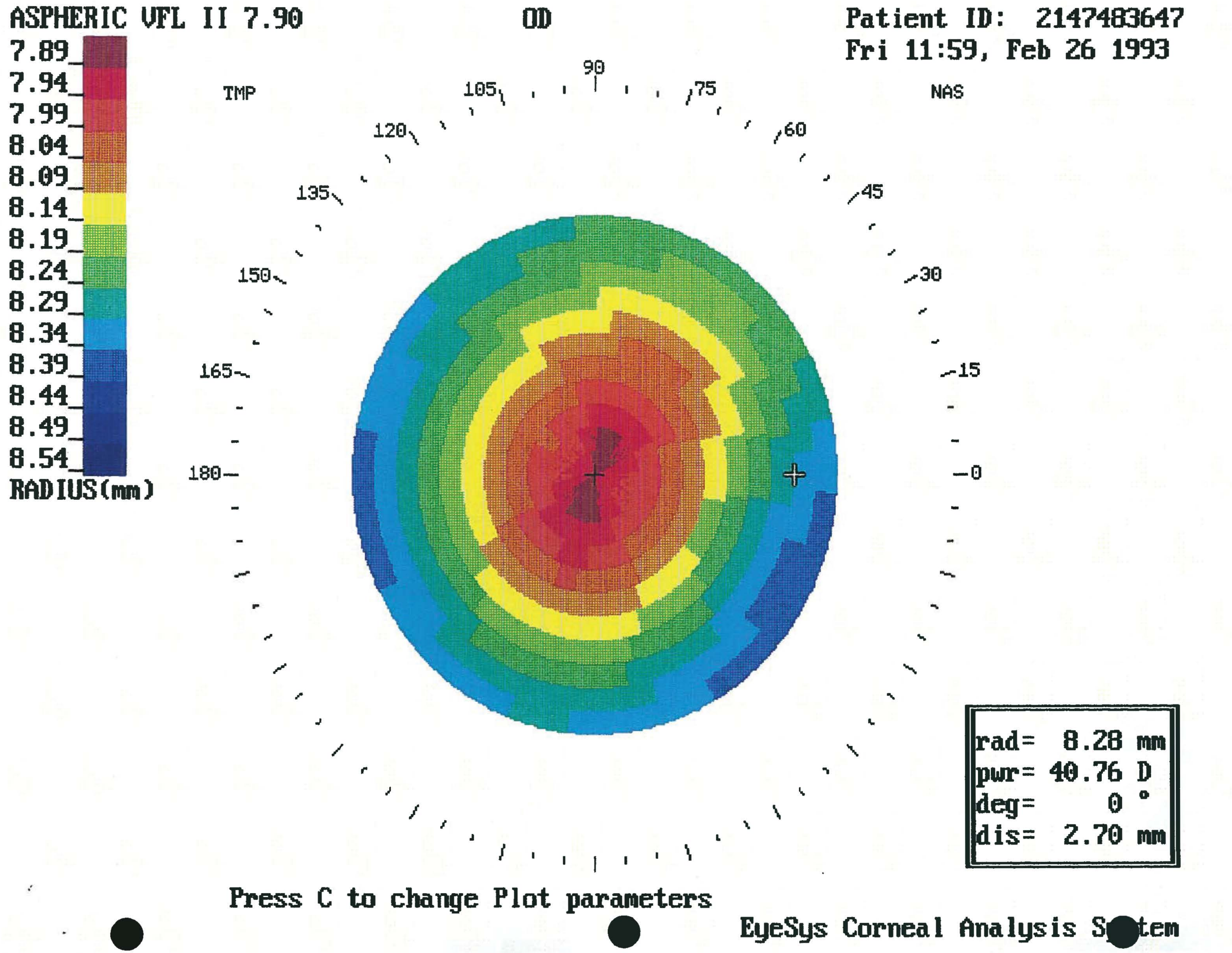

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8.14
8.19
8.24
8.29
8.34
8.39
8.44
8.49
8.54
RADIUS(mm)
TMP
NAS
90
105
75
120
60
135
45
150
30
165
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Press C to change Plot parameters
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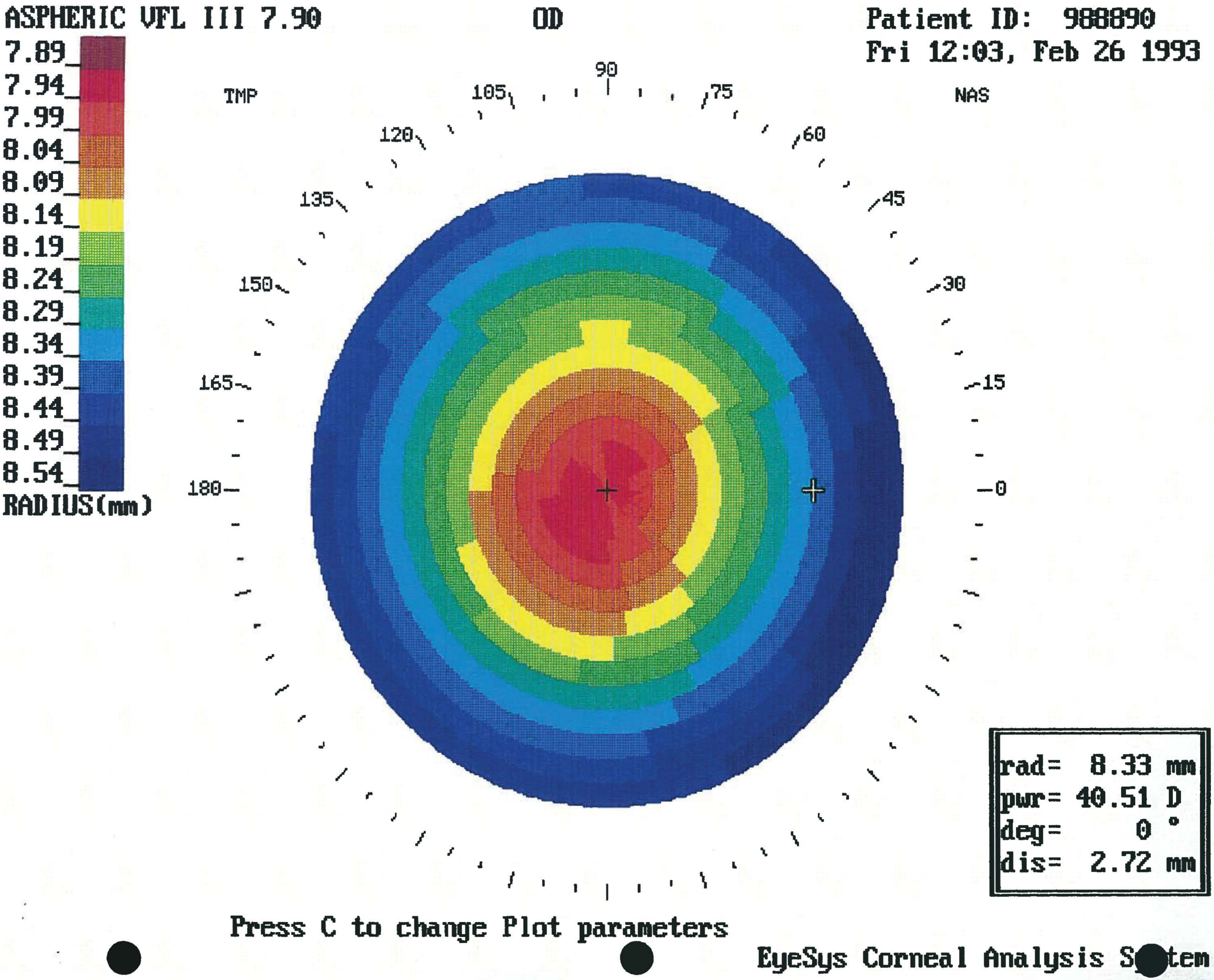
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7.89
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8.09
8.14
8.19
8.24
8.29
8.34
8.39
8.44
8.49
8.54
RADIUS(mm)
TMP
NAS
90
105
75
120
60
135
45
150
30
165
15
180
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rad= 8.33 mm
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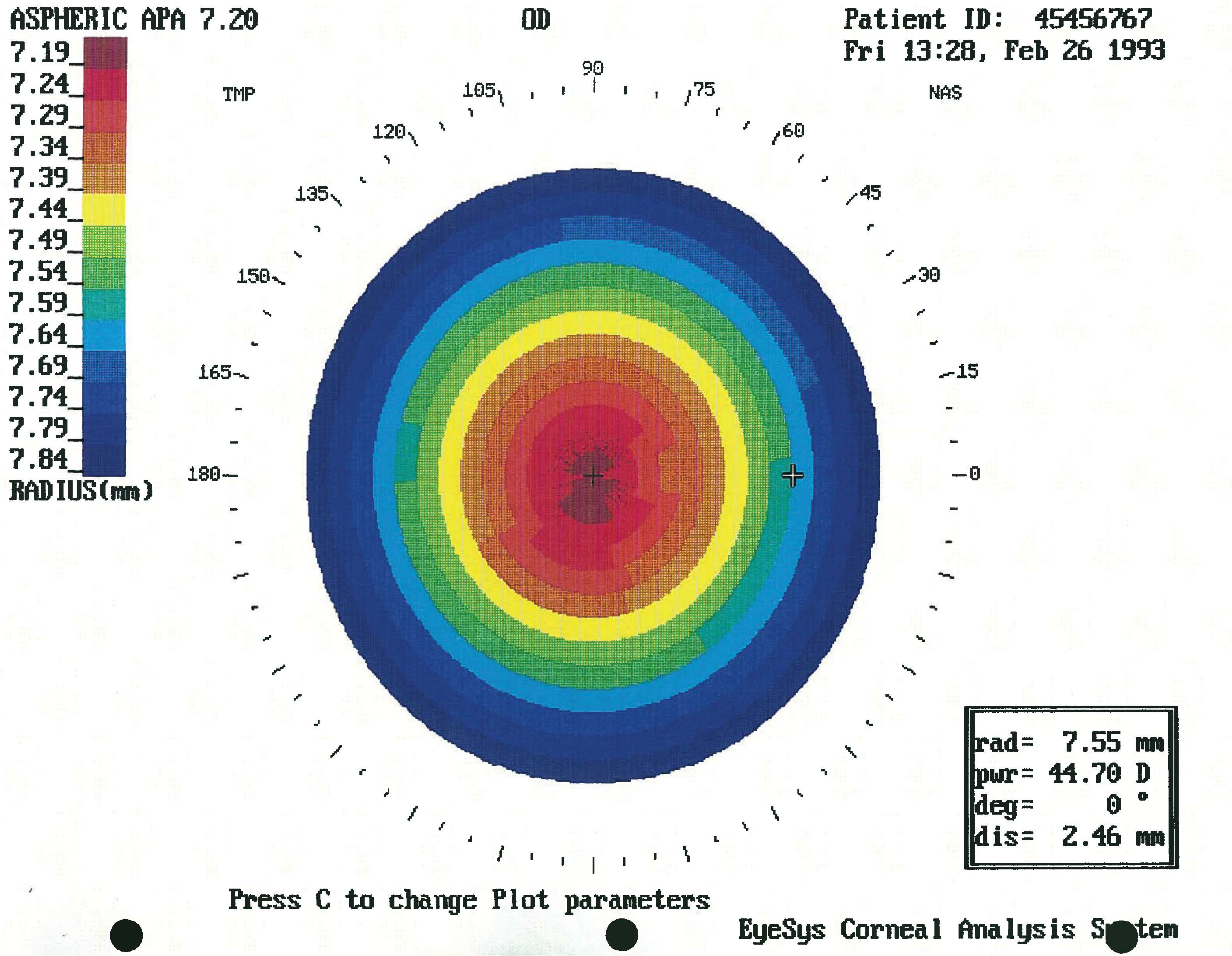
dis= 2.72 mm
Press C to change Plot parameters
EyeSys Corneal Analysis S tem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7.79
7.84
RADIUS(mm)
TMP
NAS
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105
75
120
60
135
45
150
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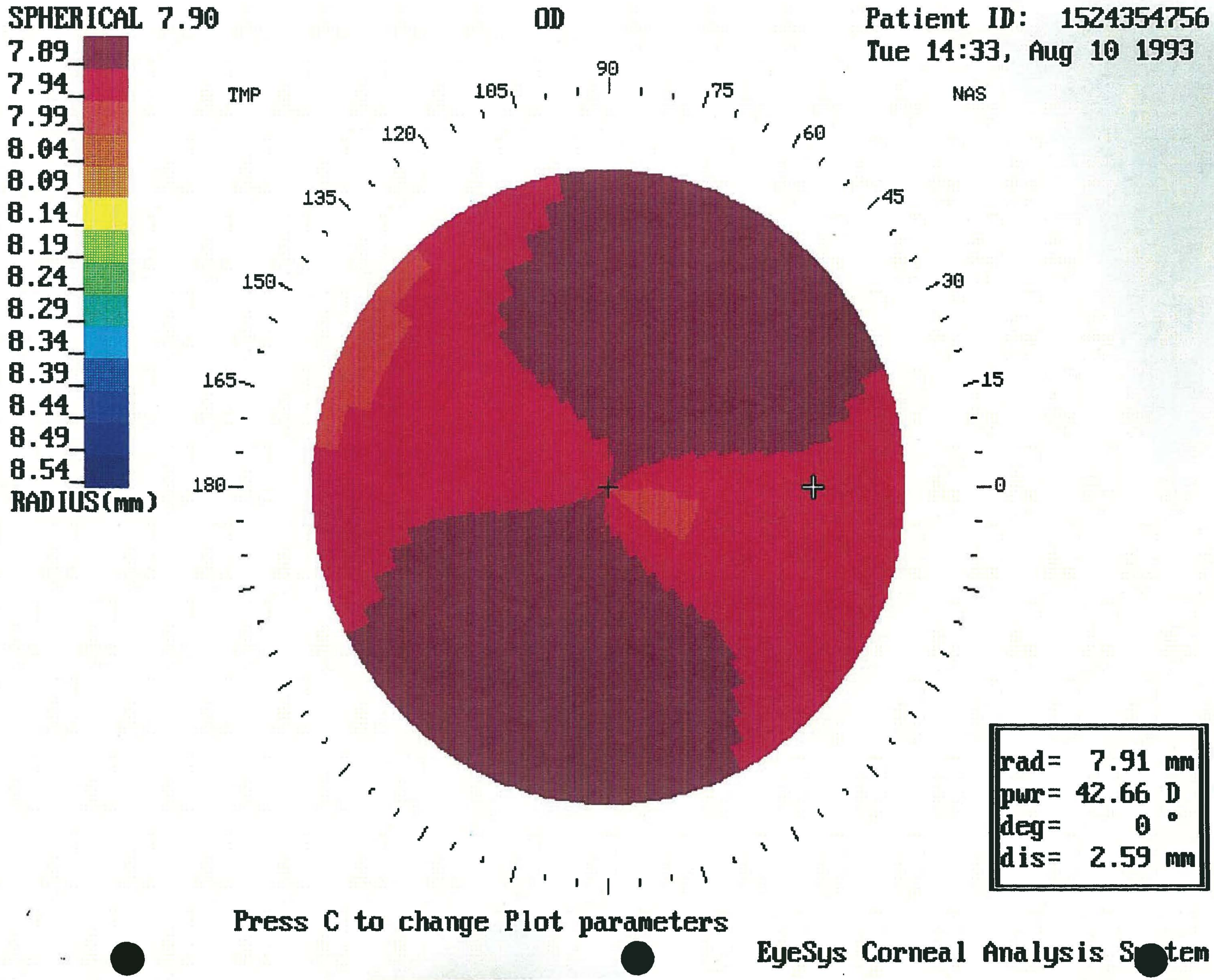
EyeSys Corneal Analysis System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8.34
8.39
8.44
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8.54
RADIUS(mm)
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NAS
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120
60
135
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150
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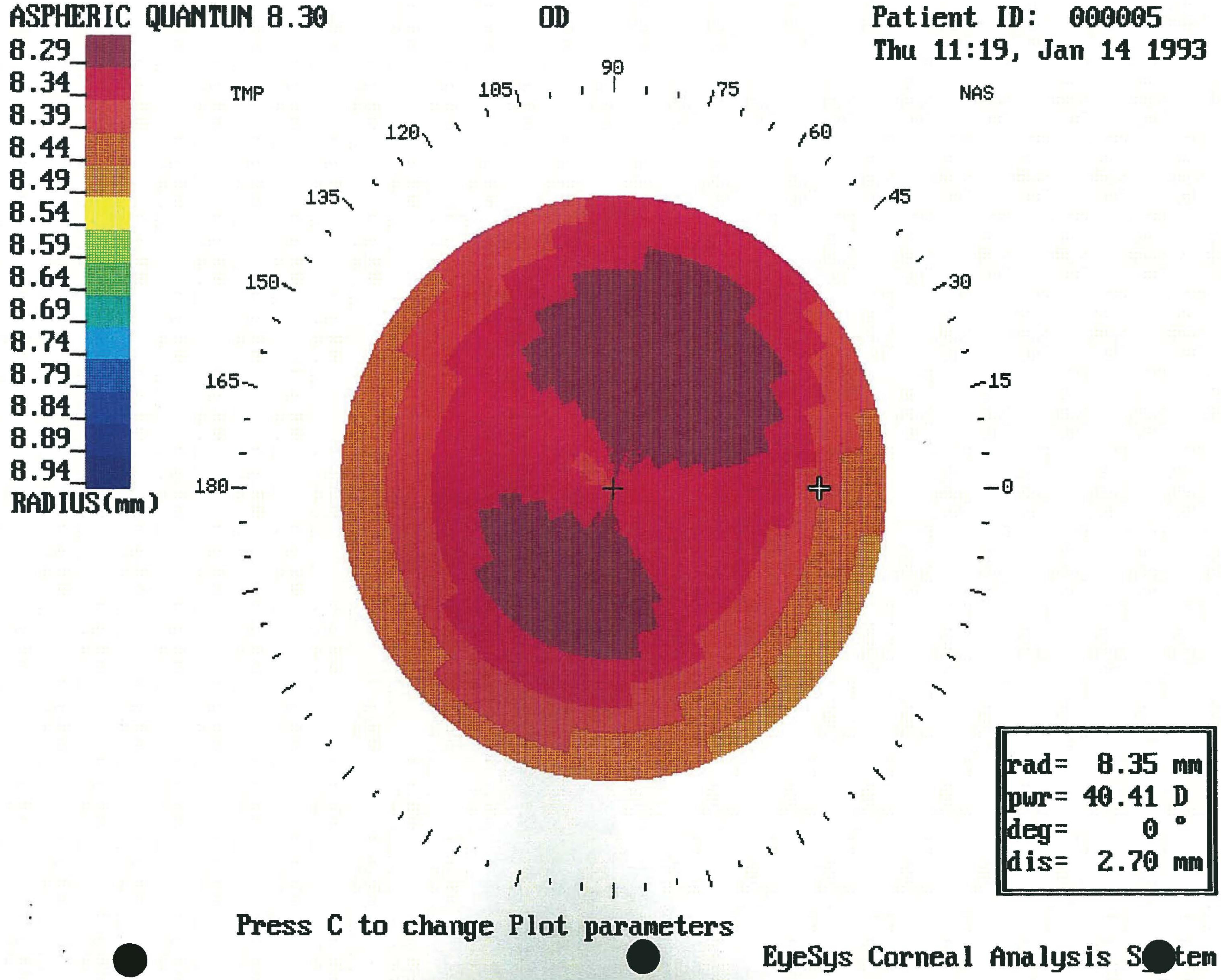
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8.89
8.94
RADIUS(mm)
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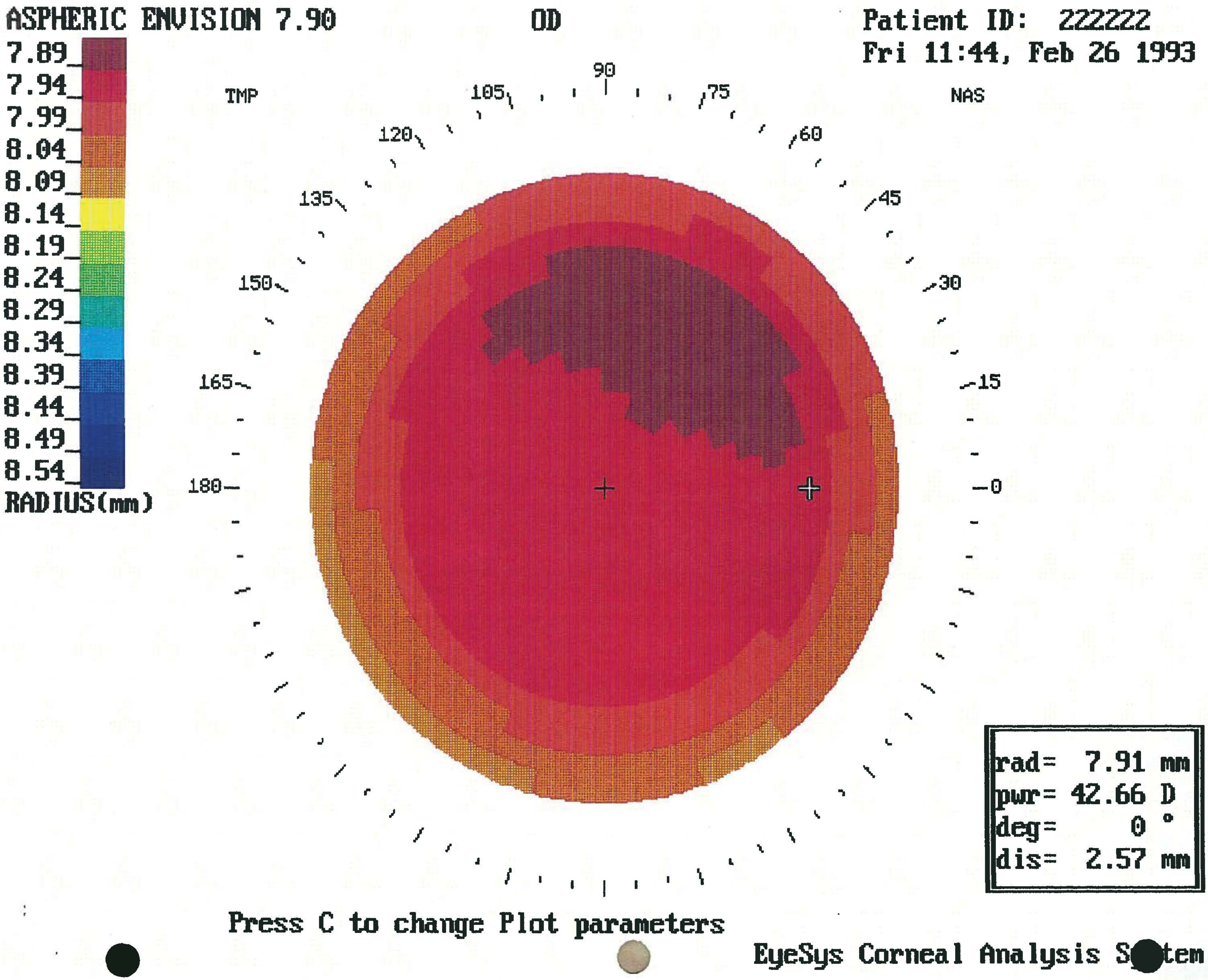
EyeSys Corneal Analysis S tem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8.54
RADIUS(mm)
TMP
NAS
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120
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150
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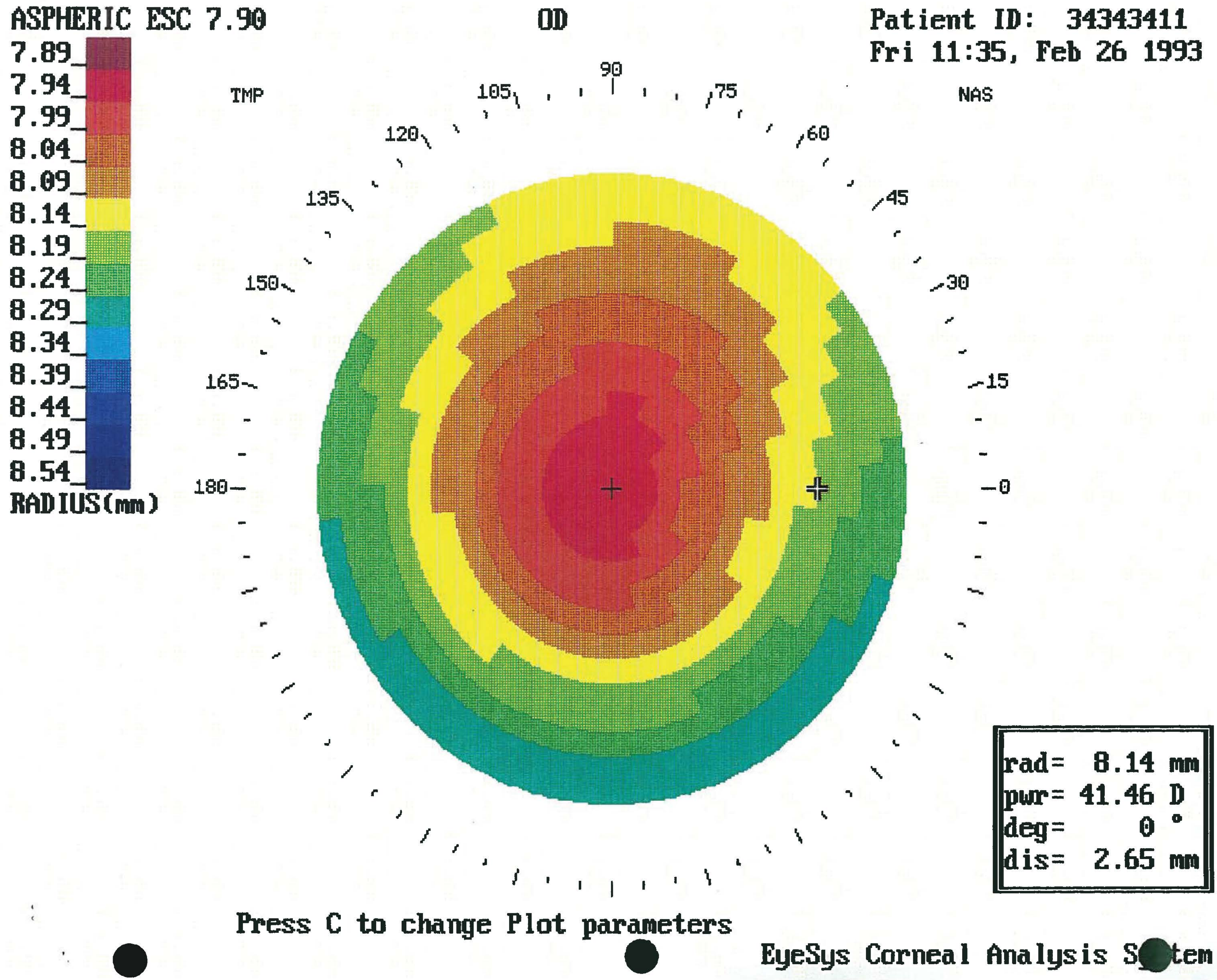
EyeSys Corneal Analysis System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8.29
8.34
8.39
8.44
8.49
8.54
RADIUS(mm)
TMP
NAS
90
105
75
120
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135
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150
30
165
15
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Press C to change Plot parameters
EyeSys Corneal Analysis System

REFERENCES

Ames, Keith S. and Jones, W.F., "Spherical Vs. Aspheric Designs: A Clinical Difference?", Contact Lens Forum, May 1988: 18-22.

Barr, Joseph T., "Aspheric Hard Corneal Lenses Are Better?", International Contact Lens Clinic, 11(4): 204, 1984.

Barr, Joseph T., "Aspheric Update 1988 Part I", Contact Lens Spectrum, November 1988: 56-60.

Barr, Joseph T., "Back Surface Aspheric Multifocal Hard Contact Lenses", International Contact Lens Clinic, November 1984: 138-140.

Barr, Joseph T., Contact Lens Continuing Education Module-Aspheric Contact Lenses.

Bennet, A.G., "Aspherical Contact Lens Surfaces Part I", The Ophthalmic Optician, October, 1968: 1037-1040.

Bennet, A.G., "Aspherical Contact Lens Surfaces Part II", The Ophthalmic Optician, November, 1968: 1297-1311.

Bennet, A.G., "Aspherical Contact Lens Surfaces Part III", The Ophthalmic Optician, 8 March, 1969: 222-224,229,230.

Buckingham, Robert and Lowther, Gerald E., "Power Distribution Across A Back-Surface Aspheric, Rigid Multifocal Contact Lens", International Contact Lens Clinic, July/August 1982: 213-217.

Bussaker, Hilmar, "Toposcopic Examination of Aspheric Contact Lens Back Surfaces", The Optician, 2 September, 1983: 16-22.

Caroline, Patrick J., Garbus, Carl, Garbus, Jenny, and Norman, Craig W., "Comparison of Aspheric RGP Lens Contours, Contact Lens Spectrum, July, 1992: 43-45.

Conforma Contact Lenses, Conforma Contact Lens Fitting Guide.

DeFazio, Anthony J. and Lowther, Gerald E., "Inspection of Back Surface Aspheric Contact Lenses", American Journal of Optometry and Physiological Optics, August, 1979: 471-479.

Koetting, Robert A., "Are You Ready to Try Aspherics Again?", Contact Lens Spectrum, January, 1989: 71-73.

Goldberg, Joe B., "Aspheric Multifocals' Usable Vision Zone", Contact Lens Forum, October 1982: 53,55,57.

Goldberg, Joe B., "Basic Principles of Aspheric Corneal Lenses", Contact Lens Forum, May, 1988: 35-38.

Goldberg, Joe B., "How and When to Prescribe Aspheric Lenses", Revie of Optometry, June, 1989: 47,48,50,53.

Goldberg, Joe B., "Reducing Edge Lift of an Aspheric Corneal Lens", International Contact Lens Clinic, May/June 1990: 155-156.

Neefe, Charles W., "Aspheric Multifocals: A Major Breakthrough", Contact Lens Forum, May 1977: 44-47.

Rakow, Phyllis L., "Aspheric Lenses in Europe", Contact Lens Forum, May, 1988: 24,26,28,30.

Salvatori, A.L., "Aspheric Base Curve CLs With Spherical Lens Accuracy", Contact Lens Forum, December, 1989: 42-44.

Volk, David and Goldberg, Joe B., "Physiological Optics and Effects of Aspheric Corneal Lenses", Contact Lens Spectrum, January, 1988: 65-67.