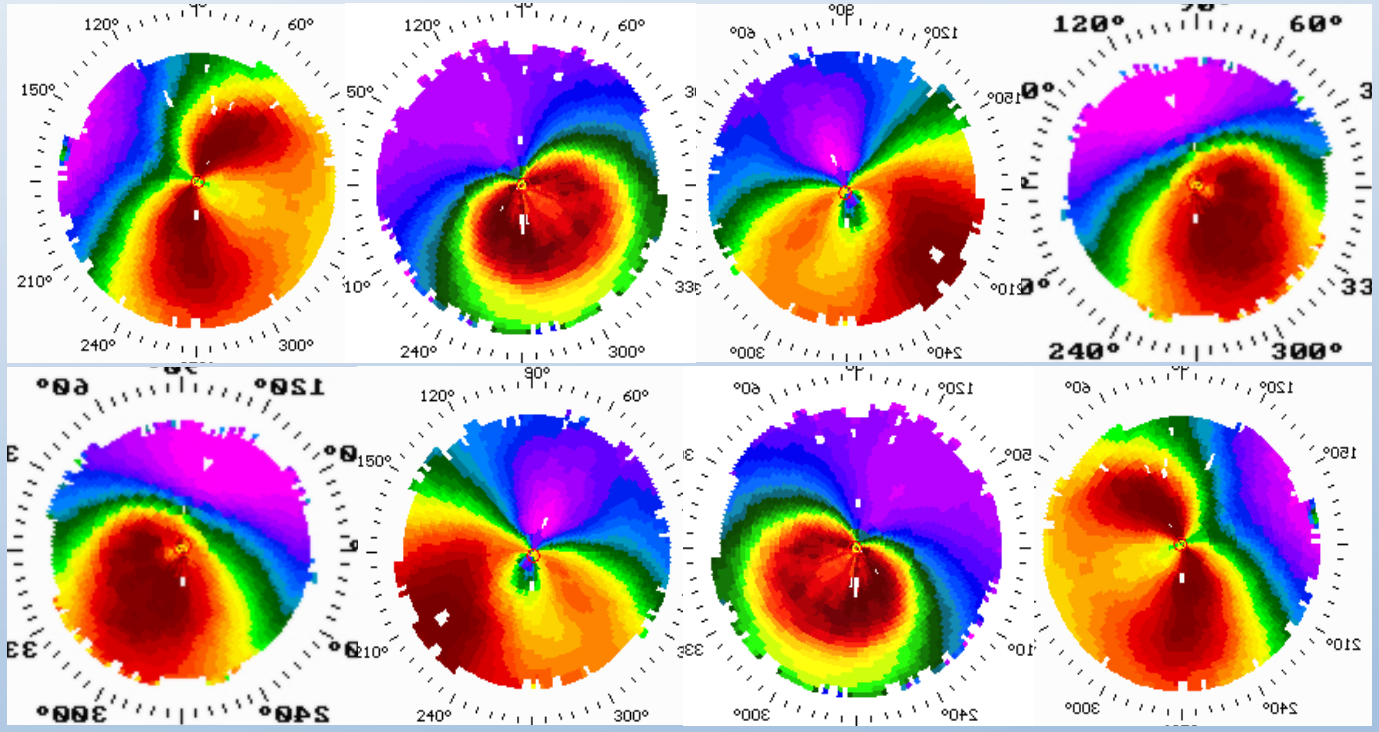


Keraring® Surgical Planning

Nomograma - 2.0 Version

Philosophy of Keraring® surgical planning

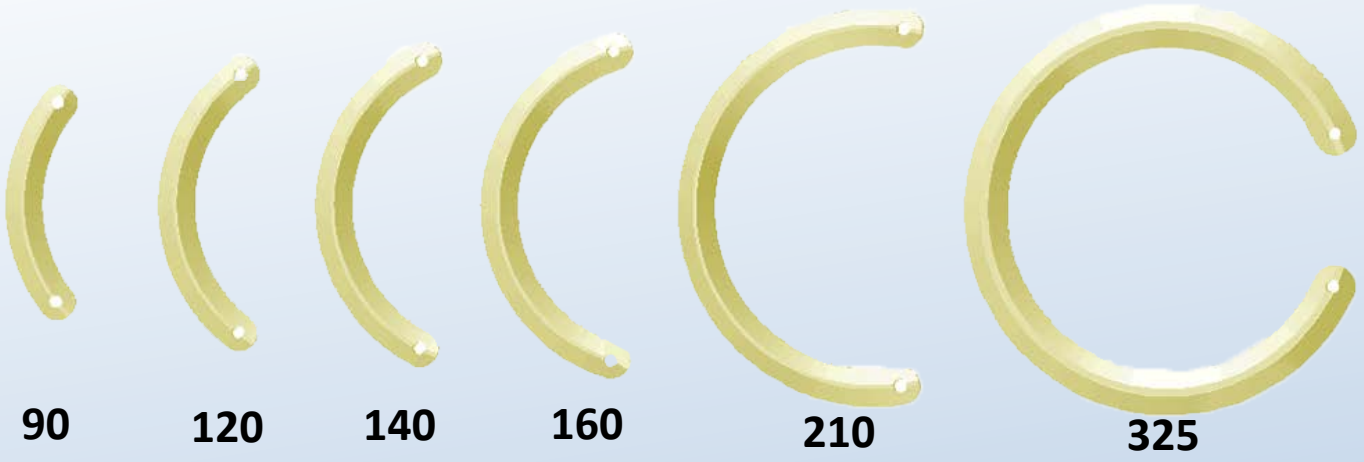
Each keratoconus is unique and should be evaluated individually and systematized to define the most appropriate surgical approach. A detailed analysis of multiple tomographic, refractive, visual and aberrometric variables is essential for good surgical planning and consequent satisfactory results.



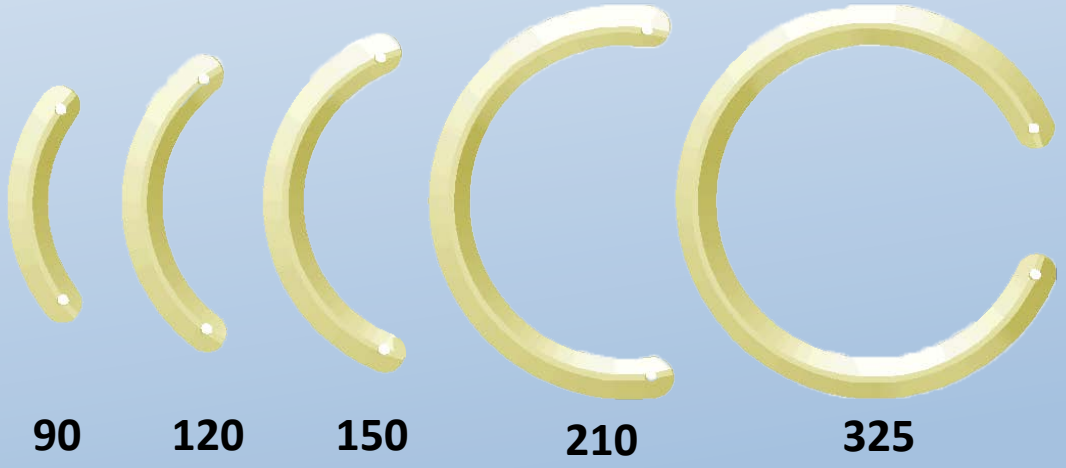
KERARING
INTRASTROMAL CORNEAL RING SEGMENTS

SYMMETRIC ICRS

Model SI-5 (5mm OZ). All arcs available from 150µm to 350µm in 50µm steps.*



Model SI-6 (6mm OZ). All arcs available from 150µm to 350µm in 50µm steps.*



*Check available models.

KERARING AS
MEDIPHACOS CORNEAL

ASYMMETRIC ICRS



ARC 160º (AS5 and AS6)
OPTICAL ZONE 5mm and 6mm

THICKNESS PROGRESSION:
150-250µm and 200-300µm

DIRECTION OF SEGMENT THICKNESS PROGRESSION:
Clockwise and anti-clockwise

KERARING AS
MEDIPHACOS CORNEAL



- **Arc 330º (AS5 330)**

  Optical Zone: 5mm

  Progressive Thicknesses: 150-250 or 200-300µm

  Variable thickness, thinner on tips and thicker in the center of the arc.



- **Arc 320º (AS5 320)**

  Optical Zone: 5mm

  Sinusoidal Thickness: 150-250-150 or 200-300-200µm

  Variable thickness in sinusoidal shape along the arc.

KERARING AS
MEDIPHACOS CORNEAL



- Arc 320° (AS6 320)

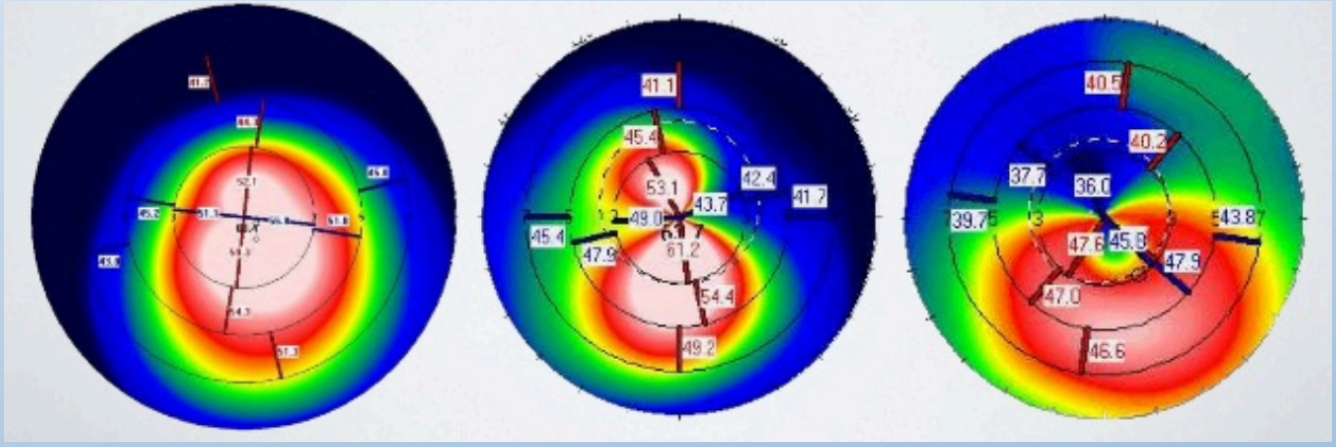
  Optical Zone: 6mm

  Sinusoidal Thickness: 150-250-150 or 200-300-200μm

  Variable thickness in sinusoidal shape along the arc.

Keraring®: Nomogram 2.0 version

- ✓ New nomogram for surgical planning based on specific algorithms for each morphological type of keratoconus and severity.
- ✓ New criteria for optical zone selection, implantation axis, and size specification
- ✓ Incorporates the latest implants (asymmetric and long arc ICRS)



Required data for Keraring surgical plan

- ✓ Corneal tomography (4 maps): axial curvature, anterior and posterior elevation BFS, pachymetry
- ✓ Aberrometric map: Coma magnitude and axis Z_3^{-1} and Z_3^{1}
- ✓ Subjective refraction: Minus cylinder
- ✓ Visual acuity: UCVA and BCVA
- ✓ Pupil diameter (mesopic conditions)
- ✓ Visual potential with a hard contact lens test or pinhole test
- ✓ Surgical technique: Mechanical or FS laser-assisted.
- ✓ Keratoconus morphological classification (Alfonso Classification)

Alfonso Morphological Classification of Keratoconus

The Alfonso Morphological Classification of Keratoconus defines specific phenotypical presentations of the disease for implantation of intrastromal corneal rings. It has been developed by Professor Jose F. Alfonso of Instituto Oftalmologico Fernandez-Vega (Oviedo, Spain).

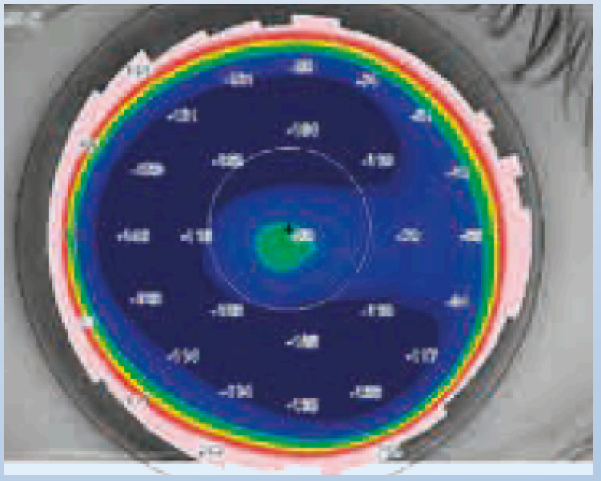
5 types of keratoconus are defined according to the following tomographic parameters:

- ✓ **Location of the cone**
- ✓ **Relationship between the 3 main diagnostic axes (flat refractive, flat topographic and coma)**
- ✓ **Orthogonality of topographic astigmatism**
- ✓ **Symmetry of topographic astigmatism**
- ✓ **Topographic aspect of anterior curvature map**

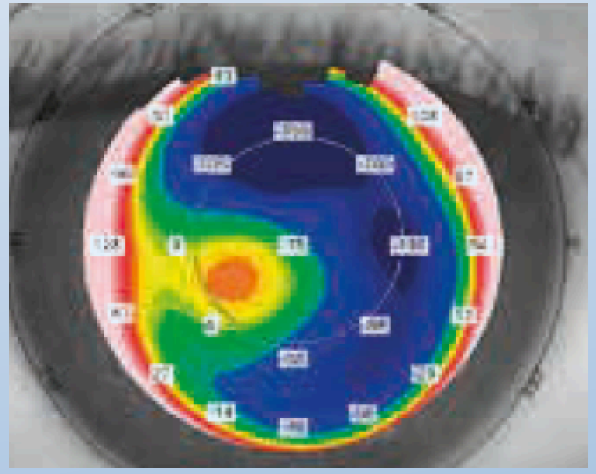
Alfonso Classification

Location of the cone: distance from the centre to the apex of the cone on posterior elevation map

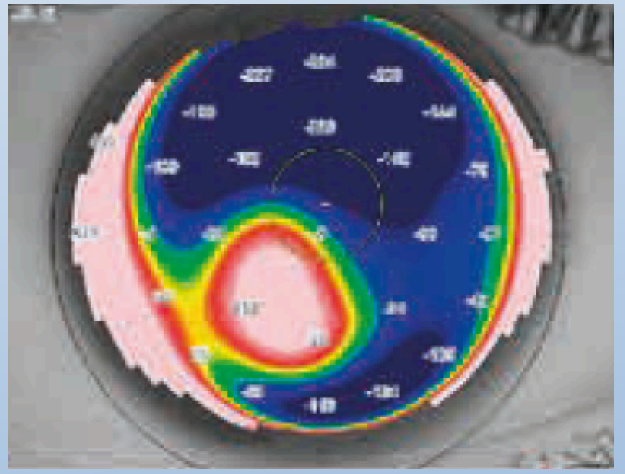
Type	Distance in mm.
Central	< 0.75
Paracentral	Between 0.76 and 1.80
Pericentral	≥ 1.81



Central



Paracentral

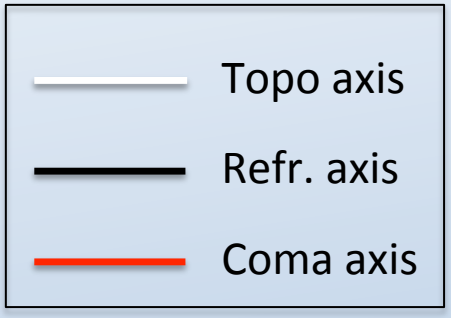


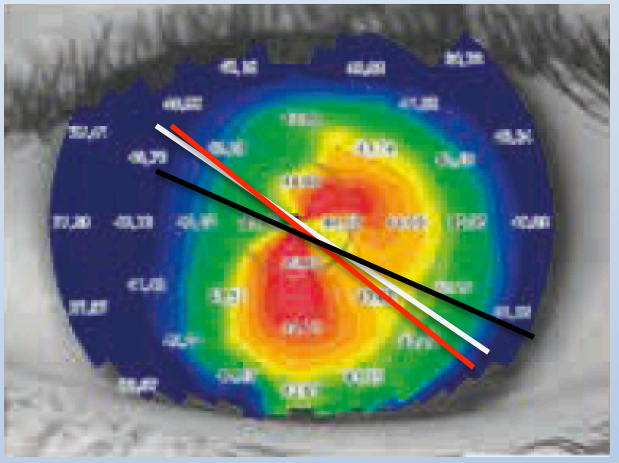
Pericentral

Alfonso Classification

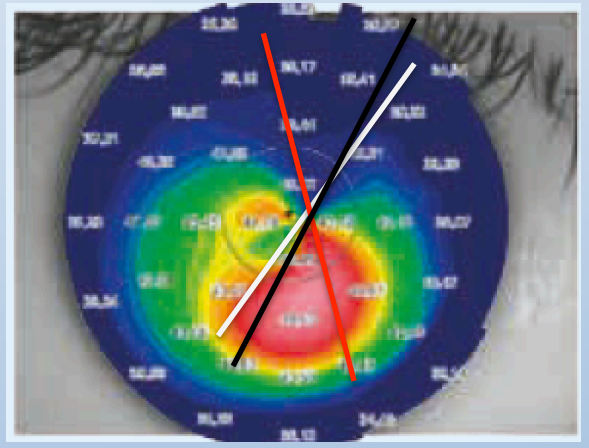
Relationship between axes: Divergence between the flat refractive axis, flat topographic axis and the coma axis.

Type	Divergence in degrees
Coincident	< 30
Non-coincident	31 ~ 60
Perpendicular	61 ~ 120





Coincident



Coma non-coincident

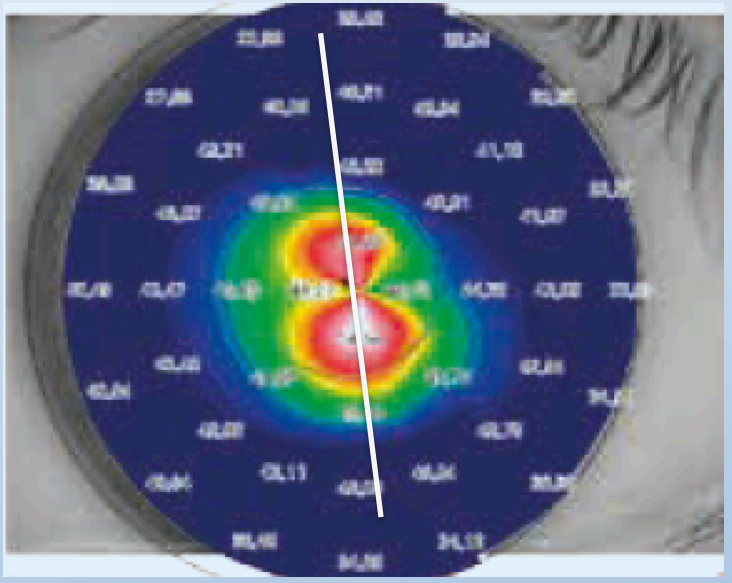


Refract. Perpendicular

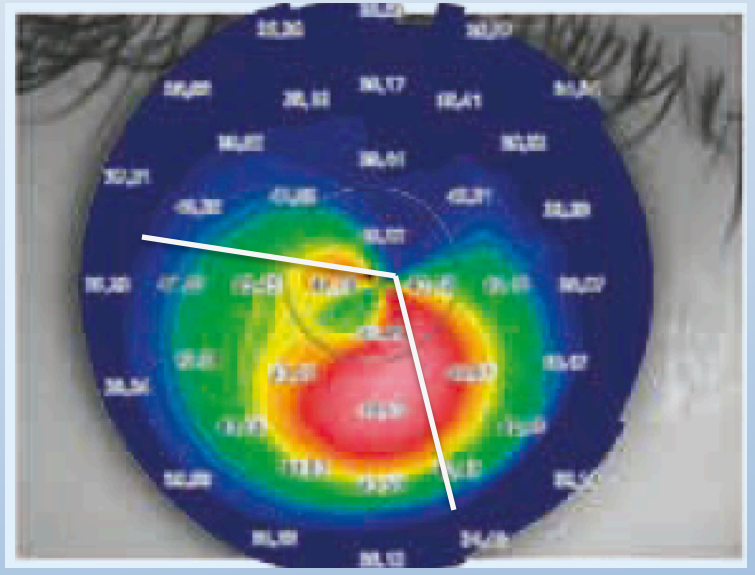
Alfonso Classification

Orthogonality of astigmatism: angulation between the lobes of topographic astigmatism

Type	Angulation in degrees
Regular	≤ 20
Irregular	≥ 21



Regular

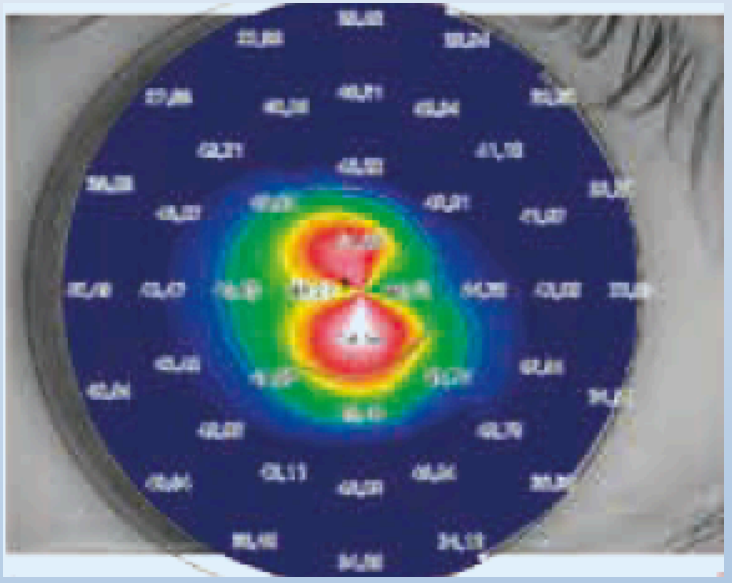


Irregular

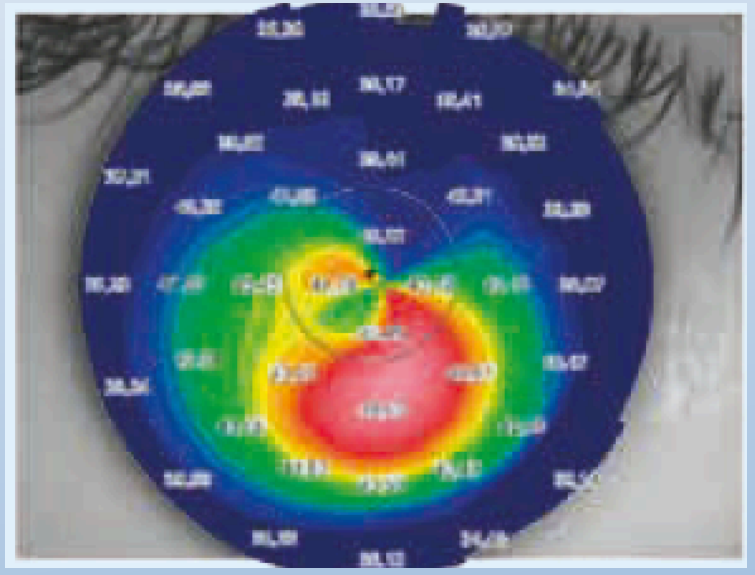
Alfonso Classification

Symmetry of Astigmatism: Symmetry between the lobes of topographic astigmatism

Type
Symmetrical (lobes of similar size)
Asymmetrical (lobes of different size)



Symmetrical



Asymmetrical

Alfonso Classification - Summary

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
1	Paracentral or Pericentral	Refractive, topographic and coma coincidental(≤ 30º)	Irregular	Symmetrical	 "croissant"
2	Paracentral	Refractive flat and coma non coincidental (>30 <60)	Irregular	Asymmetrical	 "duck"
3	Paracentral or Pericentral	Topographic and coma perpendicular	Regular	Asymmetrical	 "snowman"
4	Central	Non-determinant	Irregular	Non-determined	 "nipple"
5	Central	Refractive and topo coincidental. Coma non-determinant	Regular	Symmetrical	 "bowtie"

KERARING

INTRASTROMAL CORNEAL RING SEGMENTS

Keraring® Surgical Planning

Cone Type 1



Primary criterion for implant selection:

1. Topographic astigmatism or refractive (whichever is higher)

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
1	Paracentral or Pericentral	Refractive, topographic and coma coincidental (≤ 30º)	Irregular	Symmetrical	 "croissant"

Implant selection – Cone type 1

Cone type	No. of segments(arcs)	Axis of implantation	Optical zone	Segment type
1	1 (160) or 2 (160 + 90)	Flat topographic	$K_2 \geq 52D = 5mm$ $K_2 \leq 51D = 6mm$	Symmetrical



Astigmatism D.	Arc / Implant thickness
≤ 2.5	160/150
2.5 ~ 3.5	160/200
3.5 ~ 4.5	160/250
4.5 ~ 5.5	160/300



Astigmatism D.	Arc / Implant thickness
5.5 ~ 6.5	160/300 + 90/150
6.5 ~ 8	160/300 + 90/200
> 8	160/300 + 90/250

Cone Type 2



Variables for implant selection:

1. Mean keratometry
2. Magnitude of astigmatism
3. Relation between the diagnostic axes

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
2	Paracentral	Flat topographic and coma non-coincidental (>30 <60)	Irregular	Asymmetrical	 "duck"

Implant selection - Cone Type 2



If mean keratometry is < 52 D. , use 1 segment (160º asymmetric) or 2 segments (160º asymmetric + 120º standard), according to magnitude of astigmatism

Astigmatism D.	Arc / Implant thickness
≤ 4	AS5 150/250
4 ~ 6	AS5 200/300
> 6	AS5 200/300 + SI5 120/200

Axis of implantation:

If the refractive axis is coincident with the topographic flat axis, choose the bisector axis of these.

If the refractive axis is coincident coma axis, choose the bisector axis of these.

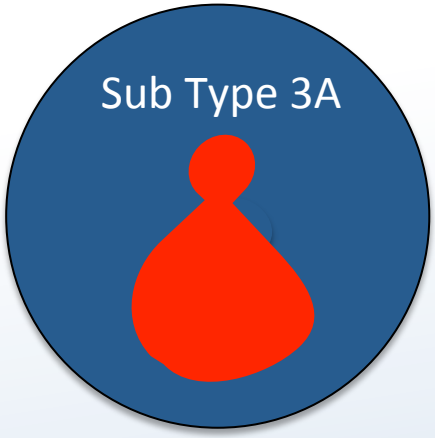
Implant selection - Cone Type 2

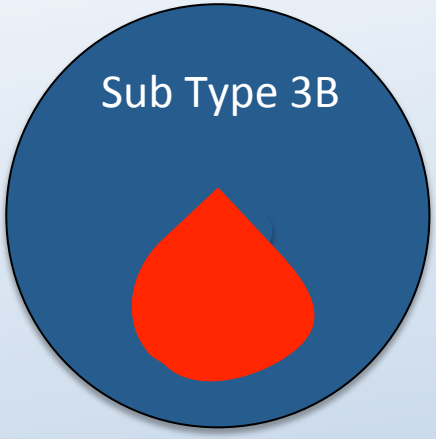


If mean keratometry is > 52 D. , use 1 segment (330º asymmetric) according to the mean keratometry value

Mean keratometry D.	Arc / Implant thickness
52 ~ 54	AS5 330 150/250
≥ 55	AS5 330 200/300

Axis of implantation:
Centre of the arc aligned to the coma axis





Cone Type 3

Differentiation by Sub Types:

3A – Flat refractive axis and flat topographic axis coincident

3B – Flat refractive axis and flat topographic axis perpendicular

Primary criterion for implant selection:

1. Mean keratometry
2. Magnitude and axis of astigmatism and coma
3. Relation between the diagnostic axes

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
3	Paracentral or Pericentral	Topographic and coma perpendicular	Regular	Asymmetrical	 "snowman"

Implant selection - Cone 3A



If mean keratometry is < 52 D. , use 2 segments (160 asymmetric) according to the magnitude of topographic cylinder

Astigmatism D.	Arc / Implant thickness
≤ 4	2 x AS5 160 150/250 (C and W)
> 4	2 x AS5 160 200/300 (C and W)

Axis of implantation:
Flat topographic

Implant selection - Cone 3A



If mean keratometry is > 52 D. , use 1 segment (asymmetric 330 degrees) according to mean keratometry value.

Mean keratometry D.	Arc / Implant thickness
52 ~ 54	AS5 330 150/250
> 54	AS5 330 200/300

Axis of implantation:
Steep topographic

Implant selection - Cone 3B



Primary criterion for implant selection:

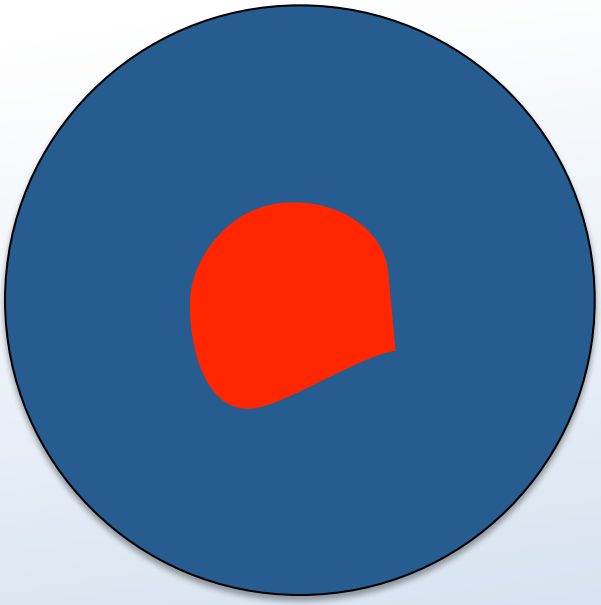
1. Magnitude and axis of coma

Axis and coma aberration value Z_3^{-1} and Z_3^{1} measured in microns at the 5mm optical zone. Use symmetric segment 210º at ø 5mm

Coma µm (5mm)	Arc / Implant thickness
≤ 1.5	SI5 210/200
1.5 ~ 2.5	SI5 210/250
> 2.5	SI5 210/300

Axis of implantation:
Coma axis

Cone Type 4



Primary criterion for implant selection:

1. Mean keratometry
2. Spherical equivalent

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
4	Central	Non-determinant	Irregular	Non-determinant	 "nipple"

Implant selection – Cone 4



Primary criterion for implant selection:

1. Mean keratometry
2. Spherical equivalent refraction

- If BCVA ≥ 20/40, use the spherical equivalent
- If BCVA < 20/40, use the mean keratometry
- Use symmetrical segment of 325º at 5mm OZ.

Sph. Eq. D.	Mean keratometry D.	Arc / Implant thickness
2 ~ 4	< 48	SI5 325/150
4 ~ 6	48 ~ 50	SI5 325/200
6 ~ 8	50 ~ 52	SI5 325/250
> 8	> 52	SI5 325/300

Axis of implantation:
270º (inferior)

Cone Type 5



Primary criterion for implant selection:

1. Magnitude and axis of astigmatism
2. Keratometry
3. Refraction

Type	Location	Relation between axes	Astigmatic orthogonality	Astigmatic symmetry	Topographic aspect
5	Central	Refractive and topo coincidental. Coma non-determinant	Regular	Symmetrical	 "bowtie"

Implant selection: Cone Type 5



Primary criterion for implant selection:

1. Magnitude and axis of astigmatism
2. Keratometry and refraction

- If the subjective refraction shows mixed or simple astigmatism, use 2 symmetric segments of 120º according to the magnitude of the topographic astigmatism

Astigmatism Topo D.	Implant thickness µm
≤ 4	150
4 ~ 6	200
6 ~ 8	250
> 8	300

Axis of implantation:
Flat topographic

Implant selection: Cone Type 5



1. Magnitude and axis of astigmatism
2. Keratometry and refraction

- If the refraction presents myopia ≤ 3 D. or if mean keratometry is ≤ 52 D. implant one AS5 150/250/150 sinusoidal thickness implant as shown

- If the refraction presents myopia > 3 D. or if mean keratometry is > 52 D., implant one AS5 200/300/200 sinusoidal thickness implant as shown

Axis of implantation:
Steep topographic

Implant Depth Guidelines

Femtosecond laser-assisted technique:

Minimum corneal thickness measured at 5mm OZ (tunnel track) should be ≥ 400µm.

- Calculate the depth: Minimum thickness at 5mm minus 100µm
- Range of tunnel depth suggested: 300µm minimum / 400µm maximum
- If calculated depth > 400µm, adjust depth to 400µm

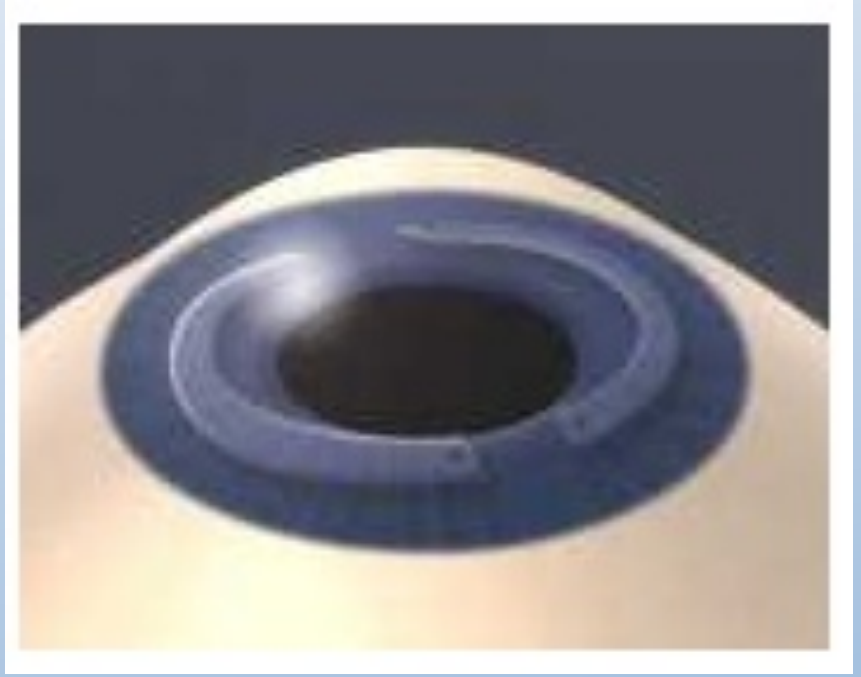
Mechanical dissection technique

Suggested incision depth: 80% of corneal thickness measured intraoperatively at the incision site

PACHYMETRIC SAFETY LIMIT REFERENCE TABLE (mechanical dissection only)					
Thickness of the proposed segment	150µm	200µm	250µm	300µm	350µm
MINIMUM corneal thickness required in the tunnel dissection area	250µm	335µ	420µ	500µ	580µ

Customisation of surgical planning

- ✓ The guidelines provided in the nomograms serve as a starting point for surgical planning. It is recommended to jointly evaluate all the diagnostic variables of the patient and the criteria of the surgeon, for better customisation of the surgical plan.



Mediphacos consulting

- ✓ The Keraring Assistant application, available for iOS and Android systems, allows the surgeon to submit clinical data and diagnostic exams to request surgical plans, clarify questions or obtain second opinions.

KERARING
INTRASTROMAL CORNEAL RING SEGMENTS

