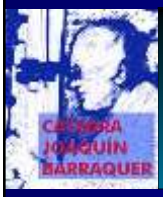
El Cairo, 25-26 January 2018

Intracorneal Rings for Keratoconus
Clues for Success



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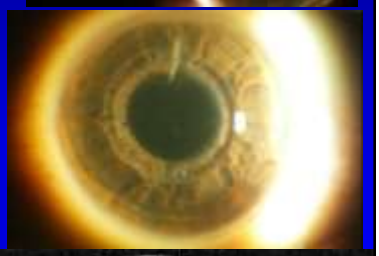
THE AUTHOR HAS NO DIRECT FINANCIAL INTEREST IN ANY OF THE PRODUCTS DISCUSSED IN THIS PRESENTATION

Background: IntraCorneal Ring Segments (ICRS)

- An established option for treating keratoconus (KC)
- However, ***KC variability*** makes ICRS implantation a complex problem
- ***What are we trying to correct?***
- ***How do they work?*** What is the effect of **each type** of ICRS on myopia, astigmatism, coma…?
- *What is **the best combination** of ICRS for a particular cornea?*



The Evidence

ICRS: Published Results

	INTACS (1141 eyes, 18 papers)	*Ferrara/Keraring* (134 eyes, 4 papers)
Mean K reduction	1.57 – 4.48 D	2.29 - 8.05 D
Mean Cyl reduction	0.29 – 2.70 D (1.58-5.69 vect.)	1.66 - 2.68 D
Mean Sph. Eq. reduct.	1.45 – 4.20 D (2.5-2.5 typ.)	1.53 - 5,80 D
Mean UCVA improvt.	75-86%eyes (+1 to +9 lin, +2-3 typ.)	77-88% (1.3 – 2.5 lin.)
Mean BSCVA improvt.	62-88%eyes (-1.2 to +4 lin, +2 typ.)	70-86% (1.7 – 2.3 lin.)
BSCVA line loss	3.7% - 14.6% eyes	0% - 11.7% eyes
Implant Extrusion	?	Man: 8-20%; FsL <4%

They do work & appear safe, but correction often only partial & quite variable

How can we improve the results?

The Problem

ICRS: *How do they work?*

- ~~Commonly assumed to follow *Thickness Law* of José I. Barraquer~~
  - The effect *does increase* with:
    - Thicker segments
    - Smaller diameter

- **HOWEVER:**
  - They work at deep position
  - Posterior indentation
  - NO anterior "thickness" effect
  - (a minor local "bump")

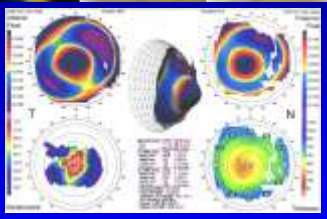
ICRS: *Compressive* biomechanical devices

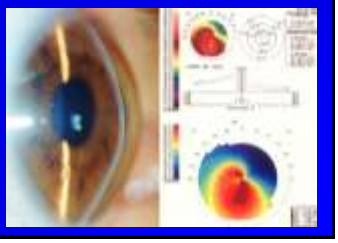
Space Occupation !

- Force lamellae to "detour" around implant ➔ longer path ➔ ***increased tension***
- ***Curvature change*** *is the (indirect) result of biomechanical (compressive) forces*

Why is correcting KC a challenge?

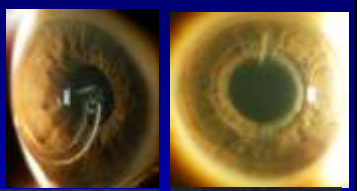
- Essentially an irregular cornea
- Still, the problem can be decomposed:
  - Increased curvature ➔ Myopia, SphAb
  - Different curvatures ➔ Astigmatism
  - Decentration
    - Can be measured as ***Coma aberration***
    - **Cannot be corrected with glasses**

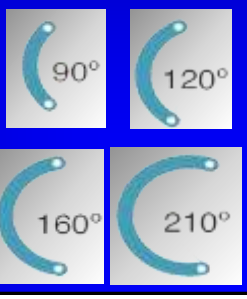




Multiple types of ICRS: *Greater control, greater complexity*

- One or two (+) ICRS
- Different sections, diameters, thickness, arc widths
- *Greater number of possible combinations*
- *How to select the best combination?*
- Possible *independent effects* on:
  - Sphere (Myopia)
  - Astigmatism
  - Decentration/Coma
  - Spherical aberration



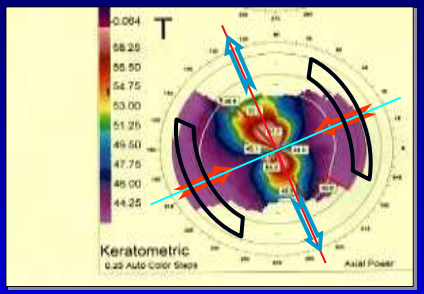


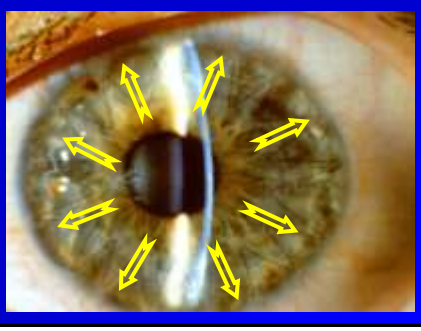
A rationale for appication?

Sectorial vs. encircling effects

Assuming a compressive effect:

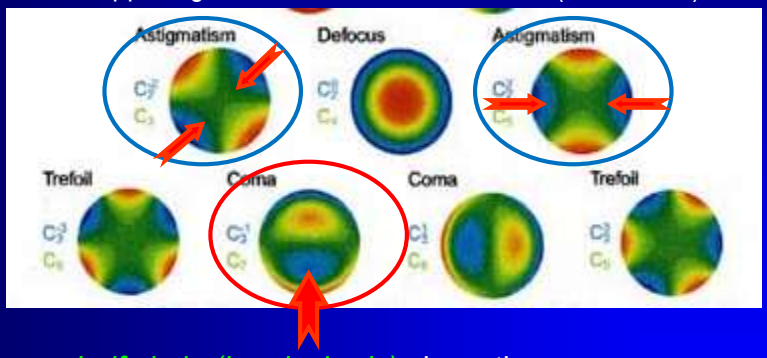
- A sector only (~ 90º)
  - ➔ steepens that meridian
  - ➔ flattens @ 90º
  - *(Just the opposite of "Thickness Law" of J.I.B.)*
  - **Corrects astigmatism**
- A circle ≈360º (180º x2)
  - ➔ gen. flattening
  - *(Just like a tightly sutured PK)*
  - **Corrects myopia**





How can we correct Coma ?

- Astigmatism: a *quadrantic* aberration
  - Max correction: acting over a quadrant **(~ 90º arc)** *or both opposite*
  - 1 or 2x opposing ICRS, centered over flat axis (effects add)



- Coma: a *half circle (hemispheric)* aberration
  - Max correction: "pushing" from one hemisphere **(~ 180º arc)** *only*
  - ICRS 1 only @decentration side (a 2nd implant will ***reduce*** the effect)

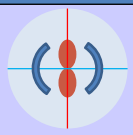
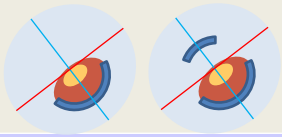
Organizing the ***Modalities of Implantation***

2x2 Basic Features/Patterns

- **Symmetry**
  - 2 equal, paired ICRS → Symmetric
  - 1 single / 2 different ICRS (or more) → Asymmetric
- **'Axiality'** *(are they on the axis?)*
  - ICRS (1 or 2) *over flat (-) axis* → Axial
  - ICRS (1 or more) *over different axis*
    (≥ 30º away from flat axis if 1x)
    (≥ 15º away from flat axis if 2x)
    → Non-Axial

The SymAx classification

Combining the two criteria: 4+2 types (The SymAx classification)

SA.ANA type	Segments (Symmetric vs. Asymmetric)	Implantation Axis (Axial= same, flat A axis vs. Non-Axial= other axis)
SA	**Symmetric** 2 ICRS (equal)	**Axial** (red= plus axis blue= minus axis) 
AA1 **AA2**	**Asymmetric** 1 ICRS 2 ICRS(unequal)	**Axial** (red= plus axis blue= minus axis) 

Summary

- Understand complexity of keratoconus ("deconstuct")
- *Compressive theory* explains observed actions of ICRS
- SymAx ➔ a simple, 2-condition classification of the implantation modalities:
  - *Symmetry:* Sym (S) vs. Asym (A)
  - *Axiality:* @*flat* Ax (A) vs. Non-Ax (NA)
- A prerequisite for a sensible analysis of ICRS results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