Understanding SIA Centroid

Why Your Toric Calculator Might Be Wrong

1 What Happens at the Incision

A standard 2.2 mm temporal CCI flattens the cornea at the incision meridian.

- Flattening at 180° → steepening at 90° (with-the-rule astigmatism)
- But the exact amount and axis vary from eye to eye
- Wound healing, tissue elasticity, and geometry all differ

2 Measuring SIA: What You Get

SIA = Post-op K values – Pre-op K values

But SIA is a VECTOR — it has magnitude AND direction.

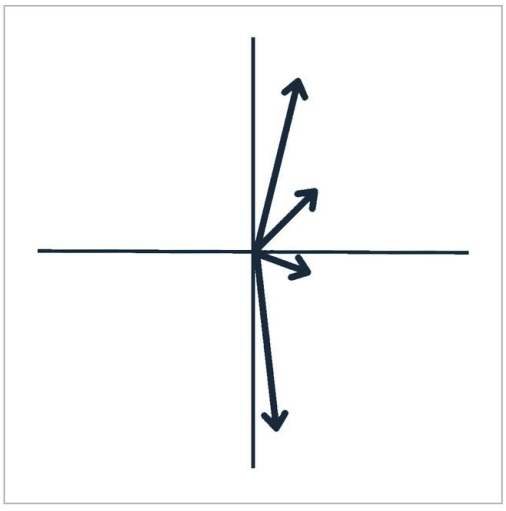
Axis convention: Astigmatism axes range from 0° to 180° only (not 360°).
Axes range from 0° to 180° only. Diagrams below use 360° for visual clarity.

Four patients, same temporal incision:

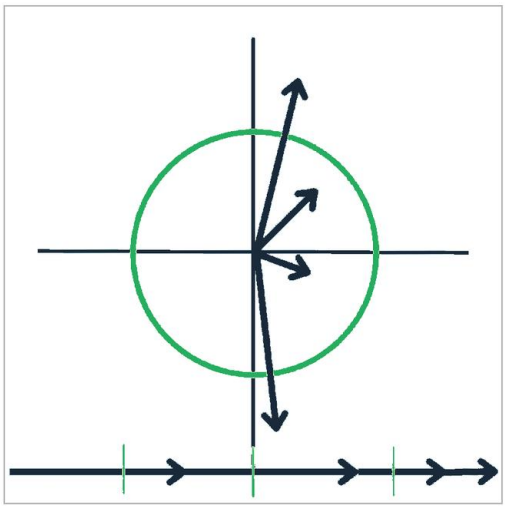
Patient A:	0.40 D @ 180°	(classic horizontal flattening)
Patient B:	0.30 D @ 170°	(slightly off-axis)
Patient C:	0.50 D @ 155°	(oblique — drifted 25°)
Patient D:	0.20 D @ 85°	(perpendicular to incision!)

3 Arithmetic Mean vs. Centroid

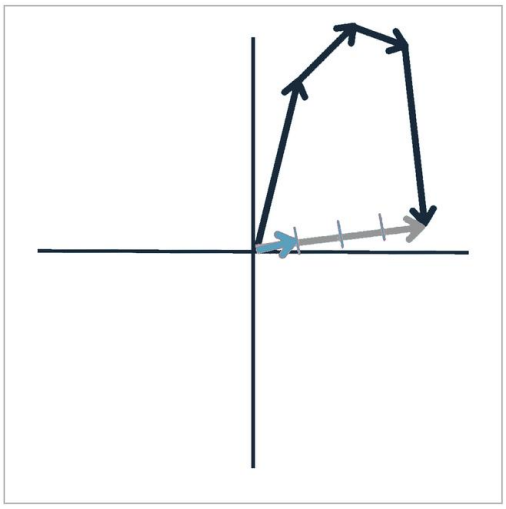
Step 1: Four SIA vectors — different lengths, different directions



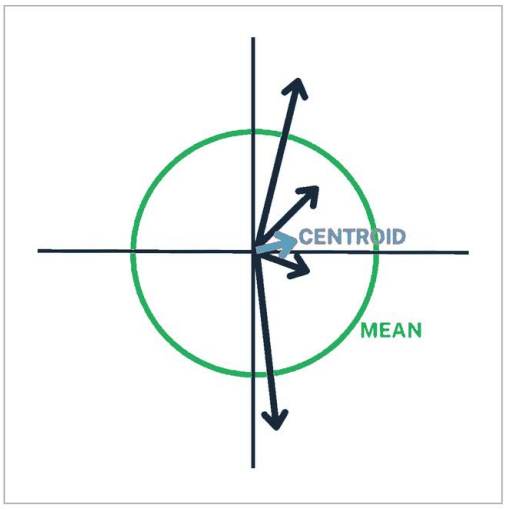
Step 2: The Mean (WRONG) — add lengths, divide by 4, ignore direction



Step 3: The Centroid (CORRECT) — chain vectors head-to-tail, find resultant, divide by 4



Step 4: The Comparison — Mean (green circle) vs. Centroid (blue arrow)



4 Beyond the Centroid — 3 Deeper Problems with SIA

(Wendelstein)

Problem 1: The Vector Mismatch

- SIA is a vector (magnitude + direction)
- But toric calculators only accept a single number — no axis input for SIA
- The calculator assumes SIA acts perpendicular to the incision meridian
- In reality, SIA direction varies from eye to eye
- This is a fundamental simplification that adds uncertainty

Problem 2: Surface ≠ Optics

- SIA is measured on the corneal SURFACE (via keratometry: pre-op vs post-op K)
- But the optical outcome depends on more than surface astigmatism — the crystalline lens is removed and replaced
- Corneal surface SIA may not equal the actual refractive change
- Measuring SIA via refraction would be more accurate but is unreliable in practice
- This means we're correcting based on a measurement that may not reflect the true optical effect

Problem 3: The scatter is larger than the effect

- Wendelstein et al. (JCRS 2023, 498 eyes, superior incision): Centroid SIA = 0.26–0.34 D, but SD = ±0.37–0.42 D
- The standard deviation is LARGER than the centroid itself. This means the scatter of individual measurements exceeds the systematic effect you're trying to measure.
- For temporal incisions it's even worse: centroid ~0.10 D vs SD ~0.40 D
- Consequence: personalizing your SIA risks OVERFITTING to noise

Side note: Some modern toric formulas (Barrett, EVO, Kane) use built-in regressions (e.g., Abulafia-Koch, Homburg-Adelaide) that account for SIA alongside many other factors — without requiring you to personalize it.

When the incision cuts the cornea, 3 things can happen:

1. **Only the magnitude of astigmatism changes**
2. **Only the axis rotates**
3. **Both change simultaneously**

Effects 2 and 3 happen far more frequently than most surgeons assume.

Source:
Wendelstein JR et al. "Characteristics of surgically induced astigmatism after standardized microincisional cataract surgery with a superior limbal incision." JCRS 2023;49(10):1025-1035.

5 Why This Matters for Toric IOL Calculation

Every toric calculator asks: "What is your SIA?"

If you enter 0.50 D (arithmetic mean):

- Calculator thinks your incision RELIABLY induces 0.50 D
- It reduces toric correction by 0.50 D at the incision meridian
- But your incision does NOT reliably do this!
- Result: You're ADDING error, not removing it.

If you enter 0.10 D (centroid):

- Calculator makes a tiny, accurate adjustment
- Matches reality. Honest and correct.

6 What to Do in Practice

Enter 0.10 D (or zero) in your toric calculator.

- Barrett Toric Calculator already defaults to 0.10 D — trust it.
- If you want precision: calculate your personal centroid from ≥50 cases.
- Do NOT use the arithmetic mean of your SIA measurements.

Formula for centroid:

x = magnitude × cos(2 × axis) average all x values
y = magnitude × sin(2 × axis) average all y values
Centroid magnitude = $\sqrt{(x^2 + y^2)}$

7 The Punchline

**"The biggest SIA mistake isn't not measuring it.
It's measuring it wrong — using the mean instead
of the centroid — and confidently entering the wrong number."**

Quick Reference

Concept	Value	Use it?
Arithmetic mean SIA	~0.30–0.50 D	NO — ignores direction
Centroid (vector mean)	~0.05–0.15 D	YES — true systematic effect
Barrett Toric default	0.10 D	YES — evidence-based
If unsure, enter	0.10 D (or 0)	YES — better than guessing high

Prepared for Dr. Lorenz Kuske · April 2026 · learnabouteyes.com
Sources: Wendelstein et al., JCRS 2023; Koch DD et al., JCRS 2012; Barrett Toric Calculator; Lahood CRSToday 2023