

## BACKGROUND

Keratoconus and corneal ectatic disorders affect **50–230 per 100,000** people globally, with substantial impact on quality of life. The principal cause of visual disability is the induction of **higher-order aberrations (HOAs)** (5–10× normal), which spherocylindrical correction cannot address.

Conventional scleral lenses neutralise corneal irregularity but leave residual HOAs of **0.6–1.7 µm RMS** over a 6 mm pupil. **Wavefront-guided lenses** aim to neutralise the eye's full optical fingerprint, restoring near-perfect retinal image quality.

*Despite emerging clinical use, no comprehensive evidence synthesis has quantified their benefit.*

## AIM

## OBJECTIVE

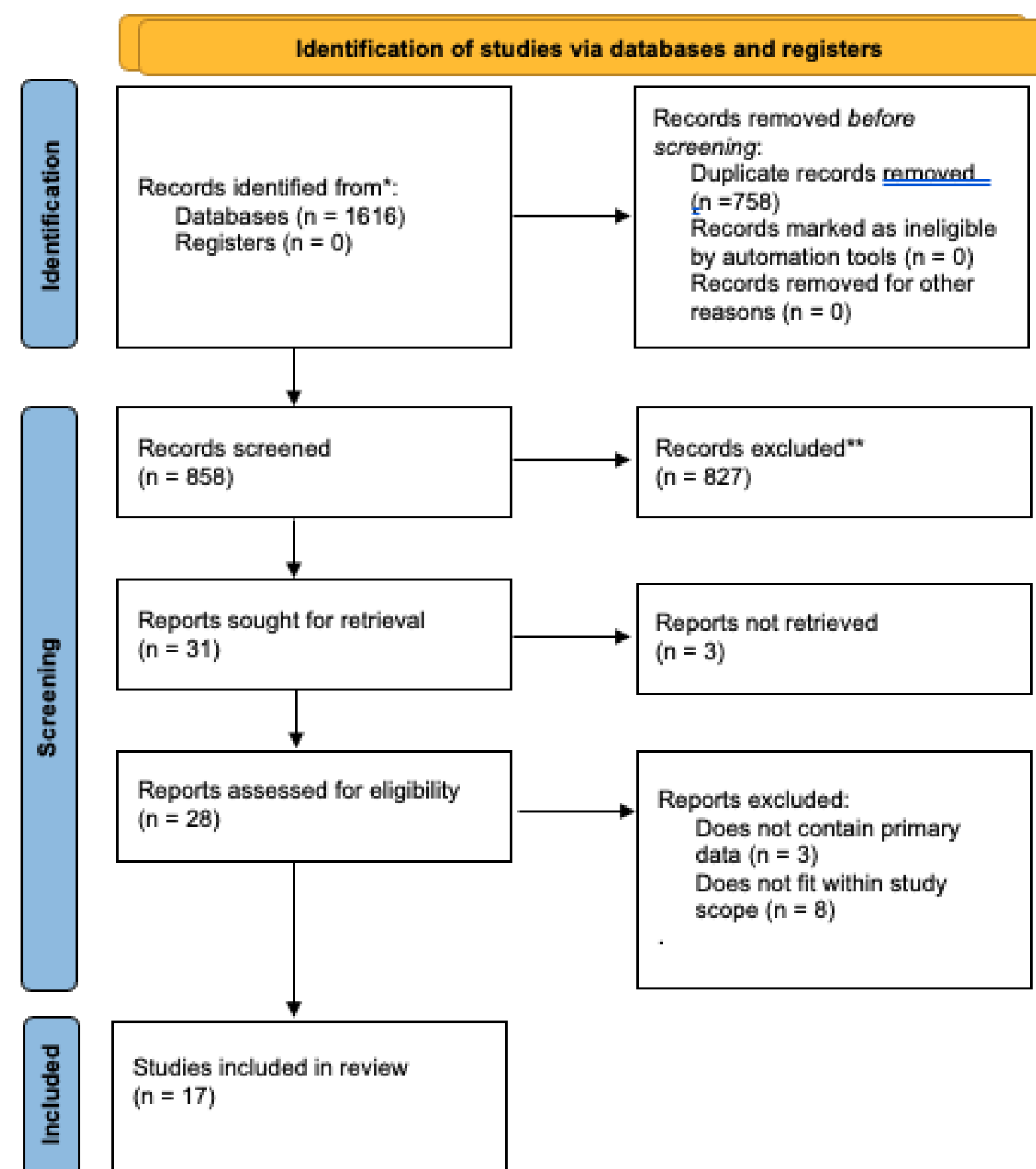
To quantify the effectiveness of wavefront-guided contact lenses on visual acuity and HOAs in corneal ectasia, compared with conventional corrections.

## METHODS

Conducted per **PRISMA 2020** (PROSPERO CRD420261328932). PubMed, Embase, Cochrane CENTRAL and Web of Science searched without date restriction (Nov 2025).

- **Population:** any age with keratoconus, PMD, post-surgical or post-LASIK ectasia
- **Intervention:** wavefront- or profilometry-guided contact lenses
- **Outcomes:** BCVA (logMAR), HO-RMS (µm), LCVA, patient preference
- **Risk of bias:** JBI tools (RCT, quasi-experimental, case series, case reports)
- **Synthesis:** random-effects inverse-variance meta-analysis (RevMan 9.15.2)

## PRISMA 2020 SELECTION



## STUDY OVERVIEW

15

studies included

172

eyes analysed

4

RCT / pooled studies

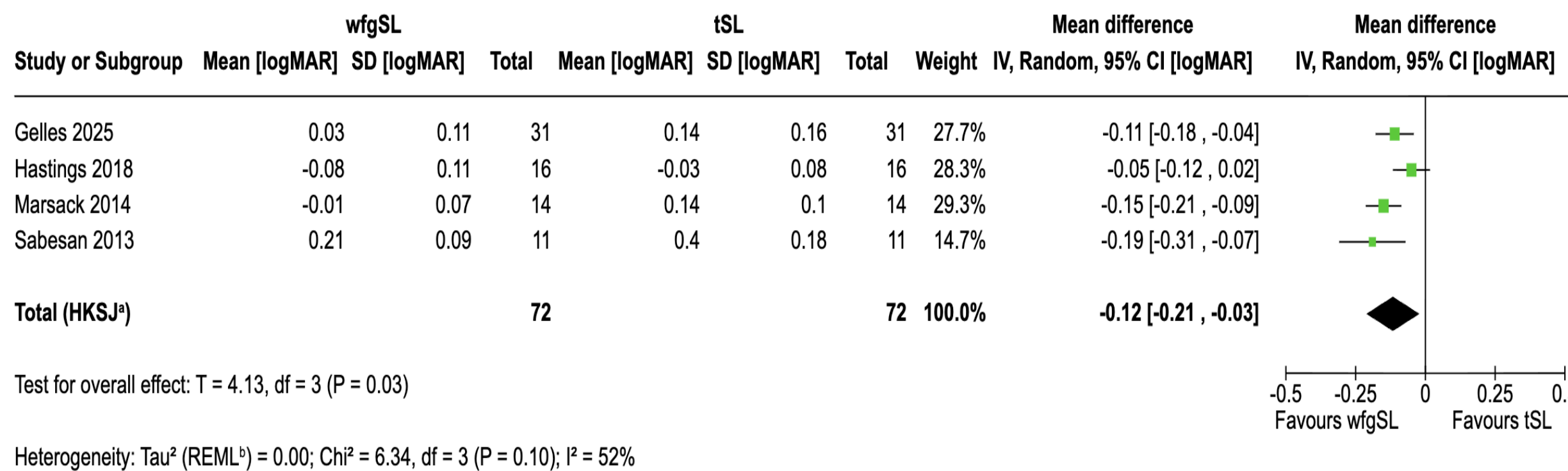
94%

patient preference

Designs: 1 RCT, 5 quasi-experimental, 5 case series, 4 case reports. Most evaluated wavefront-guided **scleral lenses (wfgSL)** versus traditional scleral lenses; four evaluated soft-lens designs.

## RESULTS — VISUAL ACUITY

Pooled (4 studies, n = 144 eyes, wfgSL vs tSL): **MD = −0.12 logMAR** (95% CI −0.21 to −0.03; **p = 0.03**; I<sup>2</sup> = 52%).

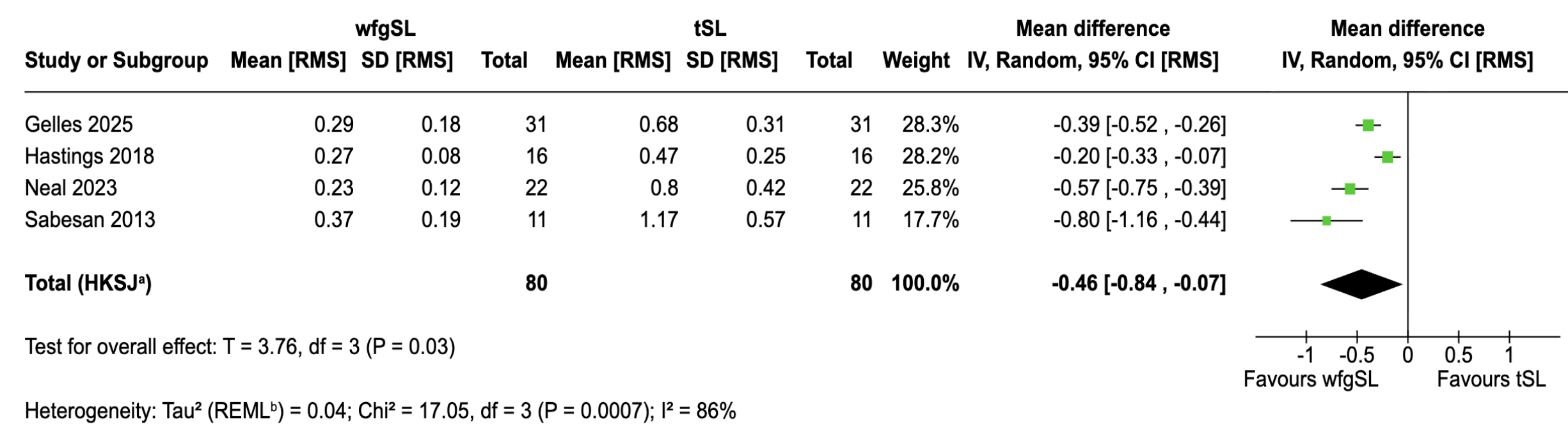


- Scleral Lens Performance:
  - Hastings et al. (2018/2022): Achieved logMAR -0.08, though noted a "ceiling effect" with minimal difference from conventional lenses in mild disease.
  - Advanced Keratoconus: Significant gains reported by Sabesan et al. (2013) (0.40 to 0.21 logMAR) and Nguyen et al. (2020) (20/18 to 20/11).
  - Specialized Fitting: Profilometry-guided lenses improved vision from 0.62 to 0.03 logMAR (Barone et al., 2025), while impression-based WFG lenses reached 20/20 compared to 20/30 traditional optics (Gelles et al., 2022).
- Soft & Hydrogel Innovations:
  - Visual Gains: Jinabhai et al. (2014) and Marsack et al. (2007) showed substantial logMAR improvements (e.g., 0.58 to 0.23).
  - Custom Correction: Coma-correcting hydrogel lenses improved baseline vision from 0.74 to -0.003 logMAR (Katsoulos et al., 2009).
  - Comparison: WFG soft lenses provide visual acuity comparable to habitual gas permeable (GP) lenses (Marsack et al., 2008).

*Best outcomes: Hastings 2018 logMAR −0.08 (≈ 20/17); Sabesan 2013 0.40 → 0.21 in advanced keratoconus; Nguyen 2020 ≈ 20/11. Modest gains in mild disease suggest a ceiling effect.*

## RESULTS — HIGHER-ORDER ABERRATIONS

Pooled (4 studies, n = 160 eyes, wfgSL vs tSL): **MD = −0.46 µm RMS** (95% CI −0.84 to −0.07; **p = 0.03**; I<sup>2</sup> = 86%).



## Footnotes

\*CI calculated by Hartung-Knapp-Sidik-Jonkman method.

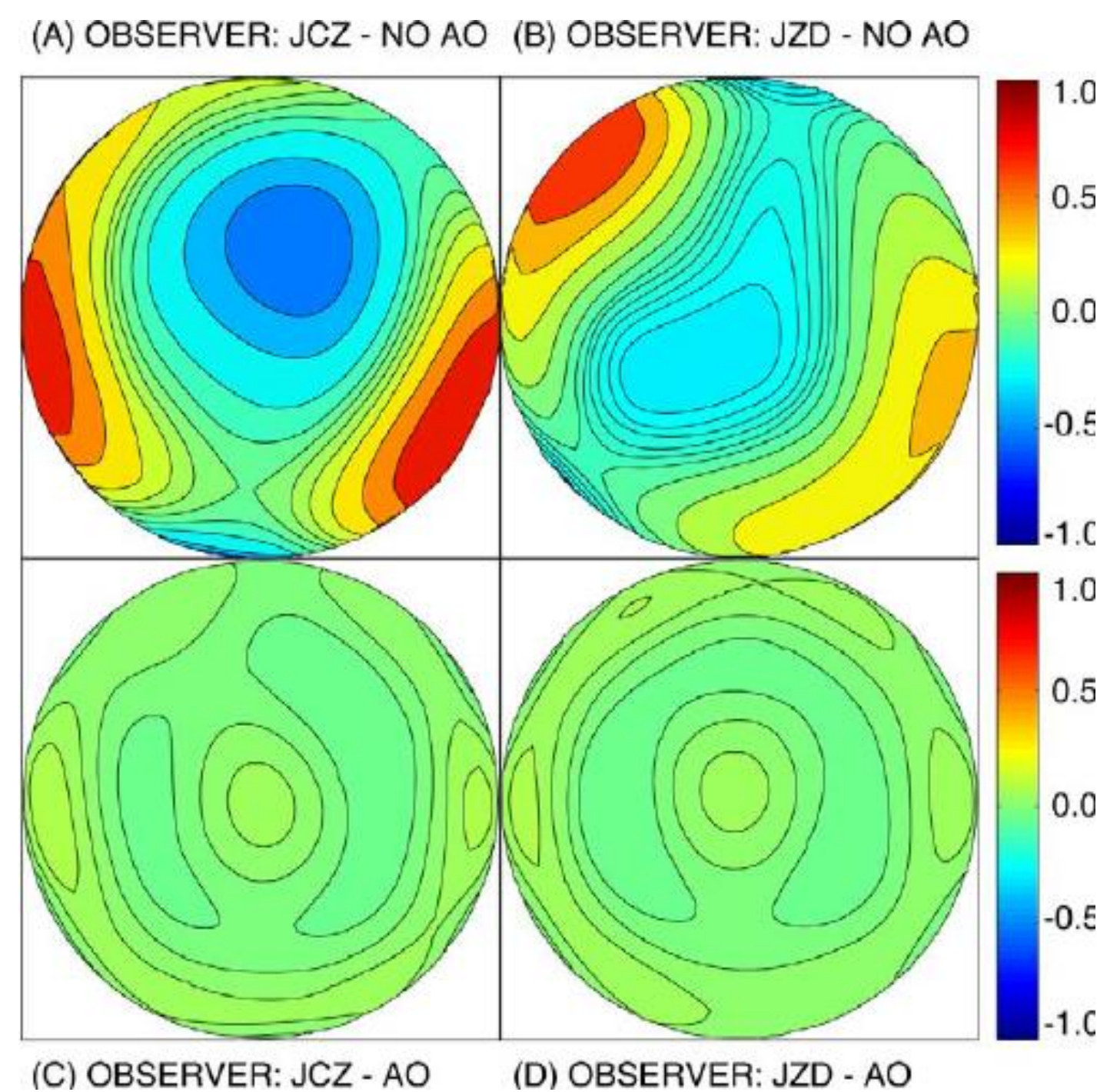
†Tau² calculated by Restricted Maximum-Likelihood method.

## Aberration Reduction &amp; Lens Performance

- **WFG Scleral Lenses:** Consistently outperformed conventional designs, reducing total **HO-RMS by 40%–71%** across multiple studies
- **Specialized Fitting Outcomes:** \* **Impression-based:** Significant reductions from 0.82 to 0.29 (Gelles, 2022) and 0.44 to 0.22 (Nguyen, 2020).
  - **Profilometry-guided:** Reduced HO-RMS from 2.70 to 1.00 compared to naked eye baseline [6].
- **Soft Lens Designs:** Generally effective at lowering aberrations [10, 23, 25], though one study found habitual **gas permeable (GP)** lenses maintained lower HO-RMS than custom WFG soft lenses [24].
- **Keratoconus Impact:** WFG scleral lenses achieved an average **77% HOA reduction**; 75% of eyes reached normal HO-RMS levels, compared to only 25% using spherical correction [21].

HO-RMS reductions of **40–71%** across studies. Hemmati 2017: mean **77% reduction** versus uncorrected eyes; HO-RMS normalised in 6/8 keratoconic eyes.

## PATIENT-REPORTED OUTCOMES



- **Gelles 2025:** 94% (17/18) preferred wfgSL over traditional SL.
- Improved night vision, reduced haloes, glare and shadowing (Nguyen 2020; Gelles 2022).
- **Barone 2025:** LCVA 1.34 → 0.50 logMAR — a real-world functional gain.
- Hastings 2022: avoided referral for corneal surgery.

## DISCUSSION

- Substantial HOA reduction translates into only modest gains in high-contrast acuity — consistent with a **neural adaptation ceiling**.
- **Scleral platforms outperform soft lenses:** stable centration is essential for wavefront correction to be realised on the eye.
- Patients with longstanding aberrated vision may need weeks of wear before the visual cortex 're-learns' (Chung 2022).
- Snellen acuity under-captures real benefit; **LCVA, contrast sensitivity** and **Visual Strehl ratio** reflect lived experience.
- Heterogeneity is largely driven by varying pupil diameters (4 vs 6 mm), disease severity, and timing of post-fit measurements.

## LIMITATIONS

- Predominance of small, uncontrolled designs; many conference abstracts.
- GRADE certainty **very low** for both pooled outcomes.
- Acute (30–60 min) outcome measurement in most studies.

## CONCLUSION

Wavefront-guided contact lenses produce statistically significant and **clinically meaningful improvements** in visual acuity and HOAs in corneal ectasia. **Larger, longer, standardised RCTs are now needed** to define optimal patient selection and capture the full benefit of neural adaptation.

## KEY REFERENCES

1. Gelles JD et al. Eye Contact Lens 2025;51(2):58–64.
2. Barone V et al. Eye Contact Lens 2025;51(10):445–9.
3. Sabesan R et al. Optom Vis Sci 2013;90(4):314–23.
4. Marsack JD et al. Optom Vis Sci 2014.
5. Page MJ et al. PRISMA 2020. BMJ 2021;372:n71.