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# Surgical versus optical treatment for anisometropia in adults: a randomized controlled trial

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## ABSTRACT

**Background:** We evaluated and compared outcomes of laser-assisted in situ keratomileusis (LASIK) versus optical spectacle correction for the treatment of anisometropia in adult patients.
**Methods:** This prospective, randomized controlled clinical trial included 50 eyes of 50 patients. We randomly allocated participants to Group A (25 eyes with anisometropia assigned to LASIK treatment) and Group B (25 eyes with anisometropia assigned to optical spectacle correction). All patients underwent preoperative and postoperative visual acuity, subjective and cycloplegic refraction, fundus, slit-lamp, and corneal topography examinations.
**Results:** In Group A, at 1-month postoperatively, there were statistically significant differences in uncorrected distance visual acuity, corrected distance visual acuity, refractive sphere, cylinder, and spherical equivalent (SE) as compared to baseline. At 3-months postoperatively in Group A, SE showed good stability within ± 0.50 diopter (D) in 22 eyes (88%) and within ± 0.75 D in 23 eyes (92%), while two eyes had an SE beyond 1.00 D emmetropia. Five eyes had amblyopia with minimal improvement in two eyes in Group A after LASIK, and no improvement in three eyes treated with spectacles in Group B. Two amblyopic eyes had developed ocular deviations by the end of the study that referred to the strabismus unit.
**Conclusions:** Our outcomes revealed that LASIK was more effective and advantageous than spectacles in the treatment of different types of anisometropia in adults. However, future randomized trials should focus on optical versus surgical treatment of anisometropia and anisometropic amblyopia in both pediatric and adult patients, to verify these conclusions before generalizing this treatment modality.

## KEY WORDS

anisometropia, myopia, hyperopia, amblyopia, LASIK, spectacles



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## INTRODUCTION

Anisometropia is defined as a marked refractive power difference of more than two diopters (D) between the bilateral eyes of the same individual. It comprises simple, compound, and mixed anisometropia [1-3]. The etiology of unilateral amblyopia is classified into three major categories of visual abnormalities. The first category is anisometropia, the second category is strabismus. The third category is visual deprivation in one eye only due to opacities in the media, such as unilateral congenital cataract, corneal haziness or opacification, corneal ectasia, or advanced ptosis [4]. On the other hand, the etiology of bilateral amblyopia is classified into two major categories of visual abnormalities. The first category is marked ametropia, such as bilateral high hypermetropic and bilateral high astigmatic refractive errors. The second

category is visual deprivation in one eye only due to opacities in the media, such as bilateral congenital or developmental cataracts, bilateral corneal scarring, and bilateral advanced ptosis [5].

Amblyopia is a disorder in which the eye and brain cannot work together well, resulting in decreased vision in an eye that may typically appear normal. This may affect 1–5% of the population, while anisometropic amblyopia is the second most common cause [6, 7]. Without treatment, amblyopia typically persists into adulthood. Treatment prognosis in adults is not promising [8].

Anisometropic amblyopia may be treated optically with spectacles or surgically with laser-assisted in situ keratomileusis (LASIK). LASIK is the most popular refractive surgery for the correction of refractive errors and is one of the most common surgeries performed worldwide [9]. The efficacy of treatment is affected by numerous prognostic factors, including uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA) prior to treatment, level of anisometropia severity, patient age, and cooperation [10, 11].

In this prospective, randomized, controlled clinical trial, our primary objective was to document the efficacy of LASIK in treating anisometropia, while our secondary objective was to compare LASIK versus spectacles for treating anisometropia.

## METHODS

This study was a prospective, comparative, randomized, controlled clinical trial approved by the Ethical Committee of the Faculty of Medicine, Sohag University, Egypt. It was registered at the Pan-African Clinical Trial Registry (PACTR) with registry number (PACTR201906462665442). This study was performed from July 2019 to March 2020 and was designed as a double-blind, randomized clinical trial in which both the treatment assignments were masked for both recruited participants and investigators (treatment team and evaluators).

The subject inclusion criteria were as follows: age > 18 years, clear cornea, and refractive difference of ≥ 4 D between bilateral eyes. The exclusion criteria consisted of unstable refraction; a difference between the manifest refraction and cycloplegic refractions > 1 D; hazy, thin or ectatic corneas; corneal or lens opacities; diabetic patients; pregnancy; and lactation. Participants with anisometropic amblyopia were also included in the study. The nature of the disease (anisometropia or anisometropic amblyopia) was explained in detail to the patient or their guardians while receiving consent prior to surgery. We recruited 62 patients; however, 12 patients with thin, opaque, or ectatic corneas were excluded. Finally, this study included 50 patients who were randomized to two groups. Group A (experimental group) included 25 eyes of 25 patients with anisometropia assigned for LASIK surgery at the Eye LASIK Center, Sohag, Egypt, using the 200-Hz Allegretto excimer laser (Alcon Laboratories, Inc., Irvine, CA). Group B (control group) included 25 eyes of 25 patients with anisometropia treated with spectacles.

All patients underwent a complete ophthalmological examination, including the following: Both UDVA and CDVA were assessed with a decimal system (Auto Chart Projector PACP-7000/PACP-7000L, Potec Co., Ltd. Dong-gu, Korea). Manifest refraction was evaluated using a Topcon RM-800 autorefractometer (Topcon Medical System, Japan), and subjective refraction was evaluated using a trial lens set (TLS-232, Shanghai Link Instruments Co. China). Slit-lamp examination (SL-3 slit-lamp, ChongQing SunKingdom Medical Instrument Co. Ltd, China), fundus examination, and corneal topography (TMS-4; Tomey, Erlangen, Germany) were also evaluated. Cycloplegic refraction was evaluated by instillation of one drop of combined 0.2% cyclopentolate and 0.1% phenylephrine (Cyclophrine; Kahira Pharmaceuticals & Chemical Industries Company, Cairo, Egypt) into the eyes every 10 min for 30 min, after which cycloplegic refraction was measured using a Topcon RM-800 auto-refractometer.

All patients were subjected to subjective refraction measurement using a trial for spectacles tested with the trial lens set. Cyclophrine eye drops were instilled every 10 min for 30 min before cycloplegic refraction was measured. Spectacle prescription accuracy was checked using a lensmeter (Topcon, LM-8, 75-1 Hasunuma-Cho, Itabashi-Ku, Tokyo, Japan).

For recruited subjects in Group A, Benox® (benoxinate hydrochloride 4 mg, Egyptian International Pharmaceutical Industries Company, 10th Of Ramadan City, Egypt) was instilled 10 min before surgery. The patient was reassured and requested to remain calm. The eyelids, lashes, forehead, and part of the face were sterilized with betadine, after which a disposable plastic eyelid drape was used to cover the eye. We then inserted an eye speculum, followed by marking the corneal paracentral area with a pen marker. A suction ring was then applied to the sclera surrounding the limbus. A microkeratome (Moria Inc., Amico, Doylestown, PA) was then used to create a uniformly thick corneal flap. A spatula was used to reflect the corneal flap, and a microsponge was used to dry the stromal bed. LASIK was performed using a 200-Hz Allegretto excimer laser (Alcon Laboratories, Inc., Irvine, CA). The patient was instructed

to fixate on the flashing light that emerged from the excimer laser during the stromal ablation. Finally, the flap was repositioned by washing the interface between the flap and the stromal bed. Topical dexamethasone 0.1% + tobramycin 0.3% eye drops (Tobradex; Alcon, Fort Worth, TX) were then instilled into the eye, and the speculum was gently removed from the eye. In Group B, the patients' spectacles were carefully adjusted to achieve the best CDVA. Of note, amblyopic therapy was not performed, because all patients were 18 years old and older.

In Group A, a drop of topical gatifloxacin 0.3% (Tymer Jamjoom Pharmaceuticals, Jeddah, Saudi Arabia), as antibiotic eye drops, was instilled every hour on the first day and then five times per day in the first week. In addition, a drop of prednisolone acetate ophthalmic suspension 1.0% (Optipred, Jamjoom Pharma, Saudi Arabia) was instilled every hour on the first day, then five times per day in the first week, four times per day in the second week, three times per day in the third week, and two times per day in the fourth week of surgery. Furthermore, a drop of lubricant eye drops containing polyethylene glycol 0.4% and propylene glycol 0.3% (Systane ® Ultra Lubricant Eye Drops, Alcon Laboratories, Inc.) was instilled every hour on the first day of surgery, then five times per day in the first month and three times per day for another two months after LASIK. All patients were examined after LASIK for 10–15 min. Follow-up visits were scheduled at the first postoperative day, first postoperative week, and first and third postoperative months. All patients were examined using a slit lamp, and visual acuity was measured. All study patients completed their 3-month follow-up; there were no drop-out cases. Figure 1 shows a flowchart of the distribution of the participants included in our study.

Wilcoxon's test was used to analyze non-normally distributed data. Furthermore, we used a paired-samples *t*-test to compare normally distributed data. Data were analyzed using IBM SPSS Statistics for Windows version 22 software (IBM Corp., Armonk, NY). Postoperative outcomes were considered significant at the 5% level.

## RESULTS

Our study included 50 eyes of 50 patients (23 men and 27 women). Group A included 13 men and 12 women, while Group B included 10 men and 15 women. The mean ± standard deviation (SD) of age was 23.86 ± 4.29 years in the LASIK group (Group A) and 25.88 ± 6.73 years in the spectacles group (Group B).

Of the 25 included cases in Group A, 17 were myopic eyes, six were hyperopic eyes, and two were astigmatic eyes. Of the 25 included cases in Group B, 14 were myopic eyes, eight were hyperopic, and three were astigmatic (Table 1). Of the five eyes with anisometropic amblyopia, two eyes in Group A , while three eyes in Group B. Figures 2 and 3 show the mean differences between the baseline and final spherical, cylindrical, and SE values of refraction in Groups A and B. Table 1 summarizes the baseline distribution of the refractive errors in Groups A and B.

In Group A, the mean ± SD sphere of myopic eyes was -4.0 ± 1.0 D, the mean ± SD sphere of hyperopic eyes was +3.9 ± 1.2 D, and the mean ± SD refraction values of astigmatic eyes was -3.0 ± 0.0 D. In Group B, the mean ± SD sphere of myopic eyes was -5.3 ± 1.6 D, the mean ± SD sphere of hyperopic eyes was +4.2 ± 1.9 D, and the mean ± SD refraction values of astigmatic eyes was -4.3 ± 0.4 D. The baseline values of myopia and astigmatism in Group A were significantly lower than those in Group B ($P$ = 0.001 and $P$ = 0.0001, respectively); however, although the baseline values of hyperopia were lower than those in Group B, there was no significant difference between the two groups ($P$ = 0.50) (Table 1).

Tables 2 and 3 summarize the baseline and final data of sound versus anisometropic eyes in in both groups, respectively. Overall, the final UCVA improved by two or more lines in all participants in both groups. We detected the same CDVA as baseline or even better than baseline in 92% of the patients at the end of the trial. The mean ± SD of baseline UDVA and CDVA of the sound eye in Group A, was 0.8 ± 0.13, and 0.9 ± 0.06, respectively. The mean ± SD of baseline spherical component of refraction, cylindrical component of refraction, and spherical equivalent (SE) in the sound eye for Group A, was -0.33 ± 0.7 D, -0.59 ± 0.39 D, and -0.64 ± 0.7 D (Table 2). The mean ± SD baseline UDVA and CDVA of anisometropic eye in patients in Group A were 0.24 ± 0.16, and 0.82 ± 0.13, respectively. The mean ± SD baseline spherical component of refraction, cylindrical component of refraction, and SE were -1.6 ± 3.5 D, -1.28 ± 0.9 D, and -2.19 ± 3.3 D, respectively (Table 2). The mean ± SD baseline UDVA and CDVA of the sound eye for Group B were 0.76 ± 0.13 and 0.98 ± 0.04, respectively. The mean ± SD baseline spherical component of refraction, cylindrical component of refraction, and SE in the sound eyes of Group B were -0.34± 0.8 D, -0.65 ± 0.4 D, and -0.76 ± 0.8 D (Table 2). The mean ± SD baseline UDVA and CDVA of the anisometropic eye in patients in Group B were 0.18 ± 0.16 and 0.6 ± 0.2, respectively. The mean ± SD of the baseline spherical component of refraction, cylindrical component of refraction, and SE were -1.7 ± 3.5 D, -1.4 ± 1.4 D, and -2.9 ± 4.1 D, respectively. Except for baseline CDVA, which was significantly different ($P$ = 0.0001), we did not detect any significant differences in other variables between the two study groups (Table 2).

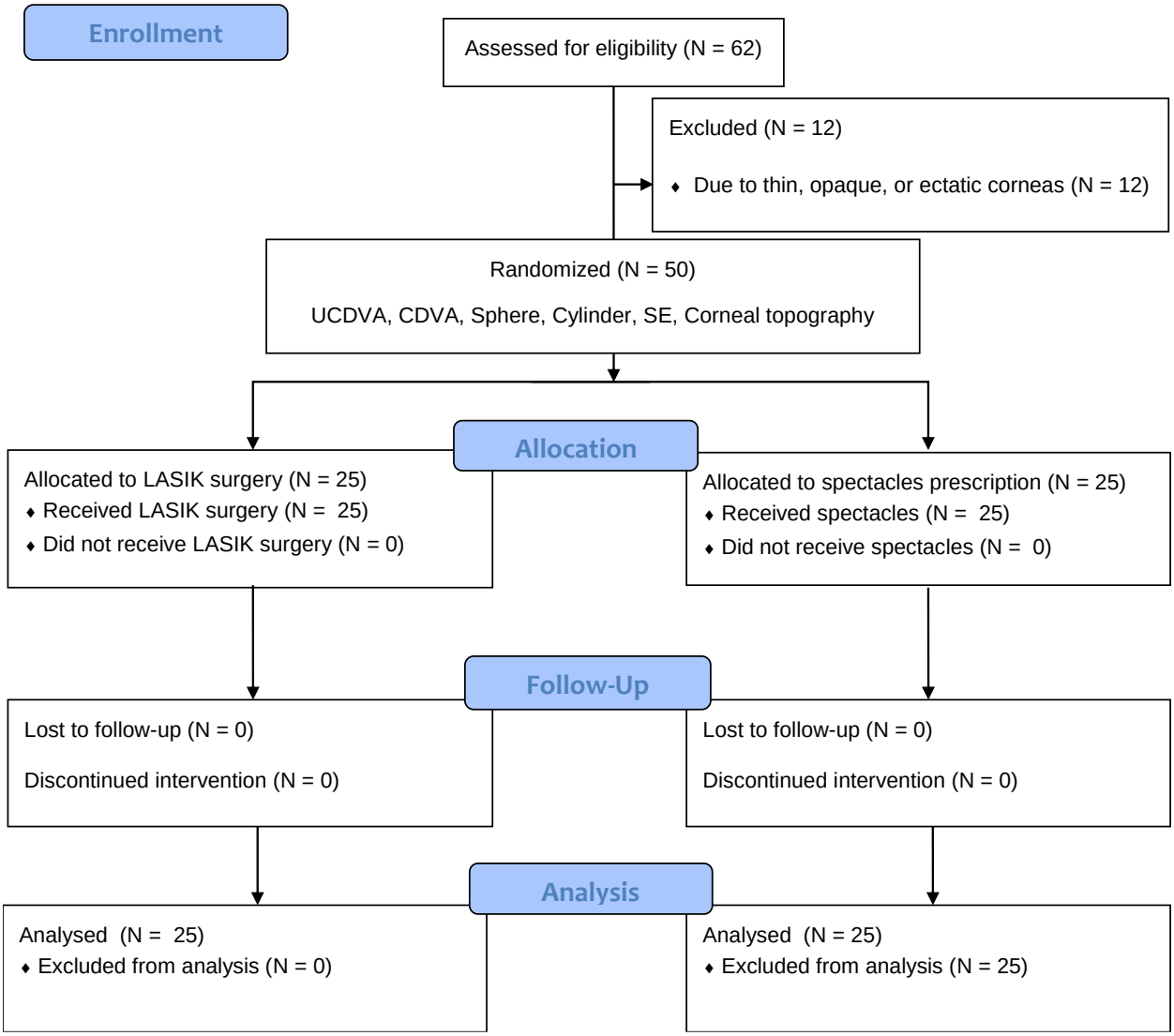


**Figure 1. Flowchart of the distribution of participants in the refractive surgical versus optical treatment for anisometropia in adults clinical trial. Abbreviations: n, number; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; LASIK, laser–assisted in situ keratomileusis**

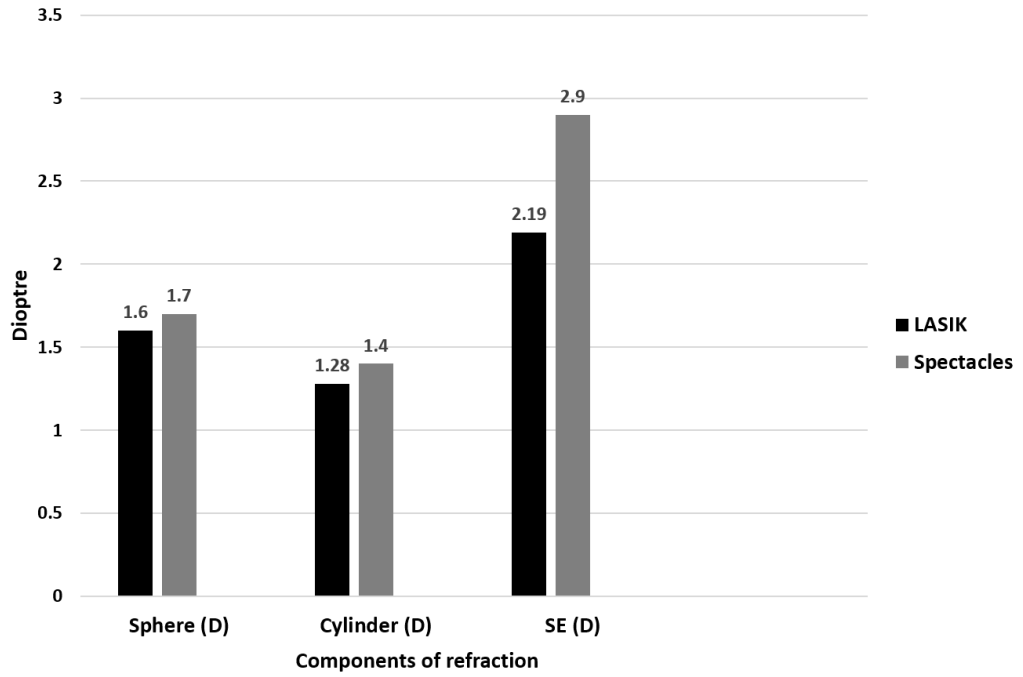


**Figure 2. Mean differences between the baseline sphere, cylinder, and the spherical equivalent (SE) values of Group A (LASIK) versus Group B (Spectacles). Abbreviations: LASIK, laser–assisted in situ keratomileusis; D, diopter; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction**

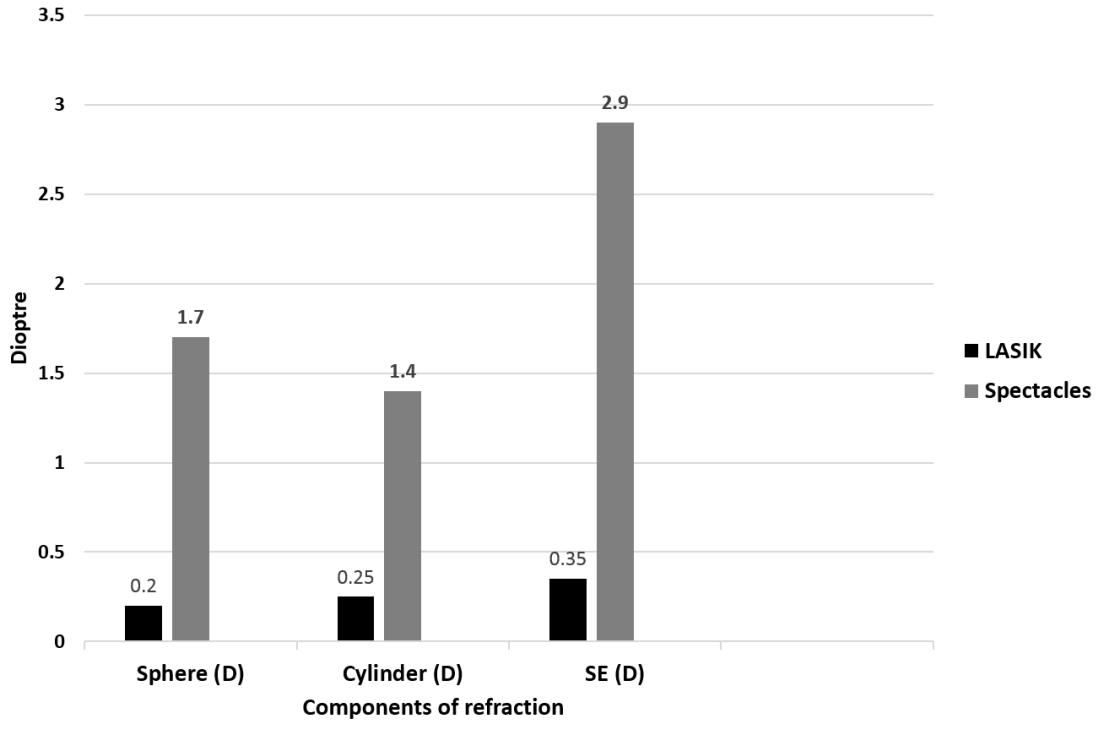


**Figure 3. The mean differences between the final sphere, cylinder, and the SE of Group A versus Group B. Abbreviations: LASIK, laser–assisted in situ keratomileusis; D, diopter; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction**

**Table 1. Baseline distribution of the refractive errors in Group A (LASIK) versus Group B (Spectacles).**

| Variable | Group A mean ± SD | Group B mean ± SD | 95% Confidence Interval of mean differences | *P*-value |
|---|---|---|---|---|
| **Myopia:** | | | | |
| **Patients (n)** | 17 | 14 | 1.3 (0.5–2.1) | **0.001** |
| **Sphere (D)** | -4.0 ± 1.0 | -5.3 ±1.6 | | |
| **Hyperopia:** | | | | |
| **Patients (n)** | 6 | 8 | -0.3 (-1.2–0.6) | 0.5 |
| **Sphere (D)** | +3.9 ± 1.2 | +4.2 ±+1.9 | | |
| **Astigmatism:** | | | | |
| **Patients (n)** | 2 | 3 | | |
| **Cylinder (D)** | -3.0 ± 0.0 | -4.3 ± 0.4 | 1.3 (1.1–1.5) | **0.0001** |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; %, percentage; n, number; D, dioptre; SD, standard deviation; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 is shown in bold**

**Table 2. Baseline data of sound versus anisometropic eyes in Groups A (LASIK) and B (Spectacles).**

| Variable | Sound eyes of Group A mean ± SD | Sound eyes of Group B mean ± SD | *P*-value | Anisometropic eyes of Group A mean ± SD | Anisometropic eyes of Group B mean ± SD | *P*-value |
|---|---|---|---|---|---|---|
| **UDVA (decimal)** | 0.8 ± 0.13 | 0.76 ± 0.13 | 0.3 | 0.24 ± 0.16 | 0.18 ± 0.16 | 0.2 |
| **CDVA (decimal)** | 0.9 ± 0.06 | 0.98± 0.04 | **0.0001** | 0.82 ± 0.13 | 0.6 ± 0.2 | **0.0001** |
| **Sphere (D)** | -0.33 ± 07 | -0.34 ± 0.8 | 0.9 | -1.6 ± 35 | -1.7 ± 3.5 | 0.9 |
| **Cylinder (D)** | -0.59 ± 0.39 | -0.65 ± 0.4 | 0.6 | -1.28 ± 0.9 | -1.4 ± 1.4 | 0.7 |
| **SE (D)** | -0.64 ± 0.7 | -0.76 ± 0.8 | 0.6 | -2.19 ± 3.3 | -2.9 ± 4.1 | 0.5 |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; SD, standard deviation; D, dioptre; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 is shown in bold**

**Table 3. Final outcome of sound versus anisometropic eyes in Groups A (LASIK) and B (Spectacles).**

| Variable | Sound eyes of Group A mean ± SD | Sound eyes of Group B Mean ± SD | *P*-value | Anisometropic eyes of Group A mean ± SD | Anisometropic eyes of Group B mean ± SD | *P*-value |
|---|---|---|---|---|---|---|
| **UDVA (decimal)** | 0.9 ± 0.08 | 0.76 ± 0.13 | **0.0001** | 0.82 ± 0.13 | 0.18 ± 0.16 | **0.0001** |
| **CDVA (decimal)** | 0.96 ± 0.06 | 0.98 ± 0.04 | 0.2 | 0.87 ± 0.1 | 0.6 ± 0.2 | **0.0001** |
| **Sphere (D)** | -0.17 ± 0.4 | -0.34 ± 0.8 | 0.3 | -0.2 ± 0.3 | -1.7 ± 3.5 | **0.0001** |
| **Cylinder (D)** | -0.4 ± 0.3 | -0.65 ± 0.4 | **0.02** | -0.25 ± 0.3 | -1.4 ± 1.4 | **0.0002** |
| **SE (D)** | -0.42 ± 0.4 | -0.76 ± 0.8 | 0.06 | -0.35 ± 0.4 | -2.9 ± 4.1 | **0.003** |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; SD, standard deviation; D, dioptre; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 is shown in bold**

**Table 4. Baseline and final visual acuity and refractive outcomes in Group A (LASIK).**

| Variable | Baseline data mean ± SD | Final data mean ± SD | *P*-value |
|---|---|---|---|
| **UDVA (decimal)** | 0.24 ± 0.16 | 0.82 ± 0.13 | **<0.0001** |
| **CDVA (decimal)** | 0.82 ± 0.13 | 0.87 ± 0.1 | **0.001** |
| **Sphere (D)** | -1.6± 3.5 | -0.2 ± 0.3 | **0.02** |
| **Cylinder (D)** | -1.28 ± 0.9 | -0.25 ± 0.3 | **<0.0001** |
| **SE (D)** | -2.19 ± 3.3 | -0.35 ± 0.4 | **<0.0001** |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; SD, standard deviation; D, dioptre; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 is shown in bold**

**Table 5. Baseline visual acuity and refractive outcomes in Group A (LASIK) versus Group B (Spectacles).**

| Variable | Group A mean ± SD | Group B mean ± SD | 95% Confidence Interval of mean differences | *P*-value |
|---|---|---|---|---|
| **UDVA (decimal)** | 0.24 ± 0.16 | 0.18 ± 0.16 | 0.06 (-0.03–0.15) | 0.2 |
| **CDVA (decimal)** | 0.82 ± 0.13 | 0.6 ± 0.2 | 0.2 (0.12–0.32) | **0.0001** |
| **Sphere (D)** | -1.6 ± 3.5 | -1.7 ± ٣.5 | 0.1 (-2.2–2.4) | 0.٩ |
| **Cylinder (D)** | -1.28 ± 0.9 | -1.4 ± 1.4 | 0.12 (-0.55–0.79) | 0.7 |
| **SE (D)** | -2.19 ± 3.3 | -2.9 ± 4.1 | 0.7 (-1.4–2.8) | 0.5 |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; SD, standard deviation; D, dioptre; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 in bold**

**Table 6. Final visual acuity and refractive outcomes in Group A (LASIK) versus Group B (Spectacles).**

| Variable | Group A mean ± SD | Group B mean ± SD | 95% Confidence Interval of mean differences | *P*-value |
|---|---|---|---|---|
| **UDVA (decimal)** | 0.82 ± 0.13 | 0.18 ± 0.16 | 0.64 (0.56–0.72) | **0.0001** |
| **CDVA (decimal)** | 0.87 ± 0.1 | 0.6 ± 0.2 | 0.27 (0.18–0.36) | **0.0001** |
| **Sphere (D)** | -0.2 ± 0.3 | -1.7 ± 3.5 | 1.5 (-0.3–3.3) | **0.0001** |
| **Cylinder (D)** | -0.25 ± 0.3 | -1.4 ± 1.4 | 1.15 (0.6–1.7) | **0.0002** |
| **SE (D)** | -0.35 ± 0.4 | -2.9 ± 4.1 | 2.6 (0.9–4.2) | **0.003** |

**Abbreviations: LASIK, laser–assisted in situ keratomileusis; SD, standard deviation; D, dioptre; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; SE, spherical equivalent; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction. *P* < 0.05 is shown in bold**

**Table 7. Outcome of the five eye with anisometropic amblyopia in both study groups.**

| n | Group | Patient | UDVA | | CDVA | | Sphere (D) | | Cylinder (D) | | SE (D) | | Strabismus | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | B | F | B | F | B | F | B | F | B | F | | |
| 1 | A | OD of 27-year-old female patient | 0.05 | 0.2 | 0.2 | 0.2 | -5.00 | -0.5 | -0.5 | -0.5 | -5.25 | -0.75 | No | Slightly improved |
| 2 | A | OS of 20-year-old female patient | 0.05 | 0.1 | 0.1 | 0.1 | -4.00 | 0.0 | -1.00 | -0.5 | -4.50 | -0.25 | XT | Slightly improved and referred for strabismus surgery |
| 3 | B | OD of 18-year-old male patient | 0.1 | NI | 0.3 | NI | +4.00 | NI | -0.5 | NI | +3.75 | NI | ET | Referred for strabismus surgery |
| 4 | B | OD of 23-year-old male patient | 0.05 | NI | 0.2 | NI | -4.25 | NI | -1.25 | NI | -3.50 | NI | No | - |
| 5 | B | OS of 31-year-old female patient | 0.05 | NI | 0.05 | NI | +5.50 | NI | -1.00 | NI | +5.00 | NI | No | - |

**Abbreviations: n, eye number; Group A, LASIK (laser–assisted in situ keratomileusis) treatment group; Group B, spectacle corrected Group; OD, right eye; OS, left eye; B: baseline data; F, Final data; D, diopter; UDVA, uncorrected distance visual acuity in decimal; CDVA, corrected distance visual acuity in decimal; Sphere, spherical component of refraction; Cylinder, cylinderical component of refraction; SE, spherical equivalent; XT, exotropia; ET, esotropia; NI, not improved**

The mean ± SD of the final UDVA and CDVA of the sound eyes in Group A were 0.9 ± 0.08 and 0.96 ± 0.06, respectively. The mean ± SD final spherical component of refraction, cylindrical component of refraction, and SE were -0.17 ± 0.4, -0.4 ± 0.3 D and -0.42 ± 0.4, respectively (Table 3). The mean ± SD final UDVA and CDVA of the anisometropic eyes in patients in Group Awere 0.82 ± 0.13 and 0.87 ± 0.1, respectively. The mean ± SD final spherical component of refraction, cylindrical component of refraction, and SE were -0.2 ± 0.3 D, -0.25 ± 0.3 D, and -0.35 ± 0.4 D, respectively (Tables 3, 4, and 6). The mean ± SD final UDVA and CDVA of the sound eyes in Group B were 0.76 ± 0.13, and 0.98 ± 0.04, respectively. The mean ± SD of final spherical component of refraction, cylindrical component of refraction, and SE was -0.34 ± 0.8, -0.65± 0.4 D and -0.76 ± 0.8, respectively (Table 3). The mean ± SD of the final UDVA and CDVA of the anisometropic eyes in Group B was 0.18 ± 0.16, and 0.6 ± 0.2, respectively. The mean ± SD final spherical component of refraction, cylindrical component of refraction, and SE were -1.7 ± 3.5 D, -1.4 ± 1.4 D, and -2.9 ± 4.1 D, respectively (Tables 3, and 6). In sound eyes, UDVA, and the cylindrical component of refraction improved significantly in Group A as compared to the Group B (*P* = 0.0001, and 0.02, respectively). However, in anisometropic eyes, all variables, including UDVA, CDVA, spherical component of refraction,

cylindrical component of refraction, and SE improved significantly in Group A as compared with Group B ($P$ = 0.0001, 0.0001, 0.0001, 0.0002, and 0.003, respectively) (Table 3). Compared with baseline values, all variables including UDVA, CDVA, spherical component of refraction, cylindrical component of refraction, and SE had improved significantly in Group Aby the end of the trial ($P$ < 0.0001, 0.001, 0.02, < 0.0001, and < 0.0001, respectively) (Table4). In terms of the accuracy of LASIK eyes, at the end of the follow-up, the final SE was within ± 0.50 D in 22 eyes (88%) and within ± 0.75D in 23 eyes (92%). Two eyes had an SE beyond 1.00 D of emmetropia. In terms of UDVA by 3 months after LASIK, 8% (two eyes) obtained CDVA 1.0, 20% (five eyes) obtained CDVA 0.9, 28% (seven eyes) obtained CDVA of 0.8, 28% (seven eyes) obtained a CDVA of 0.7, and 16% (four eyes) had a CDVA ≤ 0.6. In this study, compared with their preoperative CDVA values, five eyes (20%) experienced a two-line visual acuity improvement, 14 eyes (56%) experienced a one-line improvement, three eyes had no improvement (or worse UCVA) in their postoperative CDVA, while two eyes were worse by one line. In our study, 19 eyes (76%) had increased CDVA by one to two lines, three eyes (16%) had the same CDVA as preoperatively, and two eyes (8%) had lost one line.

In Group B, the mean ± SD baseline UDVA and CDVA were 0.18 ± 0.16 and 0.6 ± 0.2, respectively. The mean ± SD baseline spherical component of refraction, cylindrical component of refraction, and SE were -1.7 ± 3.5 D, -1.4 ± 1.4 D, and -2.9 ± 4.1 D (Table 5). Moreover, 8% (two eyes) obtained CDVA 1.0, 12% (three eyes) obtained CDVA 0.9, 16% (four eyes) obtained CDVA 0.8, 28% (seven eyes) obtained CDVA 0.7, and 36% (nine eyes) had a CDVA ≤ 0.6. In our study, there were five eyes with anisometropic amblyopia: two in the LASIK group, and three in the spectacle group. The two amblyopic eyes in the LASIK group showed a slight improvement in visual acuity (Table 7). Despite our documentation of new strabismus in two eyes at the end of the study, we acknowledge that strabismus was not one of our inclusion criteria. Eventually, we referred both patients to the Strabismus Unit for further assessment and management (Table 7).

During the study, seven eyes of the LASIK group experienced complications. One case had an intraoperative complication in the form of minimal limbal bleeding that was treated by gentle pressure on the oozing vessels and irrigation of the interface. LASIK ablation continued as usual and the patient was examined 15 minutes after LASIK and the next day by slit-lamp for any blood or debris, and was found to have none. Two eyes had dry eye and were prescribed artificial tears with close follow-up for 3 months. Postoperative haze was documented in two eyes (8%) following LASIK and revealed a good response to medical treatment. Finally, two eyes (8%) exhibited slight postoperative under-correction.

## DISCUSSION

In anisometropia, the main aim of treatment is to correct the refractive errors in the anisometropic eye to mimic the refractive status of the sound eye. In the current study, in all study eyes of the LASIK group, the final UDVA exhibited good improvement, by at least two lines. Furthermore, the final UDVA in 92% of LASIK eyes was the same as the baseline or better than the baseline CDVA. In sound eyes, UDVA, and cylindrical component of refraction SE were significantly improved in the LASIK group as compared with the spectacle group. In the anisometropic eyes, all variables including UDVA, CDVA, spherical component of refraction, cylindrical component of refraction, and SE improved significantly in the LASIK group compared with the spectacle group. In our study, compared with baseline values, all variables, including UDVA, CDVA, spherical component of refraction, cylindrical component of refraction, and SE, had improved significantly in the LASIK group by the end of the trial.

Dedhia and Behl [12] evaluated the efficacy and benefits of LASIK in the treatment of anisometropic amblyopia. The study included 21 anisometropic amblyopic eyes in adult and pediatric patients, with a mean age of 27.71 years, who underwent LASIK treatment and were followed-up for 3 months. On the other hand, our study included only five anisometropic amblyopic eyes, in adult patients only, with a mean age of 23.86 years, who underwent LASIK treatment and were followed-up for 3 months. The preoperative mean ± SD of manifest SE refraction in their study was -2.19 ± 3.3 D, and the postoperative UCVA improved by at least two visual acuity lines in all cases. This was similar to or even better than the baseline CDVA in 95.2% of eyes [12]. In our study, the mean ± SD baseline UDVA and CDVA were 0.24 ± 0.16 and 0.82 ± 0.13, respectively. The mean ± SD baseline spherical component of refraction, cylindrical component of refraction, and SE were -1.6 ± 3.5 D, -1.28 ± 0.9 D, and -2.19 ± 3.3 D. Finally, the mean ± SD UDVA and CDVA were 0.82 ± 0.13 and 0.87 ± 0.1, representing a significant improvement compared to baseline. The mean ± SD final spherical component of refraction, cylindrical component of refraction, and SE were -0.2 ± 0.3 D, -0.25 ± 0.3 D, and -0.35 ± 0.4D, which also represented a significant improvement compared to baseline.

Sakatani et al. [13] evaluated improvement in CDVA using spectacles after LASIK in adult patients with amblyopia. UDVA in seven eyes (33.3%) improved by at least one line

postoperatively, as compared to the preoperative values, and nine eyes (42.8%) improved by at least one line in postoperative CDVA compared to the preoperative values. Furthermore, they reported stability of postoperative CDVA in > 50% of eyes with unchanged preoperative best spectacle-corrected visual acuity values. They also recorded deterioration of postoperative CDVA in one eye, which lost two visual acuity lines postoperatively [13]. In contrast, our study included only five eyes with anisometropic amblyopia, and only two eyes were treated with LASIK, who had only one visual acuity line of postoperative UDVA improvement.

Ghanem et al. [14] reported the outcomes of the treatment of 18 pediatric eyes with LASIK. Their study eyes were myopic, anisometropic, and amblyopic, which failed to respond to amblyopia therapy for 6 months before LASIK treatment. Furthermore, after LASIK treatment, the study eyes were subjected to another round of amblyopia therapy, particularly occlusion therapy, on a 6-hourly basis for 12 weeks, followed by maintenance occlusion therapy on a 4-hourly basis for a few more months. Finally, they concluded that LASIK treatment could be considered as an ideal treatment in pediatric eyes with intolerance to contact lenses or spectacle wear. They also stated that LASIK is effective in the treatment of amblyopic eyes due to myopic anisometropia, as it also improved both postoperative CDVA and binocular vision [14]. On the other hand, our study included only adult patients with a limited number (five eyes) of anisometropic amblyopia due to myopia, hyperopia, or astigmatism. We did not recommend amblyopia therapy in our patients, as they were all adults.

In another study, Rafai et al. [15] analyzed the effectiveness of LASIK in treating refractive errors to improve postoperative CDVA in anisometropic amblyopic eyes. Their study included 20 eyes with amblyopia originating from related anisometropia. All of their study eyes underwent LASIK treatment. The mean ± SD age of the patients was 28.00 ± 7.91 years, ranging from 16 to 42 years. Sixteen eyes (80%) improved by one to five lines of CDVA, whereas the remaining four eyes (20%) had the same CDVA as preoperatively. Finally, none of their study eyes deteriorated or exhibited loss of any visual lines of CDVA [15]; however, in our study, 19 eyes (76%) improved by one to two lines of CDVA, three eyes (16%) had the same CDVA as preoperatively, and two eyes (8%) lost one line. In our study, compared with baseline values, all variables, including UDVA, CDVA, spherical component of refraction, cylindrical component of refraction, and SE, had improved significantly in the LASIK group by the end of the trial. However, as we had a limited number of patients with anisometropic amblyopia, an accurate comparison of our results with the outcomes of Rafai et al. is not possible

The strengths of our study originate from two main factors. First, our study was a randomized controlled trial that included a relatively larger sample size (50 eyes) than previous relevant studies. The second factor was the inclusion of a limited number of anisometropic amblyopic eyes in each group, to document the impact of LASIK versus spectacles in treating anisometropic amblyopia in adults. However, our study was limited in that the follow-up period was short (3 months).

Considering the significant improvement in all variables in the LASIK group, we suggest that LASIK might be a better option for treating anisometropia in adults in our area, as many patients are farmers and construction workers who seek non-optical options to treat their anisometropia to suit their work conditions. However, anisometropic amblyopia remained an obstacle and showed almost no significant improvement in response to either optical or surgical treatment. Finally, we recommend further randomized trials with a focus on optical versus surgical treatment of anisometropia and anisometropic amblyopia in both pediatric and adult patients to confirm the conclusions of this study, before generalizing this treatment modality. We also recommend that future studies should include a patient satisfaction scale and the outcomes of corneal tomography and topography.

## CONCLUSIONS

In conclusion, our results showed that LASIK was effective and sometimes more advantageous than spectacles in the treatment of different types of anisometropia in adults. However, future randomized trials with a focus on optical versus surgical treatment of anisometropia and anisometropic amblyopia in both pediatric and adult patients are needed to verify our conclusions, to confirm the generalizability of this treatment modality.

## ETHICAL DECLARATIONS

**Ethical approval:** This study was approved by the Ethical Committee of the Faculty of Medicine, Sohag University, Sohag, Egypt. It was registered at the Pan-African Clinical Trial Registry (PACTR) with registry number (PACTR201906462665442).

**Conflict of interest:** None.

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**REFERENCES**

1. Vincent SJ, Collins MJ, Read SA, Carney LG. Myopic anisometropia: ocular characteristics and aetiological considerations. Clin Exp Optom. 2014;97(4):291-307. doi: 10.1111/cxo.12171 pmid: 24939167
2. Li Y, Sun H, Zhu X, Su Y, Yu T, Wu X, et al. Efficacy of interventions for amblyopia: a systematic review and network meta-analysis. BMC Ophthalmol. 2020;20(1):203. doi: 10.1186/s12886-020-01442-9 pmid: 32450849
3. Somer D, Budak K, Demirci S, Duman S. Against-the-rule (ATR) astigmatism as a predicting factor for the outcome of amblyopia treatment. Am J Ophthalmol. 2002;133(6):741-5. doi: 10.1016/s0002-9394(02)01345-4 pmid: 12036662
4. Flynn JT. 17th annual Frank Costenbader Lecture. Amblyopia revisited. J Pediatr Ophthalmol Strabismus. 1991;28(4):183-201. pmid: 1919965
5. Barrett BT, Bradley A, McGraw PV. Understanding the neural basis of amblyopia. Neuroscientist. 2004;10(2):106-17. doi: 10.1177/1073858403262153 pmid: 15070485
6. Webber AL, Wood J. Amblyopia: prevalence, natural history, functional effects and treatment. Clin Exp Optom. 2005;88(6):365-75. doi: 10.1111/j.1444-0938.2005.tb05102.x pmid: 16329744
7. Gharebaghi AH, Heidary F, Gharebaghi R, Heidary R. Mehdi-ODM; a modified digital monitoring of the occlusion therapy for amblyopia. Graefes Arch Clin Exp Ophthalmol. 2011;249(6):945-6; author reply 7-8. doi: 10.1007/s00417-010-1491-x pmid: 21234584
8. Tsirlin I, Colpa L, Goltz HC, Wong AM. Behavioral Training as New Treatment for Adult Amblyopia: A Meta-Analysis and Systematic Review. Invest Ophthalmol Vis Sci. 2015;56(6):4061-75. doi: 10.1167/iovs.15-16583 pmid: 26114483
9. Moshirfar M, Brown TW, Heiland MB, Rosen DB, Ronquillo YC, Hoopes PC. Comparative Analysis of LASIK Flap Diameter and its Centration Using Two Different Femtosecond Lasers. Med Hypothesis Discov Innov Ophthalmol. 2019;8(3):241-9. pmid: 31598523
10. Ghanem A, Nematallah E, El-Adawy I, Anwar G. Facilitation of amblyopia management by laser in situ keratomileusis in children with myopic anisometropia. Curr Eye Res. 2010 35(4):281-6. doi: 10.3109/02713680903556551 pmid: 20373894
11. Papageorgiou E, Asproudis I, Maconachie G, Tsironi E, Gottlob I. The treatment of amblyopia: current practice and emerging trends. Graefes Arch Clin Exp Ophthalmol. 2019 257(6):1061-78. doi: 10.1007/s00417-019-04254-w pmid: 30706134
12. Dedhia NC, Behl S. Laser in situ Keratomileusis for Anisometropic Amblyopia. J Refract Surg. 2000;16(2 Suppl):S264-7. doi: 10.3928/1081-597X-20000302-15 pmid: 24364821
13. Sakatani K, Jabbur NS, O'Brien TP. Improvement in best corrected visual acuity in amblyopic adult eyes after laser in situ keratomileusis. J Cataract Refract Surg. 2004;30(12):2517-21. doi: 10.1016/j.jcrs.2004.06.026 pmid: 15617918
14. Ghanem AA, Moad AI, Nematallah EH, El-Adawy IT, Anwar GM. Laser in situ keratomileusis for treated myopic anisometropic amblyopia in children. Saudi J Ophthalmol. 2010;24(1):3-8. doi: 10.1016/j.sjopt.2009.12.001 pmid: 23960866
15. Rafai T, Hassanin O. Evaluation of improvement of best corrected visual acuity following LASIK treatment in anisometropic amblyopia. Australian J Basic & Appl Sci. 2011;5(11):23-9.