

Progression of Corneal Astigmatism after Phaco-Alternative at the University Hospital Center of the Oueme-Plateau Department in Porto-Novo

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Abstract

Objective: To study the postoperative evolution of corneal astigmatism following phaco-alternative at the University Hospital Center of Ouémé-Plateau (UHC-OP) in Porto-Novo. **Method:** This was a prospective, cross-sectional study with a descriptive and analytical purpose conducted from April 19 to September 20, 2021; a period of 6 months. The study included all patients presenting with senile or non-senile cataracts without a history of corneal trauma and who underwent phaco-alternative during the study period. **Results:** A total of 62 eyes underwent phaco-alternative. The average age was 63 ± 12 years with a male predominance of 59.7%. Phaco-alternative was performed with 74.2% linear incision and 25.8% smile incision. Perioperative incidents were mainly capsular ruptures with vitreous loss occurring in 8.1% of cases. The mean preoperative astigmatism was 1.29 ± 1.5 D with an axis of $180^\circ \pm 20^\circ$, indicating with-the-rule astigmatism. The mean postoperative astigmatism was 2.2 ± 1.5 D with an axis of $90^\circ \pm 20^\circ$, indicating against-the-rule astigmatism. The mean induced astigmatism at Day 30 was 1.4 ± 1.2 D for smile incision and 1.8 ± 1.2 D for linear incision. **Conclusion:** Phaco-alternative yields good results with few complications but remains astigmatogenic. The smile incision appears to be less astigmatogenic.

Keywords

Cataract, Phaco-Alternative, Smile Incision, Astigmatism

1. Introduction

Cataracts remain the leading cause of blindness worldwide, particularly in low-income countries, and are considered as a public health problem. In Benin, there are few hospitals practicing cataract surgery. This situation leads to increasing backlog of cataract in the country. To overcome this situation the Ministry of health through the National program of blindness has built a partnership with the social investment of the government through the first lady. Currently there is outreach plan covering all the country to reach remote area thus poor people. Benin has four teaching hospital in ophtalmologie and our study is conducted in one of this hospital. Cataract surgery is done using the manual small incision cataract surgery (MSICS).

Surgical techniques in the world have seen significant improved over the past twenty years. Intra-capsular extraction has been followed up by extra-capsular extraction. Nowadays, in developed countries, phacoemulsification is considered the “gold standard” for cataract surgery. A more recent technique currently under experimentation is femtosecond laser surgery. However, these methods are costly and technically inaccessible to developing countries [1]. Phaco-alternative, or the Ruit technique, is a sutureless cataract surgery involving nucleus extraction through a corneoscleral tunnel with posterior chamber implantation. The goal of cataract surgery is to achieve improved visual acuity with minimal postoperative astigmatism. Phaco-alternative is a reference technique as it fulfills this objective. Postoperative astigmatism is induced and varies over time [2]. It is influenced by several factors, including the type of incision, perioperative cauterization, and the power of the implant.

This technique has several advantages. Although considered conventional, the issue of astigmatism has gained renewed interest due to recent developments in anterior segment surgery. Many authors have explored this topic, and we aim to contribute to the field through the present study.

2. Framework and Study Method

This was an observational, cross-sectional, descriptive, and analytical study with prospective data collection over six months, focusing on all patients who consulted the ophthalmology department at CHUD-OP and were diagnosed with non-traumatic cataracts, subsequently undergoing phaco-alternative surgery. The sampling was exhaustive, systematically including patients meeting the inclusion criteria. The selection criteria were patients diagnosed with cataract without any anterior segment associated complication and with normal B-scan in the posterior segment and with normal general condition. The follow-up were set at day 1, day 7, day 15 and day 45. The short time of follow up is the main limitation of the study. They will be taken account in a further study covering 3 to six months.

The dependent variable was astigmatism, while the independent variables comprised sociodemographic and clinical characteristics. Data were collected using a questionnaire based on patients’ medical records and operative reports.

Preoperative and postoperative astigmatism of the patients were measured using a Topcon auto refracto-keratometer. For each eye, three recordings were made, and the device automatically calculated the average values of sphere, cylinder, and axis. Astigmatism was categorized as:

- Direct when the vertical meridians between 60 and 120 degrees were more curved and powerful than the horizontal meridians between 0°/30° or 150°/180°, resulting in vertical flattening of the cornea.
- Indirect when the horizontal meridians (0°/30° and 150°/180°) were more curved and powerful than the vertical meridians (60°/120°), leading to horizontal flattening of the cornea.
- Oblique when the situations were intermediate.

The surgical technique was the MSICS starting with superior conjunctiva dissection followed by one-third to half-thickness scleral incision around 2 mm behind the limbus. The size of the incision varies depending on the hardness and size of the nucleus, and it varies from 5.5 to 7 mm. After this incision, a corneo-scleral tunnel is made with the help of crescent blade and then an entry is made into the anterior chamber using the keratome. Capsulorrhexis is made followed by hydrodissection then nuclear removal and intraocular lens is set according to the power. All the selected patients had sutureless surgery.

Before data collection the questionnaire was tested and correction was done prior to starting the study.

Data entry was performed using KoBocollect software version 2021.2.4, and analysis was conducted with R Core Team version 4.0.1-2020. The significance threshold was set at 5%. Prior to the study, free and informed consent was obtained from the patients.

The aim was to investigate the outcome regarding unexpected astigmatism after cataract surgery at Oueme Plateau regional hospital.

3. Results

In total, 62 eyes from 62 patients were included in our study. The mean age of the patients was 63 ± 12 years, ranging from 27 to 81 years. The most represented age group was 60 to 80 years.

Male gender was more prevalent, accounting for 59.7% of the participants, resulting in a sex ratio of 1.48. Retirees constituted the largest group, representing 33.9%.

3.1. Clinical Aspects

➤ Preoperative Ophthalmological Examination

Operated Eye

The majority of the operated eyes, 67.7%, were left eyes. Most patients, 64.2%, had visual acuity lower than 1/10.

Preoperative Astigmatism

More than half, 53.2%, of the eyes had preoperative astigmatism less than 1 diopter, with a mean of 1.29 ± 1.5 diopters (See **Table 1**).

Table 1. Distribution of eyes according to preoperative astigmatism in diopters (2021, CHUD-OP).

	n	%
<1	33	53.2
[1 - 2]	16	25.8
>2	13	21.0
Total	62	100.0

Table 2. Distribution of eyes according to the axis of preoperative astigmatism (2021, CHUD-OP).

	n	%
Direct	25	40.3
Indirect	21	33.9
Oblique	16	25.8
Total	62	100.0

Table 3. Distribution of intraoperative incidents (2021, CHUD-OP).

	n	%
Capsular rupture	5	8.1
Vitreous loss	5	8.1
Zonular rupture	3	4.8
Iris dehiscence	2	3.2

Table 4. Distribution of patients according to the type of early complications (occurred before the 15th day) (2021, CHUD-OP).

	1st Day n (%)	7th Day n (%)	30th Day n (%)
Corneal edema	32 (51.6)	17 (27.4)	8 (12.9)
Striated keratitis	1 (1.6)	-	-
Hyphema	4 (6.5)	-	-
Tyndall effect in the anterior chamber	1 (1.6)	1 (1.6)	-

3.2. Preoperative Astigmatism Axis

The majority of eyes, 40.3%, exhibited direct astigmatism (See **Table 2**).

3.3. Surgical Intervention

Procedure and Type of Incision

A smile incision was performed in 25.8% of patients, and in 74.2% of cases, the incision was linear. The interventions were underdone mostly without complications (72.6%).

The complication primarily consisted of posterior capsular ruptures and vitreous loss, with respective proportions of 4.8% (See **Table 3**).

3.4. Postoperative Complications

Early Postoperative Complications

On the 1st, 7th, and 15th postoperative days, corneal edema was the main early complication (See **Table 4**).

Late Postoperative Complications (after 30 days)

Chronic corneal edema and posterior capsular opacification are late postoperative complications in respective proportions of 4.8%.

3.5. Preoperative and Postoperative Astigmatism

The mean preoperative astigmatism changed from 1.29 ± 1.5 D to 1.85 ± 1.2 D at D15 postoperative and to 2.2 ± 1.2 D at D30 postoperative (See **Table 5**).

The mean astigmatism according to the type of incision were:

- Smile incision: 1.85 ± 1.2 D.
- Linear incision: 2.1 ± 1.2 D.
- Progression of curves in postoperative astigmatism according to the type of incision.

The smile incision induces postoperative astigmatism that consistently remains lower than that induced by the linear incision (See **Figure 1**).

Table 5. Distribution of pre and postoperative astigmatism values in diopters (2021, CHUD-OP).

	Preoperative	15 th day	30 th day	45 th day
	n (%)	n (%)	n (%)	n (%)
[0 - 1]	33 (53.2)	13 (20.9)	9 (14.5)	12 (19.4)
[1 - 2]	16 (25.8)	20 (32.3)	22 (35.5)	18 (29.0)
≥ 2	13 (21)	29 (46.8)	31 (50.0)	32 (51.6)
Mean (D)	1.29 ± 1.5	1.85 ± 1.2	2.2 ± 1.2	2.2 ± 1.5

$P < 0.0001$.

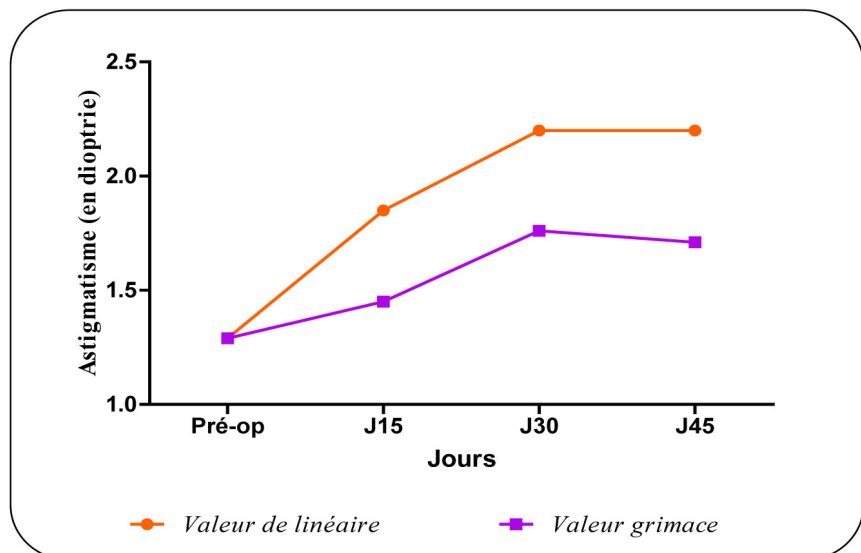


Figure 1. Evolutionary curves of postoperative astigmatism according to the type of incision (2021, CHUD-OP).

3.6. Astigmatism Axis Preoperatively and Postoperatively

The astigmatism axis was mainly direct (40.3%) before the intervention. On the 15th day postoperative, 50% of astigmatisms were oblique and then 41.9% were indirect. On the 30th and 45th postoperative days, the majority of eyes had indirect astigmatism, 56.5% and 67.7% respectively (See **Table 6**).

3.7. Induced Astigmatism

The average induced astigmatism on the 15th day is 1.45 ± 1.38 D; on the 30th day (1.76 ± 1.5 D) and on the 45th day (1.71 ± 1.48 D) (See **Table 7**).

The average induced astigmatism on the 15th day according to the type of incision were:

- Smile incision: 1.4 ± 1.5 D.
- Linear incision: 1.8 ± 1.5 D.

3.8. Axis

The following table presents the axis of induced astigmatism. Postoperative astigmatism was predominantly indirect (See **Table 8**).

Table 6. Distribution of astigmatism axis in degrees (2021, CHUD-OP).

	Preoperative	15 th day	30 th day	45 th day
Astigmatism	n (%)	n (%)	n (%)	n (%)
Direct	25 (40.3)	5 (8.1)	6 (9.6)	5 (8.1)
Indirect	21 (33.9)	26 (41.9)	35 (56.5)	42 (67.7)
Oblique	16 (25.8)	31 (50.0)	21 (33.9)	15 (24.2)
Mean	90.9 ± 45.3	99.7 ± 39.7	103.9 ± 98.5	100 ± 48.5

P = 0.001.

Table 7. Distribution of induced astigmatism values in diopters (2021, CHUD-OP).

	15 th day	30 th day	45 th day
	n (%)	n (%)	n (%)
< 1	26 (41.9)	20 (32.3)	20 (32.3)
[1 - 2]	17 (27.4)	20 (32.3)	18 (29.0)
≥2	19 (30.6)	22 (35.5)	24 (38.7)
Mean (D)	1.45 ± 1.38	1.76 ± 1.5	1.71 ± 1.48

P < 0.0001.

Table 8. Distribution of induced astigmatism axis in degrees (2021, CHUD-OP).

	15 th day	30 th day	45 th day
Astigmatism	n (%)	n (%)	n (%)
Direct	10 (16.1)	9 (14.5)	5 (8.1)
Indirect	30 (48.4)	33 (53.2)	38 (61.3)
Oblique	22 (35.5)	20 (32.3)	19 (30.6)

4. Discussion

4.1. Sociodemographic Perspective

The average age of 63 ± 12 years found in our study is comparable to those of Sowagnon *et al.* [3] and Bile *et al.* [4] in Ivory Coast, who reported an average age of 62 years and 63.17 years, respectively. Meanwhile, Diallo *et al.* [5] in Burkina Faso found an average age of 66 years. This average age corresponds to the age of senile cataracts, especially since senile cataracts are the most encountered in our study.

The male predominance in our sample could be linked to the ease of access to healthcare for men, often benefiting from administrative support, unlike women. Alamou *et al.* [6] and Diallo *et al.* [5] reported 53.5% and 57.7% men, respectively. In contrast, Djiguimde *et al.* [7] in Burkina Faso mentioned a discreet female predominance with a sex ratio of 0.98.

Retirees were the most represented at 33.9%. This could be explained by the fact that senile cataracts become troublesome only after a certain age, often corresponding to retirement age. Furthermore, Bile *et al.* [4] in Côte d'Ivoire noted a predominance of housewives in their study, while Djiguimdé *et al.* [7] in Burkina Faso found a majority of farmers and housewives.

These disparities could be explained by differences in sampling techniques between studies.

4.2. Clinical Perspective

Preoperative Ophthalmological Examination

The majority of operated eyes, 67.7%, were left eyes. In contrast, Sounouvou *et al.* [8] in Cotonou, Benin, recorded 50.4% right eyes. This difference remains a notable observation.

Preoperative Astigmatism

The average preoperative astigmatism was 1.29 ± 1.5 D. This value is close to that of Nganga Ngabou *et al.* [9] in Brazzaville, Congo, with an average preoperative astigmatism of 1.37 diopters. However, Ji-Guo *et al.* [10] in China found predominantly (34.96%) corneal astigmatism preoperatively between 0.51 and 1.00 diopter. Similarly, Diallo *et al.* in Burkina Faso [5] reported an average preoperative astigmatism of 0.87 D. However, a higher preoperative astigmatism than ours was reported by Alamou *et al.* [6] at CNHU, with 1.7 D.

Preoperative Astigmatism Axis

Astigmatism was direct in 40.3% of cases, confirming literature data stating that direct astigmatism is the most common [11].

4.3. Surgical Perspective

Types of Surgical Incision

In our study, 25.8% of patients underwent a frown incision, while 74.2% had a linear incision. Note that the type of incision depended on the surgeon, as each surgeon exclusively performed one of the two incisions.

4.4. Perioperative Incidents

Incidents were mainly capsular ruptures in 8.1% of cases with vitreous loss. These results are consistent with Bile *et al.* [4] in Côte d'Ivoire, who reported 8% capsular rupture with vitreous loss. Alamou *et al.* [6] at teaching hospital at Cotonou in Benin recorded 8.5% vitreous loss. However, Gian Maria Cavallini *et al.* [12] in Italy reported 2.7% capsular rupture with vitreous loss with the phaco-alternative. This could be explained by differences in technical capabilities, and the phaco-alternative technique may vary between surgeons.

4.5. Postoperative Complications

Early Postoperative Complications

Corneal edema was the main early complication with 51.6% on the 1st day, 27.4% on the 7th day, and 12.9% on the 15th day. From the 7th to the 15th postoperative day, spontaneous regression of corneal edema was observed in patients. Our values are lower than those of Alamou *et al.* [6] in Cotonou, Benin, who found 72.9% on the 1st day and 28.7% on the 15th day of postoperative corneal edema. However, Diomandé *et al.* [4] in Côte d'Ivoire reported 20% early postoperative corneal edema. Diallo *et al.* [5] in Burkina Faso also reported postoperative complications, mainly corneal edema, in 26.33% of cases.

Late Postoperative Complications

The main late complications encountered were chronic corneal edema at 8.1% on the 30th day, 4.8% on the 45th day, and posterior capsular opacification at 4.8% on the 30th day and 4.8% on the 45th day. However, Alamou *et al.* [6] found chronic corneal edema at 24% on the 30th day, 8.5% on the 45th day, and posterior capsule opacification in 1.6% of patients. Conversely, Warad *et al.* [13] in India reported lower results than ours, with 1.9% posterior capsular opacification on the 30th postoperative day.

Preoperative and Postoperative Astigmatism

A slight increase in astigmatism was observed after surgical intervention, ranging from an average of 1.29 diopters preoperatively to 1.85 diopters on the 15th day postoperatively and 2.2 diopters on the 30th day postoperatively. However, Alamou *et al.* [6] reported slightly higher values than ours, with an average postoperative astigmatism of 2.8 D on the 15th day, 2.6 D on the 30th day, and 2.3 D on the 45th day. After the intervention, the sclero-corneal tunnel and architectural changes in the cornea (corneal edema) are sources of postoperative astigmatism. However, Nganga Ngabou *et al.* [9] in Brazzaville reported a lower average postoperative astigmatism than ours, which is 0.87 D. The same goes for Kongsap [14] in Chanthaburi, Thailand, who reported an average postoperative astigmatism of 0.87 ± 0.62 diopters with the Blumenthal technique, which is phaco-alternative with a superior incision.

In the preoperative period, 53.2% of eyes had non-significant astigmatism according to Holmström's grading. In the postoperative period, a regression in the rate of non-significant astigmatism was noted, with values of 20.9% on the 15th

day, 14.5% on the 30th day, and 19.4% on the 45th day. In contrast, the rate of significant astigmatism increased from 32.3% on the 15th day to 35.5% on the 30th day and 29% on the 45th day.

However, the rate of “strong” astigmatism, *i.e.*, greater than 2 diopters, doubled from 21% preoperatively to 46.8% on the 15th day, 50% on the 30th day, and 51.6% on the 45th day. From these results, it can be inferred that the average astigmatism is lower with a frown incision, namely 1.85 ± 1.2 diopters, compared to 2.1 ± 1.2 diopters when the incision was linear. These results confirm literature data stating that a frown incision is less astigmatogenic than a linear incision [10].

Two other arguments could justify these results, namely the incision size in our study, which averaged 6 mm, and the type of incision and its position relative to the limbus (about 2.5 mm).

Kongsap *et al.* [14] in Thailand performed a non-sutured tunnelled scleral incision of 6.5 to 7.00 mm and reported a lower average postoperative astigmatism of 0.87 ± 0.62 D for the Blumenthal group and 0.86 ± 0.62 D for the Ruit group (phaco-A with temporal incision). These figures are lower than ours. Similarly, Day *et al.* [15] in the UK, after a study involving eight ophthalmic surgery clinics, found a majority of postoperative astigmatism between 0.50 and 1.0 D in 90% of cases. Furthermore, Malik *et al.* [16] noted that the farther from the visual axis, the less induced astigmatism. This explains that the temporal approach is the best site to minimize induced astigmatism.

4.6. Postoperative Astigmatism by Incision Type

The evolving curves of postoperative astigmatism indicate a constant progression that tends to stabilize after 30 postoperative days.

Axis

The astigmatism axis was mostly direct before the intervention, accounting for 40.3% of cases. On the 30th postoperative day, the majority of eyes had an indirect astigmatism, representing 56.5% of cases. This observation could be explained by the fact that direct and indirect astigmatism existing preoperatively are aggravated by surgery, as surgery itself induces an indirect astigmatism of 2.7 D on average in our study. Direct astigmatism decreased postoperatively from 40.3% to 8.1%. This could be explained by the fact that phaco-alternative surgery with a superior incision induces indirect astigmatism [10].

4.7. Induced Astigmatism

The mean induced astigmatism on the 15th day is 1.45 ± 1.38 D, 1.76 ± 1.5 D on the 30th day, and 1.71 ± 1.48 D on the 45th day. A comparison of the mean induced astigmatism on the 30th day by incision type reveals a mean induced astigmatism of 1.4 ± 1.5 D with a frown incision and 1.8 ± 1.5 D with a linear incision.

It appears that the frown incision is less astigmatogenic than the linear one. Diallo *et al.* [5] in Burkina Faso reported slightly lower induced astigmatism

than ours, at 1.31 diopter with the same surgical technique. This could be explained by the choice of incision sites. In our study, we made a superior incision, while Diallo made a superior incision when the preoperative astigmatism was direct and a temporal incision when it was inverse. In his study, he predictively reduced induced astigmatism by choosing the incision site to correct preoperative astigmatism.

Nidhi [17] in India reported a lower average induced astigmatism with an inverted V incision, statistically significant compared to a straight incision.

5. Conclusion

Advancements in cataract surgery offer hope for minimizing induced astigmatism. Thus, we can deduce that phaco-alternative surgery results in significant and indirect astigmatism. This astigmatism could be reduced by acting on several factors such as incision type, size, distance from the limbus, and position. Other factors, such as cauterization type and implant power, could also be explored.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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