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Outcomes of bent ab interno needle goniectomy in a regional eye hospital in South Africa

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Background: Bent ab interno needle goniectomy (BANG) is a novel technique for glaucoma surgery.

Aim: This study aimed to evaluate the outcomes of the BANG technique.

Setting: The study was conducted in Durban, South Africa.

Methods: A retrospective chart review of 34 patients who underwent BANG with cataract extraction over two years was conducted. Data on demographics, preoperative antiglaucoma medications (AGMs), and intraocular pressures (IOP) were collected. Postoperative IOP and AGM counts were recorded at set intervals.

Results: The IOP changes were significant only at 6 months, with a reduction from 19 mmHg to 14 mmHg (standard deviation [s.d.] 4; $P = 0.024$), representing a 27% decrease. A total of 93.8% of patients had IOPs of 21 mmHg or less, 87.5% had IOPs of 18 mmHg or less, and 43.8% had IOPs of 12 mmHg or less. Additionally, 43.8% of patients experienced an IOP reduction exceeding 20%. The mean AGM use dropped significantly at all visits: 0.4 at 1 week, 1.1 at 1 month, and 1.2 at 3 months (all $P < 0.001$). At 6 months, AGM use averaged 1.4 (s.d. 1.5; $P = 0.002$), a 55% reduction from the preoperative mean of 3.1. Over half (56.3%) of patients reduced AGM use by one or more, and 31.3% became drop-free.

Conclusion: The BANG procedure combined with cataract extraction is an effective and cost-efficient option for managing glaucoma, particularly in resource-limited settings.

Contribution: To our knowledge, this is the first study on BANG outcomes in Africa and among a majority of African patients.

Keywords: goniectomy; glaucoma; MIGS; microinvasive glaucoma surgery; BANG.

Introduction

Glaucoma is a leading cause of irreversible vision loss, significantly impacting the quality of life for affected patients. It is the second most common cause of blindness globally and in Africa.[1] In South Africa, primary open-angle glaucoma (POAG) predominates.[2,3]

Managing glaucoma in South Africa and across the African continent presents numerous challenges. Many of our patients reside in rural regions with limited access to specialised ophthalmic care. Up to 50% of patients may present with blindness in one eye because of delayed diagnosis.[1] Compliance with treatment regimens and follow-up is often poor, compounded by a lack of disease awareness – up to 87% of treated patients are reportedly unaware of their diagnosis.[3,4]

Treatment strategies for POAG encompass both medical and surgical interventions. Surgical strategies primarily involve bypassing the trabecular meshwork (TM) through techniques such as trabeculectomy, glaucoma drainage devices or tube shunt procedures. More recently, microinvasive glaucoma surgery (MIGS) has gained popularity, particularly when combined with cataract extraction. Resource constraints and poor follow-up make treatment of glaucoma patients in rural areas difficult. Cataract outreach initiatives to rural areas occur sporadically, while glaucoma surgery outreach initiatives are uncommon. This may be related to the complexities involved in the follow-up management of glaucoma patients.

Trabeculectomy remains the preferred surgical intervention for patients of African descent,[5,6] but it carries a risk of potentially serious complications, including under- or over-filtration, bleb leaks,

and endophthalmitis.[7,8] These complications necessitate close postoperative monitoring, posing logistical and financial challenges for patients who live far from healthcare facilities. Furthermore, the extended hospitalisation required in some cases is impractical, given the scarcity of hospital beds in South African public hospitals. Social and work-related constraints further hinder patient adherence to long-term care. Moreover, trabeculectomy tends to have higher failure rates in patients of African descent compared to Caucasians.[9] The use of adjunctive wound modulation agents, such as mitomycin C, can improve outcomes.

Given these challenges, there is a pressing need for a safe, effective, and cost-efficient surgical technique to reduce intraocular pressure (IOP). Ideally, such a procedure should require minimal intensive follow-up in the early postoperative period. This study evaluates the outcomes of the 'bent ab interno needle goniectomy' (BANG) surgical technique within the context of a resource-limited African healthcare setting, aiming to address the unmet need for a more accessible glaucoma intervention.

Methods

A retrospective chart review was conducted for all patients who underwent BANG at McCord Provincial Eye Hospital (MPEH) between 01 January 2021 and 31 December 2022. Patients were excluded from the study if they were under 18 years old or had previous incisional glaucoma surgeries.

The demographic data for the cohort, including gender, age, and race, were recorded, along with preoperative details such as the number of antiglaucoma medications (AGMs) and IOP, measured using Goldmann applanation tonometry. Postoperative data encompassed IOP and the number of AGMs at specific time points: day 1, week 1 and month 1, month 3, and month 6, as available. Antiglaucoma medications included any topical glaucoma medications as well as oral acetazolamide. Intraoperative or postoperative complications were also documented to assess surgical safety and efficacy. The data were compiled on an anonymised Excel sheet.

The technique of surgery was similar to the technique described by Shute et al.[10]

The operative eye was prepared and draped using standard sterile ophthalmic technique and a wire eyelid speculum was placed. A clear corneal incision was made temporally with a 2.4 mm or 2.75 mm keratome, followed by the injection of viscoelastic to maintain anterior chamber depth. Cataract surgery was performed before performing the BANG. To optimise the visualisation of the angle structures, the patient's head and the operating microscope were tilted and a gonioprism was used to visualise the angle. Using a needle driver, a goniotome was created by bending the distal 1 mm of a sterile 25-gauge hypodermic needle towards the bevel. The bent needle was then used to excise as much of the nasal TM as was visible, with a minimum excision of 60 degrees. The viscoelastic was subsequently removed with the irrigation–aspiration system. All incisions were confirmed to be watertight, and an antibiotic was administered either subconjunctivally or intracamerally based on surgeon preference.

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of KwaZulu-Natal Biomedical Research Ethics Committee (No. BREC/00005493/2023). The study adhered to the principles of the Declaration of Helsinki.

Results

The procedure was performed on 34 eyes, with the demographic characteristics summarised in Table 1. The majority of patients were of black African descent, with a mean age of 64.

A paired t-test was utilised to compare preoperative and postoperative data, with a P-value of < 0.05 considered statistically significant.

The mean preoperative IOP was 19 mmHg (standard deviation [s.d.] 6.7), and the mean number of preoperative AGMs was 3.1 (s.d. 0.8).

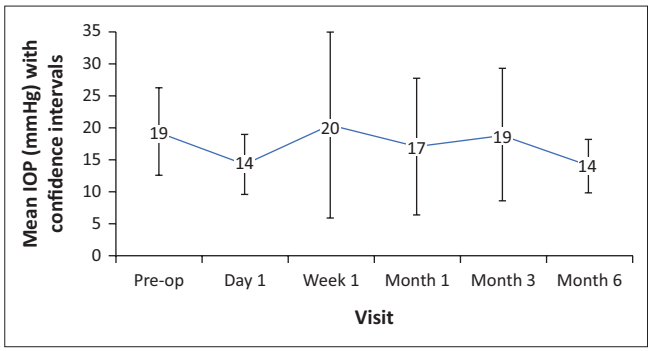
While changes in IOP at postoperative visits were not statistically significant, a significant reduction was observed at the 6-month follow-up, where the IOP had decreased from 19 mmHg to 14 mmHg (s.d. 4 $P = 0.024$), representing a 27% reduction (Figure 1). Postoperatively, 93.8% of patients achieved IOPs of 21 mmHg or less: 6.3% achieved IOP 19 mmHg to 21 mmHg, 43.8% achieved IOP 13 mmHg – 18 mmHg, and 43.8% achieved IOP of 12 mmHg or less. Thus, 43.8% of patients experienced a reduction in IOP of more than 20%.

The mean number of glaucoma medications fell significantly at all visits following surgery. The mean number of AGMs at 1 week was 0.4, 1.1 at 1 month, and 1.2 at 3 months (all $P < 0.001$). At 6 months, the mean number of AGMs was 1.4 (s.d. 1.5; $P = 0.002$), a 55% decrease compared to the pre-operative mean of 3.1 medications (Figure 2). A total of

TABLE 1: Demographic data of study cohort.

Characteristics	Overall ($N = 34$)				
	n	%	Mean	s.d.	Range
Sex					
Female	16	47.1	-	-	-
Male	18	52.9	-	-	-
Race					
African	30	88.2	-	-	-
Indian	3	8.8	-	-	-
White	1	2.9	-	-	-
Age (years)	-	-	64.4	10.8	38.0–84.0

s.d., standard deviation.



IOP, intraocular pressure.

FIGURE 1: Intraocular pressure at each visit.

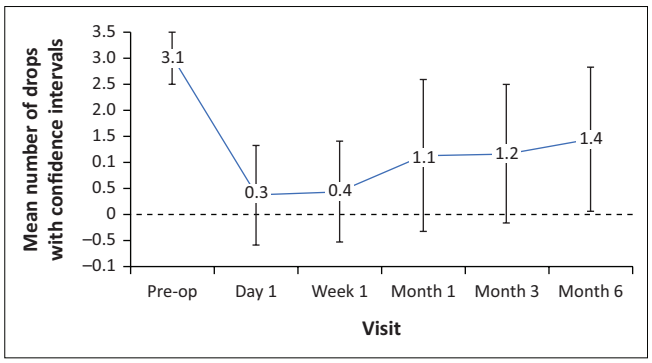


FIGURE 2: Number of antiglaucoma medications at each visit.

56.3% of patients had a decrease of one or more AGMs and 31.3% of patients were drop-free.

No sight-threatening complications occurred during the surgery or follow-up. Seven (20.5%) of the operated eyes had minor postoperative hyphaemas, all of which resolved without needing further surgical intervention. Seven eyes (20.5%) had significant postoperative corneal oedema. Six (17.6%) operated eyes had IOP spikes within the first month after surgery (Table 2).

TABLE 2: Complications of bent ab interno needle goniectomy combined with cataract extraction.

Total eyes	*N* = 34	
	n	%
Intraoperative complications		
Iris trauma	1	2.9
Iris prolapse	1	2.9
Postoperative complications		
Hyphaema	7	20.5
Hyphaema requiring AC washout	0	-
Corneal oedema	7	20.5
Postoperative inflammation	12	35.3
IOL malposition	1	2.9
IOP spike	6	17.6
Late PAS formation	3	8.8
Endophthalmitis	0	-
Hypotony	0	-
Choroidal effusions	0	-

Note: IOP spike was defined as IOP > 30 mmHg within the first month after surgery.

AC, anterior chamber; PAS, peripheral anterior synechiae; IOL, intraocular lens; IOP, intraocular pressure.

Discussion

Microinvasive glaucoma surgery encompasses a set of minimally invasive procedures aimed at reducing IOP through small incisions and less tissue disruption. These techniques improve aqueous humour drainage by targeting specific pathways, such as the TM, suprachoroidal space, or subconjunctival route. Microinvasive glaucoma surgery offers advantages over traditional surgeries, including a lower risk of complications and faster recovery times. It is suitable for patients with mild to moderate glaucoma or those requiring cataract surgery. Despite its growing popularity, the implementation of MIGS in resource-constrained environments is limited because of cost and the need for specialised surgical expertise.[11]

Trabecular meshwork disrupting surgeries aim to reduce resistance to aqueous outflow into Schlemm's canal and the collector channels. Both incisional and excisional techniques have been described, utilising either ab externo or ab interno approaches. The ab interno approach offers the additional benefit of preserving the conjunctiva.

In conventional ab interno needle goniectomy, the TM is incised with a sharp needle. A study by Eslami et al. found that the TM often appeared normal postoperatively despite reductions in IOP. The authors hypothesised that this could be because of the refusion of the intact TM remnants. They suggested that large microscopic pores in the TM might enhance the aqueous outflow.[12]

Specialised instruments designed to excise or incise the TM have been shown to reduce intraocular pressure in glaucoma patients effectively. These include devices such as the Kahook Dual Blade[13,14,15] and the Trabectome.[16,17,18] However, these instruments are costly and are not widely available in South African public-sector hospitals.

The 'BANG' procedure is a relatively newly described MIGS procedure adapted from other ab interno TM-disrupting surgeries, first described by Shute et al.[10.] This technique requires minimal specialised equipment, as the necessary equipment can be easily fashioned by modifying a standard hypodermic needle, which is both inexpensive and readily available in most South African hospitals. The procedure could be performed by specialist and trainee surgeons during outreach programmes, with the added advantage of reducing the need for intensive postoperative follow-up, such as bleb care or managing serious complications.

An important advantage of the BANG procedure is that it leaves the conjunctiva intact, allowing for further glaucoma surgery if warranted. The low incidence of serious complications also reduces the need for frequent postoperative visits, which is particularly beneficial for our patient population, many of whom come from low-income backgrounds and must travel long distances for care. This reduction in follow-up

requirements also helps alleviate the burden on our already overextended clinics.

Shute et al. conducted a retrospective study of the outcomes of the BANG procedure in 41 eyes of 23 patients, of whom only four were of African descent. The procedure was performed either as a standalone surgery or in combination with phacoemulsification. Six months postoperatively, they reported an average IOP reduction of 4.1 mmHg (23.5%) from baseline. The study found that 73% of patients achieved a 20% reduction in IOP, 73% required at least one fewer medication for IOP control, 73% were able to discontinue all medication, and 41% had IOPs below 12 mmHg in the operated eye eyes.[10]

Bussel et al. also reported their findings on the results of the BANG procedure when combined with phacoemulsification in a study involving 32 eyes. They observed statistically significant decreases in IOP with an average reduction of 29% from baseline and a 77% reduction in the number of medications needed for IOP control at 3 months postoperatively across all glaucoma severities.[19]

Similarly, Townsend et al. presented their results of the BANG procedure combined with phacoemulsification in 43 eyes with glaucoma. In this study, it was found that 76% of the patients were Caucasian, although the ethnicity of the remaining patients was not specified. This group reported a statistically significant average reduction in IOP of 20.8% ($P < 0.0001$) and an average decrease in the number of medications required of 0.88 drops ($P = 0.0009$) in all types of glaucoma. A total of 55.8% of patients had their IOP reduced by more than 20%.[20]

The average IOP reduction across the studies mentioned above was 24.4%, aligning with the results observed in our research. Notably, all these studies were conducted in the United States and reported very few serious adverse events.

We believe the ideal candidates for the BANG procedure are patients with mild to moderate glaucoma who are phakic and require cataract surgery; combining TM-disrupting surgeries with cataract surgery appears to enhance the reduction in IOP. A study by Kim et al. demonstrated a significantly greater reduction in both IOP and the number of AGM in eyes that underwent ab externo goniotomy during cataract surgery compared to those who had cataract surgery alone, with both groups exhibiting similarly favourable safety profiles at 1 year postoperatively.[21]

In our study, the effect of BANG on average IOP at 3 months postoperatively was less impressive than at 6 months. This discrepancy can be attributed to two participants who exhibited significantly elevated IOP (48 mmHg and 52 mmHg) at three months, likely related to steroid response or the formation of peripheral anterior synechia in the areas of TM excision.

These eyes remain at risk for postoperative steroid response, as a substantial portion of their TM remains intact; however, an increase in IOP because of steroid use would typically be expected earlier in the postoperative period.

The BANG procedure is highly economical. A single-use Trabectome procedure pack costs around USD 750, translating to about ZAR 14 000 at the time of writing. This figure does not include the upfront cost of the machine itself. In comparison, the Kahook Dual Blades are priced at around USD 500 (ZAR 9310). Conversely, a box of 100 disposable 25 g needles costs USD 23.85 (ZAR 444.1), costing approximately USD 0.24 (ZAR 4.44) per needle.

Substantial follow-up loss was observed during this study, with only 16 (47%) of patients returning for their 6-month postoperative visit. Our centre serves a large population and many patients reside significant distances away. Consequently, it is a common occurrence for patients to miss follow-up appointments or default on care because of financial constraints related to travel or other factors.

To our knowledge, this is the first study of the BANG procedure conducted in Africa and the first study in which the majority of participants are African. Our findings contribute to the existing body of knowledge by demonstrating the procedure's efficacy in an African population.

Ab interno procedures have not been extensively explored in the context of outreach programmes, making the BANG procedure a promising option for patients undergoing surgery in rural settings.

Conclusion

The BANG procedure appears to be a promising, safe and economical alternative to other MIGS surgeries for reducing IOP in glaucoma patients in resource-constrained settings. The long-term effects of the BANG procedure on IOP and medication will be better understood with extended follow-up.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

S.H.v.W. was the principal author of the article. M.d.B. supervised the project and assisted with editing of the script. N.T.M. conceived the project and performed the majority of the procedures included in the study, as well as assisted in editing the script. C.-H.K. performed the statistical analyses and assisted with editing the script.

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Data availability

The data that support the findings of this study are not openly available because of patient privacy and are available from S.H.v.W. upon reasonable request.

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References

1. Cook C. Glaucoma in Africa: Size of the problem and possible solutions. J Glaucoma. 2009;18(2):124–128. https://doi.org/10.1097/IJG.0b013e318189158c
2. Rotchford AP, Johnson GJ. Glaucoma in Zulus: A population-based cross-sectional survey in a rural district in South Africa. Arch Ophthalmol. 2002;120(4):471–478. https://doi.org/10.1001/archopht.120.4.471
3. Rotchford AP, Kirwan JF, Muller MA, Johnson GJ, Roux P. Temba glaucoma study: A population-based cross-sectional survey in urban South Africa. Ophthalmology. 2003;110(2):376–382. https://doi.org/10.1016/S0161-6420(02)01568-3
4. Kyari F, Abdull MM, Wormald R, et al. Risk factors for open-angle glaucoma in Nigeria: Results from the Nigeria National Blindness and Visual Impairment Survey. BMC Ophthalmol. 2016;16:78. https://doi.org/10.1186/s12886-016-0264-7
5. Agbeja-Baiyeroju AM, Omoruyi M, Owoaje ET. Effectiveness of trabeculectomy on glaucoma patients in Ibadan. Afr J Med Med Sci. 2001;30(1–2):39–42.
6. Lam A, Seck C, Borzeix A, Faye M, Pintart D. [Trabeculectomy in black Africans in primary open angle glaucoma]. J Fr Ophtalmol. 2000;23(6):563–568.
7. Ashaye AO, Komolafe OO. Post-operative complication of trabeculectomy in Ibadan, Nigeria: Outcome of 1-year follow-up. Eye (Lond). 2009;23(2):448–452. https://doi.org/10.1038/sj.eye.6702979
8. Edmunds B, Thompson JR, Salmon JF, Wormald RP. The National Survey of Trabeculectomy. III. Early and late complications. Eye (Lond). 2002;16(3):297–303. https://doi.org/10.1038/sj.eye.6700148
9. The AGIS Investigators: The Advanced Glaucoma Intervention Study (AGIS): 4. Comparison of treatment out- comes within race. Ophthalmology. 1998;105(7):1146–1164. https://doi.org/10.1016/S0161-6420(98)97013-0
10. Shute TGW, Liu J, Sheybani A. An alternate technique for goniotomy: Description of procedure and preliminary results. Ophthalmic Vis Res. 2022;17(2):170–175. https://doi.org/10.18502/jovr.v17i2.10787
11. Saheb H, Ahmed IIK. Micro-invasive glaucoma surgery: Current perspectives and future directions. Curr Opin Ophthalmol. 2012; 23(2):96–104. https://doi.org/10.1097/ICU.0b013e32834ff1e7
12. Eslami Y, Mohammadi M, Safizadeh M, Tabatabaei SM. Six-month outcomes of combined conventional needle goniotomy and phacoemulsification in eyes with early to moderate primary open-angle and pseudoexfoliation glaucoma and ocular hypertension. Indian J Ophthalmol. 2022;70(6):2030–2035. https://doi.org/10.4103/ijo.IJO_2969_21
13. Al Habash A, Albuainain A. Long term outcome of combined phacoemulsification and excisional goniotomy with the Kahook Dual Blade in different subtypes of glaucoma. Sci Rep. 2021;11(1):10660. https://doi.org/10.1038/s41598-021-90223-5
14. Aoki R, Hirooka K, Goda E, et al. Comparison of surgical outcomes between microhook Ab Interno trabeculotomy and goniotomy with the Kahook dual blade in combination with phacoemulsification: A retrospective, comparative case series. Adv Ther. 2021;38(1):329–336. https://doi.org/10.1007/s12325-020-01543-3
15. Ibrahim LF, Pereira AFR, Terenzi LAO, et al. Phacoemulsification with Kahook Dual Blade goniotomy in eyes with medically treated glaucoma: Analysis of surgical outcomes and success predictors. Arq Bras Oftalmol. 2021;85(4):359–363. https://doi.org/10.5935/0004-2749.20220046
16. Esfandiari H, Shah P, Torkian P, et al. Five-year clinical outcomes of combined phacoemulsification and trabectome surgery at a single glaucoma center. Graefes Arch Clin Exp Ophthalmol. 2019;257(2):357–362. https://doi.org/10.1007/s00417-018-4146-y
17. Nazarali SA, Damji KF. Ab interno trabeculectomy with Trabectome: Outcomes in African American versus Caucasian patients. Can J Ophthalmol. 2018;53(4):361–364. https://doi.org/10.1016/j.jcjo.2017.10.018
18. Pahlitzsch M, Gonnermann J, Maier AB, Bertelmann E, Klamann MK, Erb C. Modified goniotomy as an alternative to trabectome in primary open angle glaucoma and pseudoexfoliation glaucoma: 1 year results. Can J Ophthalmol. 2017;52(1):92–98. https://doi.org/10.1016/j.jcjo.2016.07.011
19. Bussel I, Schroeder R, Sheybani A. Prospective safety and efficacy evaluation of bent ab-interno needle goniectomy (BANG); a MIGS option for the developing world. Paper presented at: ASCRS Annual Meeting; May 16–17, 2020.
20. Townsend J, Badar A, Dixon S, Parekh P, Martin E. Outcomes of bent ab interno needle goniectomy in primary open angle glaucoma. Investig Ophthalmol Visual Sci. 2021;62(8):3431.
21. Kim WJ, Kim JM, Lee WH, Kim KN, Kim CS. Effect of combined goniotomy and phacoemulsification on intraocular pressure in open-angle glaucoma patients. Clin Exp Ophthalmol. 2019;47:757–765. https://doi.org/10.1111/ceo.13506