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Original Research Article

NONCONTACT TONOMETRY(NCT) AS A SCREENING TOOL FOR GLAUCOMA IN TARGETED POPULATION

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ABSTRACT

Background: Glaucoma is the second leading cause of irreversible blindness worldwide, with increasing prevalence in India. Early detection is critical as the disease remains asymptomatic in its initial stages. Elevated intraocular pressure (IOP) is the most significant modifiable risk factor. Non-Contact Tonometry (NCT) offers a rapid, non-invasive, and infection-free method for IOP measurement, making it a potential mass-screening tool in high-risk groups.
Objectives: To evaluate the efficacy of Non-Contact Tonometry as a screening tool for glaucoma in a targeted population (individuals aged >40 years, diabetics, myopes, and those with a family history of glaucoma).
Materials and Methods: A hospital-based prospective observational study was conducted at Bhaskar General Hospital, Yenkapally, from September 2019 to March 2021, enrolling 500 participants meeting the inclusion criteria. Three NCT readings per eye were recorded, and the mean IOP was calculated. Individuals with IOP ≥21 mmHg underwent further evaluation including central corneal thickness, fundus examination, optical coherence tomography (OCT), and 24-2 visual field analysis to confirm glaucoma. Statistical analysis was performed using SPSS v25.0, with chi-square and Fisher's exact tests at a 5% significance level.
Results: Among 500 participants (mean age 53.45 ± 4.24 years), 59.2% were males. High IOP (>21 mmHg) was found in 18.2% of subjects. Of these, 69.23% showed glaucomatous fundus changes, and 82.53% demonstrated field defects on perimetry. Confirmed glaucoma was detected in 52 participants, predominantly among those aged >40 years (36.5%), diabetics (32.7%), high myopes (25%), and those with a family history (5.8%). The sensitivity and specificity of NCT were 92.31% and 95.98%, respectively, with a positive predictive value of 72.73%, negative predictive value of 99.08%, and overall accuracy of 95.6%.
Conclusion: Non-Contact Tonometry is a highly sensitive, specific, and reliable screening tool for early detection of glaucoma in high-risk populations. Incorporating NCT into community-based screening protocols can significantly aid in reducing the burden of preventable blindness due to glaucoma.
Keywords: Glaucoma, Non-Contact Tonometry, Intraocular Pressure, Screening, Myopia, Diabetes Mellitus, Optic Neuropathy.

INTRODUCTION

Glaucoma, characterised by progressive optic neuropathy, is a leading cause of irreversible visual impairment and blindness worldwide.[1] In 2020, an estimated 76 million individuals globally were affected by glaucoma, with approximately 4.5 million experiencing moderate to severe visual impairment and 3.2 million suffering from blindness. The prevalence of glaucoma in India among different populations and subgroups varies between 2.3 – 4.7%. Risk factors like raised IOP, age, gender,

refractive errors and systemic factors (hypertension, body mass index, diabetes) have growing evidence.[4] Elevated IOP is well known risk factor of POAG. Eyes with high myopia may be less able to tolerate IOP fluctuations than other eyes. In myopic eyes posterior wall may be stretched more than the non-myopic eye's as IOP increases, making optic nerve more susceptible to damage. The literature suggests that diabetic patients have a greater risk for glaucoma.[5] Diabetes directly or indirectly disrupts nutritional supply to retinal ganglion cells (RGC), may result in developing POAG. Primary open-angle glaucoma is a chronic, progressive optic neuropathy in adults characterized by optic nerve damage and retinal ganglion cell loss. Open anterior chamber angle and cupping of optic nerve head with corresponding loss of visual field are the clinical features.[6]

Primary open-angle glaucoma can occur when intraocular pressure is normal. Diagnosis of glaucoma is based on finding characteristic optic nerve changes associated with corresponding visual field defects, regardless of intraocular pressure. Current treatments are aimed at reducing intraocular pressure by medical therapies, laser modalities, or surgical management.[7,8] Reducing intraocular pressure slows the onset and progression of glaucoma. There may be gradual visual field loss, which may progress to an island of central vision and, ultimately, complete loss of vision if left untreated. A complete ophthalmic examination is required for patients who are high risk for Glaucoma (eg, those with diabetes, those with family history of glaucoma, people aged 40 years or older, Myopics). Early detection and treatment are key to protecting vision.[9,10]

Aim: Non contact tonometer as a screening tool for glaucoma in targeted population (myopes, age 40+, diabetics and family H/O glaucoma).

Objective: Early detection of glaucoma in targeted population by Topcon Non contact tonometer.

MATERIALS AND METHODS

Patients and Methods

- **Study Site:** Bhaskar General hospital, Yenkapally
- **Study Population:** Targeted Patients coming to ophthalmology OPD
- **Study design:** Hospital based Prospective observational study
- **Sample size:** 500
- **Duration:** September 2019 to March 2021 (18months)

Inclusion Criteria

All males and females above 40 years, myopes and diabetic patients and family H/O glaucoma.

Exclusion Criteria

1. Established cases of glaucoma
2. History of any previous eye surgery and eye disease
3. Secondary glaucomas, Normotensive glaucoma
4. Patients on systemic and topical steroids
5. Patients who doesn't give consent

The demographic profile of the patients with diabetes/ myopes/ age above 40 yrs and family H/O glaucoma is collected. Informed consent is obtained from the patient then only he/she will be included in the study. Three NCT readings are obtained from each eye and arithmatic mean of all three readings is taken as IOP. Intra ocular pressure < 21mmHg are excluded from study and patients with IOP ≥ 21mmHg are further evaluated with Central corneal thickness, fundus examination, Optical coherence tomography(OCT) and 24-2 Visual Fields to confirm Glaucoma.[11,12]

Non contact Tonometry (NCT)

It is new technology for intraocular pressure (IOP) measurment. Originally, an idea by Erich Zeiss in 1951 but was not recognised until Grolman made commercially available 20yrs later. Several instruments have been marketed since then and are based on principle of Zeiss 'aero-tonometry', more commonly referred to as 'air puff tonometry', which is synonymous with NCT, being the only technique by which IOP is determined without contact with the eye.[13,14]

Principle

The applanating force in NCT is a column of air emitted with increasing intensity. On corneal flattening, the air column is shut off and the force at that moment is recorded and converted into mmHg. A minimum of 3 readings should be averaged to estimate the mean IOP as IOP varies during the cardiac cycle.

Method

The patient will rest their chin on a padded support and stare straight into the machine. A brief puff of air is blown at your eye. They will hear the puffing sound and feel a coolness or mild pressure on your eye. The tonometer records the intraocular pressure (IOP) from the change in the light reflected off the cornea as it is indented by the air puff. The test may be done several times for each eye with the air-puff (noncontact) method, there is no risk of scratches or infection, since nothing but air touches your eyes.

Statistical Analysis: Descriptive statistics were reported as mean (SD) for continuous variables, frequencies (percentage) for categorical variables. Chi-Square at 5% level of significance was used to find statistical significance. Fischer's exact test is when expected cell count is less than 5. Data were statistically evaluated with IBM SPSS Statistics for Windows, Version 25.0., IBM Corp., Chicago, IL.

RESULTS

This Hospital based prospective study of Noncontact tonometer as a screening tool for Glaucoma in 500 targeted population (>40yrs, myopes, diabetics, family H/O glaucoma) fulfilling the criteria framed were included in the study. The targeted patients with

high IOP were evaluated further with fundus examination, 24-2 visual fields and OCT for glaucoma.

Table 1: Distribution of age among the study participants

Age	Frequency	Percentage
<40	81	16.2
41-50	197	39.4
51-60	132	26.4
>61	90	18
Total	500	100

In the current study patients are categorized into four age groups and 197(39.4%) patients were found in age group 41-50, followed by 132(26.4%) in age group 51-60, 90(18%) in age group > 61 and 81(16.2%) in age group <40 years. The total mean age of the study participants 53.45±4.24 years. Majority participants are in age group 41-50.

Table 2: Distribution of gender among the study participants

Gender	Frequency	Percentage
Female	204	40.8
Male	296	59.2
Total	500	100

In the above table patients are distributed according to gender and it was found that males were 296 (59.2%) and females were 204 (40.8%). Majority are males in this study.

Table 3: Distribution of diabetes mellitus among the study participants

Diabetes	Frequency	Percentage
Present	71	14.2
Absent	429	85.8
Total	500	100

In the current study the history of diabetics is divided into two groups and showed 71(14.2%) with diabetes mellitus and the rest 429(85.8%) don't have diabetes mellitus.

Table 4: Distribution of duration of diabetes mellitus among the study participants

Duration of diabetes mellitus	Frequency	Percentage
<5 years	24	33.80
5-10 years	31	43.66
>10 years	16	22.53
Total	71	100

In the above table duration of diabetes mellitus is divided into three groups and 31(43.66%) are with 5-10 years duration followed by 24(33.80%) with less than 5years duration and 16(22.53%) with more than 10 years duration. Mean duration of diabetes mellitus is 8.30±2.15 years. Majority of them are in 5 to 10 years duration.

Table 5: Distribution of high myopia among the study participants

High Myopia	Frequency	Percentage
Present	93	18.6
Absent	407	81.4
Total	500	100

In the current study history of high myopia are divided into two groups and among them 93(18.6%) are present with high myopia and the remaining 407(81.4%) are not high myopes.

Table 6: Distribution of family history of glaucoma among the study participants

Family history of glaucoma	Frequency	Percentage
Present	15	3.1
Absent	470	96.8
Total	500	100

In the current study family history of glaucoma is divided into two categories and 15(3.1%) have family history of glaucoma and the remaining 470(96.8%) are without family history.

Table 7: Distribution of Non-contact Tonometry among the study participants

Non-contact Tonometry	Frequency	Percentage
Normal (≤ 20 mm Hg)	409	81.8
High (> 21 mm Hg)	91	18.2
Total	500	100

In this study Intraocular pressure more than 21mmHg is present in 91(18.2%) individuals and the remaining 409(81.8%) individuals have IOP less than 21mmHg.

Table 8: Distribution of fundus changes among the study participants

Subjects with high pressures N=91	Fundus changes	
	Glaucoma changes N,(%)	No glaucoma changes N,(%)
	63(69.23%)	28(30.76%)

In this study, individuals with high intraocular pressure have under gone fundus examination. Among them 63(69.23%) individuals have glaucomatous disc changes and 28(30.76%) individuals don't have glaucomatous disc changes.

Table 9: Distribution of suspicious optic disc changes among study participants

CDR	Frequency	Percentage
0.5:1	12	19.04
0.6:1	14	22.22
0.7:1	20	31.74
0.8:1	14	22.22
0.9:1	3	4.76
Total	63	100

Among the subjects with suspicious disc, the majority individuals 20(31.74%) are with 0.7 cupping followed by 14(22.22%) individuals with 0.6 and 0.8 cupping each, 12(19.04%) individuals with 0.5 cupping and 3(4.76%) individuals with 0.9 cupping.

Table 10: Distribution of field changes among the study participants

Field changes	Frequency	Percentage
Present	52	82.53
Absent	11	17.46
Total	63	100

The 63 individuals with suspicious optic disc underwent visual field test and OCT to confirm glaucomatous changes. Among them 52(82.53%) had glaucomatous field changes and remaining 11(17.46%) had non glaucomatous changes.

Table 11: Distribution of OCT among the study participants

OCT	Area	Frequency	Percentage
0.5:1	Inferior RNFL Superior RNFL Nasal RNFL Temporal RNFL	4 3 4 0	7.69 5.76 7.69 0
0.6:1	Inferior RNFL Superior RNFL Nasal RNFL Temporal RNFL	5 4 3 1	9.61 7.69 5.76 1.92
0.7:1	Inferior RNFL Superior RNFL Nasal RNFL Temporal RNFL	7 2 5 2	13.46 3.84 9.61 3.84
0.8:1	Inferior RNFL Superior RNFL Nasal RNFL Temporal RNFL	4 4 1 0	7.69 7.69 1.92 0
0.9:1	Inferior RNFL Sup,nasal,temporal	3 0	5.76 0

Table 12: Distribution of glaucoma among the targeted population

Risk factors	Glaucoma	Percentage
Age above 40 years	19	36.5
Family history of glaucoma	3	5.8

High Myopia	13	25
Diabetes Mellitus	17	32.7
Total	52	100

According to the current study glaucoma has been diagnosed in target population with majority individuals 19(36.5%) are above 40years age followed by 17(32.7%) are diabetics, 13(25%) are high myopes and 3(5.8%) are individuals with family history of glaucoma.

Table 19: Efficacy of NCT as a screening tool

Sensitivity	92.31% (CI:81.46% to 97.86%)
Specificity	95.98% (CI:93.72% to 97.60%)
PPV	72.73% (CI:62.75% to 80.85%)
NPV	99.08% (CI:97.67% to 99.64%)
Accuracy	95.60% (CI:93.41% to 97.22%)

According to this study efficacy of NCT as a screening tool has a sensitivity of 92.31% (CI: 81.46% to 97.86%). Specificity of 95.98% (CI:93.72% to 97.60%). PPV of 72.73% (CI: 62.75% to 80.85%). NPV of 99.08% (CI: 97.67% to 99.64%). Accuracy of 95.60% (CI: 93.41% to 97.22%).

DISCUSSION

Glaucoma is the second most common cause for irreversible blindness, Globally. It is quoted as "sneak thief of sight" because the deterioration of vision is not appreciated until advanced stage of glaucoma. One out of two people are unaware of their disease. Now -a- days it is considered as major cause of ocular morbidity that requires immediate attention.[16,17]

Glaucoma is a chronic optic neuropathy characterised by structural and functional damage to optic nerve head (as evidence by thinning of neuro retinal rim and progressive visual field loss). In India glaucoma is the leading cause of blindness with atleast 12million people affected and nearly 1.2 million blind.

As glaucoma is asymptomatic initially, screening for glaucoma is an important criteria to reduce the incidence of loss of vision and blindness. Detection of glaucoma in earlier stages is tough because of wide variability in optic nerve head appearance. Intraocular pressure measurement would help to an extent as it is easily modifiable and detected by a screening tool with good sensitivity and specificity.[19]

To avoid or to decrease blindness due to glaucoma, risk group who are more likely to develop should be screened extensively. There are many risk factors for glaucoma, among them Intra ocular pressure(IOP) is an important modifiable factor. To measure IOP many devices are available but Non contact tonometry(NCT) is easy to perform, non invasive, minimal risk of infection in contrast to other devices which require skilled examiner and high risk of infection. NCT has a specificity of 95% and sensitivity of 85% in general population.[20]

The American Academy of Ophthalmology (AAO), identifies population at increased risk for glaucoma as: (1) individuals older than 40 years, (2) individuals with high myopia, (3) individuals with a family history of glaucoma, (4) individuals with diabetes mellitus. To the best of our knowledge this is the first hospital based study for screening in target population with NCT.[21]

Age:

Age is a major risk factor which can be used with other risk factors to compute chances of developing glaucoma. As the life expectancy is increasing the prevalence of glaucoma also rises with increasing age. Though it occurs in any age group, more common in older age. The worldwide prevalence of glaucoma in older age is 2.4%. As glaucoma is a neurodegenerative disease of optic nerve, which is formed by axons of retinal ganglion cells(RGC), ageing weakens the optic nerve and also aqueous humor outflow pathway where intraocular pressure begins to rise. The National eye institute recommends age over 40 to get glaucoma evaluation as it can manifest at any older age group.[22]

Table 20: Comparision of mean age

Study	Mean Age
Hassan Hashemi et al	50.7 ± 6.2 years
Vijaya L et al	54.8 ± 10.6 years
Vijaya et al	59.85 ± 10.43years
Present study	53.45 ± 4.24years

According to Hassan Hashemi et al mean age was 50.7± 6.2 years. Glaucoma prevalence 1.92%. According to Vijaya L et al Mean IOP 16.17± 3.74 mmHg. Mean age 54.8 ± 10.6 years. Prevalence of glaucoma 3.51%. According to Lingam Vijaya et al Mean IOP 14.29 ± 3.32mmHg. Mean age 59.85 ± 10.43 years. Prevalence of glaucoma 1.62%.[23]

In this study Mean age is 53.45 ± 4.24 years. Majority participants are in 41-60 years age group. Among the study population more than 40 years age, 36.5% developed glaucoma. Mean IOP in individuals

diagnosed with glaucoma with age more than 40years 24.026± 8.002. Incidence of glaucoma in this age group 4.6%. The difference in mean age group in different studies could have been due to inclusion of different age groups. Males are dominant in this study with 59.2%. As glaucoma increases with age screening the population above 40 years with NCT can help identify the patients at an early stage and can decrease the deleterious effects of glaucoma.[24]

High Myopia

High myopia is considered as legal blindness in many developed countries. The pathological risk factors due to high myopia are glaucoma, retinal detachment, macular degenerations. Literature have suggested that risk of glaucoma increases with increase in degree of myopia. It is often common to get confused between myopic optic disc and glaucomatous optic disc, which can be differentiated by peripapillary Chorioretinal atrophy from the latter. In myopia there can be increase in ocular pressure due to increase in secretion of aqueous humor or reduction in outflow which is explained by mechanical theory and vascular theory. According to mechanical theory, rise in IOP damages axoplasmic transport within optic nerve head(ONH) fibres and leads to death of RGC's. According to vascular theory, optic neuropathy occurs due to insufficient blood supply due to either raised IOP or systemic blood pressure or vasospasm.[25]

Individuals with moderate or high myopia had an almost 3 times higher risk of POAG compared with those with emmetropia. The prevalence of newly detected glaucoma increased with increasing myopia according to one of the largest survey done between myopia and glaucoma in sweden. In the Blue Mountains Eye Study, the glaucoma prevalence was higher in moderate to high myopes (4.4%) than in emmetropes (1.5%).[26]

In this study 18.6%(93) are present with high myopia. Among the diagnosed glaucoma individuals 25% (13) are with high myopia. Mean IOP in individuals diagnosed with glaucoma is 23.577± 6.100. Incidence of glaucoma in high myopes in this study is 13.9%. As myopia is continuously progressive, it is mandatory to keep the myopic individuals under screening because few individuals may develop glaucoma at higher degree of myopia.[27]

Family history of Glaucoma:

Positive family history (FH) is one of the major risk factor and is also associated genetically. Several genes are known to cause glaucoma but it accounts for only 10% of all the cases. Individuals with positive Family history has risk of developing glaucoma upto 18 times. Glaucoma is common in first degree relatives of the diagnosed individuals. This emphasizes that family history check during screening helps to identify individuals at risk at younger age and prevent from progressing to advanced disease when compared to individuals identified without any history at the time of diagnosis.[28]

According to the Baltimore Eye Survey and the Barbados Eye Study, siblings of affected individuals are at greatest risk of developing glaucoma, compared to parents or children. It is reported that maternal FH is more common than paternal FH. The frequency of glaucoma in positive family history of glaucoma decreased with increasing age. Targeted screening of families of individuals diagnosed with glaucoma helps to identify and prevent them from blindness. In this study 3.1%(15) are present with family history of glaucoma. Among the diagnosed individuals with glaucoma, 5.8%(3) are with family history of glaucoma. Mean IOP in individuals diagnosed of glaucoma with family history is 20.333± 6.408. Incidence of glaucoma with family history is 20%. In this study as most of the individuals are from rural areas, they are unaware of family history of glaucoma.

Diabetes mellitus

Our nation has one of the highest rates of Type 2 diabetes in the world and it is increasingly prevalent due to changes in lifestyle. POAG is the most common type in diabetic individuals, nearly 70 million are affected worldwide. Diabetic patients need repeated visits, chronic medications due to risk of end organ damage. It is postulated microvasculature and nutritional supply is reduced to RGC axons of optic nerve head which leads to degeneration of RGC's and causes glaucoma. Thus any vascular related systemic diseases disrupts nutritional supply to retinal ganglion cells.[30]

The prevalence of glaucoma in diabetics varies from 4.96% to 14.6%, but this varies due to geographic and race distribution. The prevalence of glaucoma in diabetics was 15.6%. In western India, the prevalence of glaucoma among diabetics was.[15] The incidence of glaucoma is increased by 36% in individuals with diabetes compared to individuals with non-diabetics. In this study 14.2% (71) individuals are present with diabetes mellitus. Among the individuals diagnosed with glaucoma 32.7%(17) are diabetics. The Mean IOP in individuals diagnosed with glaucoma is 23.206± 5.420. Incidence of glaucoma in diabetics in this study is 23.9%. As diabetes and glaucoma has polygenetic inheritance, all diabetic individuals should be screened for glaucoma to lower the complications in advanced stage.[31]

Screening of target population

Glaucoma being a silent disease, the importance of screening cannot be undermined. The American Academy of Ophthalmology (AAO) advices regular screening for population at increased risk for glaucoma. However, currently no organized community-screening program specifically for glaucoma detection exists in India.[32]

Non contact tonometry as a screening tool:

All methods of tonometry obey Imbert-Fick law. In earlier days Schiotz tonometer was widely used but latter new devices are invented and were quickly accepted for using in primary care setting. Among them non-contact tonometry is one which gained

popularity because it is easy to use by any medical or non-medical practitioner.[33]

Rationale for screening:

According to national health portal of India, more than 90% of the cases remain undiagnosed in the community. There is convincing evidence that treatment of increased intraocular pressure (IOP) and early glaucoma reduces the number of persons who develop small, clinically unnoticeable visual field defects and that treatment of early asymptomatic cases decreases the number of persons whose visual field defects worsen.[34]

Effectiveness of Early Detection and Treatment:

Evidence shows that medical and surgical treatment of early asymptomatic POAG reduce the number of patients whose visual field defects progress, no studies evaluated whether they reduce progression to visual impairment or improve quality of life. A systematic review of 10 studies concluded that medical treatment had a significant protective effect on incident worsening of visual field measurements compared with placebo or no treatment (odds ratio, 0.62 [95% CI, 0.47 to 0.81]).[35]

Efficacy of NCT:

There are chances of measurement errors with corneal thickness, hardness, irregularities and curvature with GAT as it is a applanation technique. Sensitivity and specificity for GAT is 96.3% and 68.8% respectively. The sensitivity and specificity for NCT are 91.7% and 95.6% respectively. The sensitivity and specificity in ours study are 92.31% and 95.98% respectively. As an ideal screening tool should have high sensitivity and specificity NCT can help to identify cases of glaucoma with high IOP in early stages.[36]

CONCLUSION

This study shows that NCT can be used as a reliable screening tool for targeted population. Framing screening protocols for targeted population and using efficient screening tools like NCT can help to decrease the burden of blindness due to glaucoma.

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