

Original research article

An Observational Study on Comparison of Non Contact Tonometer with The Goldmann Applanation Tonometer (GAT) to determine the Intraocular Pressure Readings in Healthy and Glaucomatous Population at a tertiary care centre of Banaskantha and Patan district of Gujarat (India).

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Abstract

Background: Glaucoma has been declared to be the second most common cause of blindness in adults in India. Glaucoma was undetected in more than 90 % of individuals identified in the population studies.

Aim & Objective: The aim of this study is to compare the non contact tonometer (the NIDEK NT 510) with the Goldmann applanation tonometer (GAT) and to determine the intraocular pressure readings in healthy and glaucomatous population.

Methodology: This is a Hospital based conducted at tertiary care centre of Banaskantha and Patan district of Gujarat

Results: Demographic profile of the study showed that males 157 (54%) were more than the females 132 (45.67%) in the normal individual. In glaucoma patients males 91 (67.91%) were more than the females 43 (32.08%). In our study there was linear correlation between **age** and IOP in both eyes. Higher IOP was found in both > 50 years age group depending on the instrument used. In our study, in normal patients the IOP mean±SD values of both NCT and GAT was 16.15±4.46 and 15.87±4.58. From these results, IOP readings taken by NCT and GAT readings were found to be in 12-20 mm Hg in normal group. From the above results, these studies revealed that there were no significant differences in IOP readings taken by both NCT and GAT in normal and glaucoma individual. In the present study, intraocular (IOP) recorded by NCT is slightly higher than the GAT.

Conclusion: From these studies we conclude that both the instruments important for measurement of IOP readings for early diagnosis of Glaucoma. There was a significant difference between the two tonometers if the IOP readings more than 21 mmHg. There was no significant variation in readings of IOP were taken NCT and GAT at <10 and 10-20 mmHg.

Keywords: IOP, Glucoma, NCT, GAT

Introduction

Glaucoma is one of the leading causes of blindness in the world. It is defined as an acquired optic neuropathy which leads to destruction of ganglion cells and fibres and eventually causes irreversible visual field loss. The disturbance of the outflow of aqueous humour, a natural clear nourishing intraocular fluid, resulted in increase of the IOP. Glaucoma is a critical public health issue: around 45 million patients all inclusive have open-angle glaucoma, and around 8.4 million patients wind up dazzle as a result of glaucoma⁽¹⁻³⁾. In this way, it is important to treat glaucoma and counteract blindness⁽⁴⁻⁷⁾. Glaucoma has been declared to be the second most common cause of blindness in adults in India. Glaucoma was undetected in more than 90 % of individuals identified in the population studies. Inadequate identification of glaucoma even in population undergoing ophthalmic evaluation continues to be a major determinant of preventable blindness due to glaucoma in India⁽⁸⁾. Once the blindness of glaucoma has occurred, there is no treatment that will restore vision. In nearly all cases, however, blindness is due to glaucoma is preventable. This prevention requires early detection and proper treatment⁽⁹⁾. Good case detection depends on using tests with high positive predictive values such as perimetry, tonometry and fundus examination to all the patients who visit our clinic for various eye ailments⁽¹⁰⁾.

For early diagnosis of glaucomatous damage new technologies such as new tonometers, new OCT machines & optic nerve head analysers etc. are of paramount importance⁽¹¹⁾

Nowadays even though the diagnosis of glaucoma is done on the basis of structural and functional changes found in retinal nerve fibre layer, intra ocular pressure is the only factor which can be used to titrate the treatment and also the important factor whose reduction can bring about good prognosis and disease slowing. Thus an accurate assessment of IOP is of paramount importance in glaucoma cases⁽¹²⁾.

A wide choice of instruments is now available to measure IOP. Goldmann applanation tonometry is widely accepted as the international gold standard for measurement of IOP and is the most commonly used method.

Numerous factors influence the IOP measurement, especially central corneal thickness (CCT) corneal curvature and the technique used for the measurement. More recently, the development of non- contact tonometers (NCTs) has simplified IOP screening. The non- contact tonometer measures the IOP by firing an air pulse at the cornea and calculating the IOP based on the speed at which collimated light focused at the corneal vertex is reflected back to a sensor on the instrument.

The main advantages of non-contact tonometers are that they are non – invasive and thus comfortable for the patient with a minimal risk of infection, and repeated measurements do not reduce IOP due to the ocular massage effect, as occurs with Goldmann tonometry⁽¹²⁾.

Attempts have been made to establish specific formulas to calculate the influence of CCT on IOP measurement, but there is no consensus about its use in practice⁽¹³⁾. The goal of our study is to compare goldmann applanation tonometer and non contact tonometer readings in normal and glaucomatous eyes.

The aim of this study is to compare the non contact tonometer (the NIDEK NT 510) with the Goldmann applanation tonometer (GAT) and to determine the intraocular pressure readings in healthy and glaucomatous population.

MATERIALS AND METHODS

Type of Study: This is a hospital based study conducted at tertiary care centre of banaskantha and patan district of Gujarat

Place of Study: At tertiary care centre of banaskantha and patan district of Gujarat

Study Period: 6 months

Sample Size: 200 consecutive normal patients attending the outpatient department and 100 consecutive and fulfilling the inclusion and exclusion criteria will be taken in to the study.

Study population: Patients attending the outpatient care and Glaucoma clinic Department of ophthalmology, Banas Medical College and research institute Palanpur and G.M.E.R.S. Medical college, Dharpur Patan (Gujarat)

Inclusion Criteria:

1. The subject with age 18 years and above
2. The subjects who were diagnosed as Glaucoma based an IOP, visual fields and disc evaluation
3. The subjects with normal fundus on +90D examination

Exclusion Criteria:

1. Any active eye diseases—Uveitis, corneal disease, infection, discharge.
2. Patients with corneal scarring, corneal edema, ptergium, or previous ocular surgery.
3. Patients with high corneal astigmatism, keratoconus.
4. Any previous corneal surgery, including corneal laser surgery
5. Recent use of contact lenses
6. Patients with microphthalmos, blepharospasm, or nystagmus.
7. Any condition that did not allow taking measurements

All the procedures will be explained to the subjects and an informed consent will be taken.

All the measurements will be taken from 9 AM to 10 AM to avoid the effect of diurnal fluctuations on IOP.

Methodology:

All the patients selected for the study will undergo through ophthalmic examination including visual acuity, slit lamp examination, fundus evaluation, tonometry and measurement of central corneal thickness.

Measurement by NCT: This will be done first in each patient followed by applanation tonometry. It is done before applanation tonometry to avoid ant possibility of IOP reduction by anterior chamber compression with applanation prism^(14,15). The subjects are made to sit on a chair and IOP will be measured by the NIDEK NT-510 non contact tonometer.

The Nidek NT-510 non contact tonometer automatically records three IOP readings. The average of three measurements will be taken for comparison. Examination will be conducted on neither eye (chosen randomly) of each patient.

Measurement by GAT: The applanation tonometry will be done by slit lamp mounted applanation tonometer on Haag – streit R-900 device (Haag- Strit, Koeniz, Switzerland). The subjects are seated comfortably on the slit lamp after explaining the procedure.

Equipment

1. Slit lamp mounted Goldmann's tonometer.
2. Applanation prism.
3. 70% alcohol or 1% sodium hypochlorite.
4. Anaesthetic eye drops.
5. Fluorescein strips.
6. Cotton swabs.

Methodology

1. After applying fluorescein and anaesthetic eye drops, cobalt blue
2. light is turned on.
3. For measuring right eye, the light is made to come from the
4. patient's right side; for the left eye, the beam is made to come from
5. the patient's left side.
6. Light is kept at maximum.
7. Patient is then asked to sit still with eyes open.
8. The blue light is then directed on the prism head.
9. The tonometer tip is then moved forward to rest on the cornea and
10. then slowly applanate it at its centre.
11. Then the dial is slowly turned until the two semi circles visualized
12. just touch each other at its inner margins.
13. The dial reading is noted.
14. The tip resting on the cornea is removed and then washed with
15. Disinfectant and dried for using it in the other eye.
16. Same above steps are repeated in the other eye.

Statistical Analysis:

1. Descriptive data will be presented as mean \pm SD and number and percentages.
2. Paired and unpaired t-test will be used to compare reading by both tonometers.
3. Linear regression analysis will be used to evaluate the association between tonometry measured by NCT and GAT and explore the relation between IOP and CCT.
4. The bland Altman plots will be used to evaluate agreement between IOP measurements obtained by GAT and NCT. A.P value of <0.05 will be considered as statistically significant.

Results

In this study, a total of 423 patients were categorized into to two groups; control 289 (Normal) and cases 134 (Glaucomatous patients) were subjected to method of tonometry –Goldmann's applanation and Non contact tonometer in both normal and Glaucoma patients.

Demographic Distribution

In our study, mean age in normal individual 46.65 years. The minimum and maximum range in age 11-78 years in normal group.

In the present study, mean age in glaucoma patients is 61.9. The minimum and maximum range is 31-88 years in glaucoma patients.

Table 1. Distribution of Age in normal and Glaucoma individual

Type of patients	Age (Min-Max)	Mean \pm SD
Normal	21-78	46.65 \pm 13.05
Glaucoma	31-88	61.91 \pm 10.28

Gender Distribution

From total of 289 normal patients 157 (54.32%) were males and 132 (45.67%) were females (45.67%). Hence in normal individuals majority were males.

Table 2. Male and Female ratio in normal Individuals

Variable	Number	Percentage
Male	157	54.32
Female	132	45.67
Total	289	100

Table 3. Male and Female ratio in Glucoma Individuals

Variable	Number	Percentage
Male	91	67.91
Female	43	32.08
Total	134	100

From total of 134 glaucoma patients 91 (67.91%) were males and 43 (32.08%) were females. Hence in glaucoma cases majority were males.

Table 4 . IOP measured by GAT and NCT in different groups of normal Eyes

Range IOP (mmHG)	GAT (mmhG)mean±SD	NCT (mmhG)mean±SD
G1 (<10)	7.33±1.15	8.85±0.98
G2 (10-20)	14.83±3.04	14.97±2.76
G3 (>21)	25.19±3.93	24.00±3.28

In the present study, the IOP readings measured by Both NCT and GAT in normal eyes in different groups according to their IOP readings. There was no significant variation in readings taken by NCT and GAT in normal eyes. Only slight difference which occur in readings were taken by NCT and GAT at > 21mmHg.

Table 5 . IOP measured by GAT and NCT in different groups of Glaucoma Eyes

Range IOP (mmHG)	GAT (mmhG)mean±SD	NCT (mmhG)mean±SD
G1 (<10)	7±1.41	4.5±0.00
G2 (10-20)	15.31±3.15	14.72±2.68
G3 (>21)	31.48±9.08	29.33±7.65

In glaucomatous eyes, there was a significant variation in readings were taken at > 21 by NCT and GAT. But there was no changes in IOP readings were taken at both <10 and 10-20 mm Hg. From these results revealed that, there was a statistically difference was observed when IOP readings was measure by NCT and GAT at more than >21 mm Hg.

Table 6. Comparison of mean IOP as measure by GAT and NCT as per gender

Gender	GAT (mm Hg)	NCT (mm Hg)
Male	15.88	16.18
female	15.83	16.12
Male	15.88	16.16
Female	15.91	16.28

Distribution of Eye site in both normal and cases

In total of 289 normal individuals 133 (46.02%) were right eyes and 156 (53.87%) were left eyes. Hence majority of the eyes were left eyes included in the study.

Table 7 . Distribution of Eye site in normal cases

Variable	Number	Percentage
Right	133	46.02
Left	156	53.97
Total	289	100

In total of 134 glaucoma patients 75 (55.97%) were right eyes and 59 (44.02%) were left eyes were considered in this study.

Table 8. Distribution of Eye site in glaucoma cases

Variable	Number	Percentage
Right	75	55.97
Left	59	44.02
Total	134	100

Tonometry readings in Normal and Glaucoma patients

In the present study, IOP reading measured by NCT and GAT mean value were; 19.05 and 20.14 in glaucoma patients. From these results the total patients were categorized into three groups according to their IOP readings taken by NCT and GAT. Mean paired difference IOP values between NCT and GAT in Glaucoma patients was 1.09 ± 3.86 .

Table 9. Mean IOP readings by NCT and GAT in glaucoma patients

Types of Tonometry	Mean	+S.D	SE M
NCT	19.05±1.49	8.44	0.72
GAT	20.14±1.79	9.48	0.81

NCT

Group1- Less than 10 mm Hg no of individual, 4 (2.98%)

Group2- 10-21 mm Hg no of individual, 91 (67.91%)

Group3: >21 mm Hg no of individual, 39 (29.10%).

Table 10. No of individuals and percentage of IOP measurement by NCT in glaucoma patients

Variables	No. of Individuals	%
LOW(<10) (Mean-SD)	4	2.98
MEDIUM(10-21)	91	67.91
HIGH(>21) (Mean-SD) (>21)	39	29.10
Total	134	100

GAT

Group1- Less than 10 mm Hg no of individual, 12 (8.95%)

Group2- 10-21 mm Hg no of individual, 82 (61.19%)

Group3: >21 mm Hg no of individual, 40 (29.85%).

Table 11. No of individuals and percentage of IOP measurement by GAT in glaucoma patients

Variables	No. of Individuals	%
LOW (<10) (Mean-SD)	12	8.95
MEDIUM (10-21)	82	61.19
HIGH (>21) (Mean-SD)	40	29.85
Total	134	100

From these results, most of the NCT and GCT readings were found to be in 10-21 mm Hg group.

Similar Studies carried out in normal individuals. The IOP mean \pm SD values of both NCT and GAT was 16.15 \pm 4.46 and 15.87 \pm 4.58. From these results the total patients were categorized into three groups according to their IOP readings taken by NCT and GCT.

Table 12. Showing Mean +SD of standard tonometer IOP readings in normal patients

Types of Tonometry	Mean	+S.D	SE M
NCT	16.15	4.46	0.26
GAT	15.87	4.58	0.26

NCT

Group 1- Less than 10 mm Hg no of individual, 10 (3.46%)

Group 2- 10-21 mm Hg no of individual, 239 (82.69%)

Group 3- >21 mm Hg no of individual, 40 (13.84%).

Table 13. Variables of NCT number and percentage of IOP readings measured by NCT in Normal patients

Variables	No. of Individuals	%
LOW (<10) (Mean-SD)	10	3.46
MEDIUM (10-21)	239	82.69
HIGH(>21) (Mean+SD)	40	13.84
Total	289	100

GAT

Group 1- Less than 10 mm Hg no of individual, 22 (7.61%)

Group 2- 10-21 mm Hg no of individual, 235 (81.31%)

Group 3: >21 mm Hg no of individual, 32 (11.07 %%)

From these results, IOP readings taken by NCT and GAT readings were found to be in 10-21 mm Hg in normal group. 32 eyes had shown more than 21 mmHG readings taken by GAT in normal individual.

Table 14. Variables of IOP readings taken by GAT number and percentage

Variables	No. of Individuals	%
low (<10) (Mean-SD)	22	7.61
Medium (10-21)	235	81.31
High (>21) (Mean+SD)	32	11.07
Total	289	100

Unpaired t-Test of NCT and GAT both in Glaucoma and Normal individual

In the present study, Comparison of mean±SD difference between NCT was 19.05 and GAT was 20.14 in glaucoma patients. There is no significant difference between NCT and GAT with regard to their mean IOP measurements in glaucoma patients.

Table 15. Unpaired t- Test of difference in IOP readings measured by NCT and GAT in Glaucoma Individual

Type of tonometry	Mean	Variance	T value
NCT	19.05	71.28	0.00
GAT	20.14	90.04	-

Similar studies were carried out in normal individual, mean±SD difference between NCT 16.15±4.46 and GAT was 15.87±4.58 in normal individual. When evaluated for different IOP ranges it was observed that GAT and NCT had less significant with regard to their mean IOP readings in normal individual.

Table 16. Unpaired t test of differences in IOP readings taken by NCT VS GAT in normal patients

Type of tonometry	Mean	Variance	T value
NCT	16.15	19.89	0.017
GAT	15.87	24.04	-

Correlation IOP values between NCT and GAT in normal and Glaucoma Individual

In the present study, NCT and GAT are highly positively correlated in the entire group of normal individuals $r=0.877$ ($p=0.001$).

In case of Glaucoma Individuals, both NCT and GAT are highly positively correlated $r=0.911$ ($p<0.001$) in the entire group of glaucoma individuals. From these results revealed that there was significant differences between their correlation studies in both normal and glaucoma patients.

DISCUSSION

Even though there are many parameters for glaucoma screening and diagnosis, IOP assessment is of paramount importance in diagnosing and follow up of glaucoma cases. Throughout the world many instruments and techniques are followed to measure IOP. Also newer technologies are discovered for IOP measurement with least possible error. But these instruments before they can be allowed to replace the existing or to be considered as equal with the current gold standard it has to be evaluated in different clinical settings and in different population groups. The same holds good for a gold standard instrument; that is it has to be constantly evaluated against the new technology, so that its errors and biases can be eliminated.

Such analysis and improvements in both technique and instrumentation can finally help in

quick, accurate and patient friendly diagnostic modalities for IOP assessment. Increase in intraocular pressure is one of the risk factors in the development and progression of glaucoma⁽¹⁶⁾. Control and reduction in IOP is the main goal in treatment of glaucoma⁽¹⁷⁾.

Even though there are many parameters for glaucoma screening and diagnosis, IOP assessment is of paramount importance in diagnosing and follow up of glaucoma cases.

Throughout the world many instruments and techniques are followed to measure IOP. Also newer technologies are discovered for IOP measurement with least possible error. But these instruments before they can be allowed to replace the existing or to be considered as equal with the current gold standard it has to be evaluated in different clinical settings and in different population groups.

There are various methods to measure IOP like Schiötz tonometer, Goldmann applanation tonometer (GAT), Perkins applanation tonometer, air puff non-contact tonometer, Tonopen, Pascal dynamic contour tonometer, I Care tonometer. GAT is worldwide used for measurement of IOP and is Gold standard.

In our study, even though schiötz is an age old technique it was used since it very portable, cheap & quick technique. It is used in many parts of the world even today including our outpatient department for the same above reasons.

Goldmann's applanation was used in this study to compare it against the other two as it was "The gold standard technique". Being a time consuming / cumbersome / not so patient comfortable technique for IOP assessment, it has stood the test of time in giving accurate and reliable IOP values in various groups of patients in different demographic profiles.

In our study a total of 423 patients were categorized into two groups normal (289) and Glaucoma patients (134) evaluated with two tonometers namely Non contact tonometers and Goldmann applanation tonometers in normal and glaucomatous patients.

The present study was conducted to compare the IOP readings taken by NCT and GAT in normal and glaucoma patients and also determine the IOP by both tonometers.

Demographic profile of the study showed that males 157 (54%) were more than the females 132 (45.67%) in the normal individual. In glaucoma patients males 91 (67.91%) were more than the females 43 (32.08%).

The minimum and maximum age of normal among those participated in this study was 21 & 78 years respectively. Where as in glaucomatous patients minimum and maximum age was 31 & 88. Hence both in normal and glaucoma patients majority were males.

The mean age of normal and glaucoma individual were 46.65 ± 13.05 and 61.91 ± 10.28 . From these results most of the patients in glaucoma cases were more than 60 years.

In our study there was linear correlation between **age** and IOP in both eyes. Higher IOP was found in both > 50 years age group depending on the instrument used. But all the comparative studies were statistically insignificant.

This was not the case in a study by **Qureshi IA (1995)**, which says that IOP increases with age by a factor of 0.28 mm hg every 10 years⁽¹⁸⁾.

With respect to **gender** based difference in IOP prevalence there was no sex predilection for higher IOP. Higher IOP was noted in males in both eyes in NCT compared to females in both the eyes. But in GAT males had higher IOP in both the eyes compared to females both in normal and glaucoma individual. These results were also statistically insignificant except for

the right eye care IOP values which alone were slightly significant. But considering the scale by which it was significant, it was not an important difference to consider.

In our study, in glaucoma patients mean IOP measured with NCT was 19.05 ± 1.49 mmHg and with GAT was 20.14 ± 1.79 . Paired mean differences between NCT and GAT was 1.09 ± 3.86 . Thus demonstrating that the mean IOP measurements with GAT are higher than that with NCT in glaucoma patients. In glaucoma patients where IOP less than 12 mmHg, only 9 (6.71%) individuals were present. Most of the individuals IOP reading between 12-27 mmHg was 103 (76.86). IOP readings were taken by both the tonometers showed higher readings in between the 12-27 mm Hg.

In our study, in normal patients the IOP mean \pm SD values of both NCT and GAT was 16.15 ± 4.46 and 15.87 ± 4.58 . From these results, IOP readings taken by NCT and GAT readings were found to be in 12-20 mm Hg in normal group.

From the above results, these studies revealed that there were no significant differences in IOP readings taken by both NCT and GAT in normal and glaucoma individual.

In the present study, intraocular pressure (IOP) recorded by NCT is slightly higher than the GAT. Many studies have compared IOP between GAT and NCT⁽¹⁹⁾. Friat et al⁽¹⁹⁾ study revealed that GAT results are slight lower than non-contact tonometer. Martinez-de-la-casa et al⁽²⁰⁾ concluded that results of AP tonometer were higher than GAT. Rao⁽²¹⁾ states that when IOP was < 20 mm Hg, it was more accurate with NCT. The mean IOP was less with NCT than GAT and it was found to be non statistically significant. The study done by Babalola et al. From South Africa showed no significant difference between the two instruments⁽²²⁾. This could be due to the racial differences as their subjects were Africans as in our study that was done on subjects with Indian origin. On contrary, the findings Oguchi et al. suggested that NCT consistently read higher readings⁽²³⁾. Another study also found that similar findings⁽²⁴⁾. A study done by Yucell et al. Showed that the pulsair NCT records IOP lesser than GAT⁽²⁵⁾.

In the present study, NCT and GAT are highly positively correlated in the entire group of normal individuals $r = 0.877$ ($p < 0.001$).

In case of Glaucoma Individuals, both NCT and GAT are highly positively correlated $r = 0.911$ ($p < 0.001$) in the entire group of glaucoma individuals. From these results revealed that there was a significant difference between their correlation studies in both normal and glaucoma patients.

In the present, NCT and GAT measurements showed good agreement proving that both are reliable methods of measuring IOP. In past studies also good agreement has been found with the correlation value ranging from 0.27 to 0.9 ($p = 0.03$ to $p < 0.001$).

In the present study, the pearson correlation was 0.95 which is quite significant ($p < 0.001$). A study was conducted by Bang et al,⁽²⁶⁾ comparing intraocular pressures, measured by three different non-contact tonometers and Goldmann applanation tonometer, for non-glaucomatous subjects. They stated that there was statistically significant correlation between three non-contact tonometers and Goldmann applanation tonometer. They said that IOP measured with Nidek NT-530P was lower than GAT while IOP taken by Topcan CT-IP and canon T x 20P was higher than Goldmann applanation tonometer.

Study conducted by Javed Ahmed et al⁽²⁷⁾ revealed that Goldmann applanation tonometer was more accurate but air puff tonometer was good and easy for screening purposes. Study conducted by Sana Naeem et al,⁽²⁸⁾ showed that measurement of intraocular pressure by three

different tonometers was comparable with good relation in normal adults. APT can be used as a good screening device to rule out glaucoma in patients.

Study conducted by Dibaji et al ⁽²⁹⁾ stated that non-contact air puff tonometer was quick for screening purposes but measurement should be confirmed by Goldmann applanation tonometer.

In the present study, Comparison of mean \pm SD difference between NCT was 19.05 and GAT was 20.14 in glaucoma patients. There is no significant difference between NCT and GAT with regard to their mean IOP measurements in glaucoma patients.

Similar studies were carried out in normal individual, mean \pm SD difference between NCT 16.15 \pm 4.46 and GAT was 15.87 \pm 4.58 in normal individual. When evaluated for different IOP ranges it was observed that GAT and NCT had less significant with regard to their mean IOP readings in normal individual.

CONCLUSION

Accurate IOP assessment is of pivotal importance in glaucoma diagnosis. GAT is the gold standard technique of IOP assessment in glaucoma patients, giving reliable and accurate readings. But it is time consuming, not portable and cumbersome to use. NCT tonometer is easy to use, comfortable to patients, quick, lightweight and portable. Yet it gives reliable and accurate IOP readings comparable with GAT. From these studies we conclude that both the instruments important for measurement of IOP readings for early diagnosis of Glaucoma. There was a significant difference between the two tonometers if the IOP readings more than 21 mmHg. There was no significant variation in readings of IOP were taken NCT and GAT at <10 and 10-20 mmHg.

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Conflict of Interest

None

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