Annals of Medical Research

DOI: 10.5455/annalsmedres.2019.08.466 2019;26(11):2625-9

Original Article

Effects of local anesthetic use on non-contact tonometry measurement results and patient comfort

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Abstract

Aim: To evaluate the effects of local anesthetic use on non-contact tonometry (NCT) measurement results and patient comfort and to compare the intraocular pressure (IOP) readings obtained with Shin Nippon NCT-10 tonometer and Goldmann applanation tonometry (GAT).

Material and Methods: 31 healthy participants were included in this study. Central corneal thicknesses (CCT) were measured. All IOP measurements were performed in the same order as NCT without anesthesia, NCT with local anesthesia and GAT with anesthesia, respectively. After the measurements, participants were asked to rate the pain felt during IOP measurements. The range was from 0 to 10; 0= very painful/reading impossible, 10=no sensation at all/reading very easily obtained. Less pain was evaluated as more comfort.

Results: NCT (p=0.007) and NCT-local (P=0.001) measurements overestimated IOP compared to GAT. IOP measured in NCT and NCT-local groups were similar (p=1.00). Mean patient comfort score was higher in GAT group than NCT group (p=0.006). Compared with NCT-local group, mean patient comfort score was lower in NCT group (P=0.033). Mean patient comfort scores were similar in GAT and in NCT-local groups (p=0.615). A positive but statistically insignificant correlation was found among NCT (r=0.201, p=0.277), NCT-local (r=0.259, p=0.160), GAT (r=0.272, p=0.139) measurements and CCT.

Conclusion: Compared to NCT, IOP measurement with GAT is more comfortable. Performing NCT measurements with local anesthesia increases the patient comfort without changing the IOP values. The measurements with Shin Nippon NCT-10 with or without local anesthesia overestimated IOP compared to the GAT and cannot be used interchangeably with the GAT.

Keywords: Goldmann applanation tonometry; intraocular pressure; local anesthesia; non-contact tonometry; tonometer.

INTRODUCTION

Precise measurement of the intraocular pressure (IOP) is crucial in the diagnosis and management of glaucoma. Several devices and measurement methods have been developed for this issue. Goldmann applanation tonometry (GAT) is considered to be the gold standard for IOP measurements (1). GAT is a contact IOP measurement method and needs topical anesthesia and fluorescein staining of tear film. Topical anesthetic drops may cause stinging and reflex blepharospasm in some patients resulting with inadequate IOP measurements. A significant training is needed to use this instrument accurately (2). Other disadvantages of the GAT include requiring attachment with a slit lamp, risk of contamination from contact of the tip. Also, there can be an error in IOP measurements because of central corneal thickness (CCT), corneal scars, corneal astigmatism, and excessive or insufficient fluorescein (3).

A variety of devices have been designed that would be least affected by the eye characteristics of individuals and can receive contactless IOP (4). Intraocular pressure measurements obtained with non-contact tonometry (NCT) have some advantages compared with GAT. Topical anesthesia and fluorescein staining are not necessary. Non-contact technique prevents possible corneal epithelium damages and risk of infection. IOP measurements by NCT devices are obtained automatically when the alignment is achieved by the operator (5). However, similar to GAT, NCT measurements are influenced by changes in corneal thickness, corneal astigmatism and corneal scars (3).

During the NCT measurement, the eye is deformed by a short air pulse. The pressure caused by the air puff

Received: 14.08.2019 **Accepted:** 25.09.2019 **Available online:** 06.12.2019
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flattens the cornea. A sensor detects the amount of flattening by the reflection of a light beam from the cornea (6). The sudden air puff may cause a discomfort and disturb the patient. Reflex head and eye movements and blepharospasm may be seen. As a result, false high readings or measurement failures may be encountered (3). The aims of this study were to evaluate the effects of local anesthetic use on NCT measurement and patient comfort and to compare the IOP readings obtained with the Shin Nippon NCT-10 tonometer and the GAT.

MATERIAL and METHODS

The study was conducted in accordance with the Declaration of Helsinki and was approved by the clinical trials ethics committee (approval number: 2018/01/07) and informed consent was obtained from all of the participants. Thirty-one eyes of 31 healthy subjects were included in the study. Participants did not have a history of drug use and systemic illness and ocular surgery. Patients with 3.0 D or more astigmatism or 4.0 D or more spherical refractive error were also excluded. Only right eyes of the participants were used for analysis.

CCTs were measured by Pentacam HR system before IOP measurements. Pentacam's automatic release mode was used to reduce operator-dependent variables. In this study, the CCTs at the apex of the cornea were used for analysis. All IOP measurements were performed in a sitting position by the same examiner (S.U) and always in the same order: first NCT without local anesthesia, second NCT with local anesthesia, third GAT with anesthesia. Non-contact tonometry measurements were made by Shin Nippon NCT-10 (Japan) air-puff tonometer. The device allows operator to measure automatically when alignment meets measurement requirements. Three minutes later, a drop of 0.5% proparacaine hydrochloride (Alcaine®, Alcon Co., USA) was applied for local anesthesia and NCT measurements were repeated. GAT measurements were performed three minutes after NCT measurements with local anesthesia and additional local anesthetic was not applied. After each measurement, participants were asked to rate the pain felt during the process. The directed question was "Would you please rate the pain felt during your intraocular pressure measurement procedure ?". The range was from 0 to 10; 0= very painful/reading impossible, 10=no sensation at all/reading very easily obtained (7). Less pain was evaluated as more comfort.

Statistical Analysis

Statistical analysis was performed with Statistical Package for the Social Sciences (SPSS ver.17) and P values of <0.05 were considered statistically significant. Normality was evaluated by using the Shapiro-Wilk test.

IOP measurements were normally distributed and were expressed as mean values ± SD. The repeated measures analysis of variance test was used to compare the results of IOP measurements. Adjustment for pairwise comparisons was made by Bonferroni correction. In order to achieve precise evaluation, agreement between the three IOP measurements was also assessed using Bland-Altman plot analysis with MedCalc statistical software program. In this analysis, bias was defined as a significant difference in the means of the 2 methods; 95% limits of agreement (LoA) were calculated as the mean difference ±1.96 SD.

Linear regression analyses were performed to explore the association of IOP measurements with CCT. Pearson correlation coefficients were calculated to determine the actual correlation between NCT, NCT-local, and GAT measurements.

Patient comfort scores were not normally distributed and were presented as median with range. Patient comfort scores were analyzed using the Friedman test followed by pairwise post hoc comparisons using the Wilcoxon signed rank test with Bonferroni correction. Since the current study was the first to evaluate the effects of local anesthetic use on NCT measurement results and patient comfort, a post hoc analysis was conducted to make a retrospective power analysis which determined that a cohort size of 31 participants had 85.4% power to detect a difference at the 0.05 significance level (effect size 0.61; G Power ver 3.1.9.2).

RESULTS

Of 31 participants 14 were male and 17 were female. Mean age of the participants was 30.52±9.57 (18-45) years. Mean visual acuity was 0.97±0.11 (0.5-1.0). Mean cup/disc ratio was 0.29±0.003 (0.2-0.4). Mean central corneal thickness was 553.16±13.25 (498-600) microns. Mean IOPs in NCT, NCT-local and GAT groups were 16.29±4.53(10-27), 16.29±4.03 (9-25), 13.74±2.31 (9-20) mmHg, respectively (Table 1).

Table 1. Demographic, clinical characteristics of the patients and the results of three tonometry procedures. (VA: visual acuity, C/D: cup/disc, CCT: central corneal thickness, NCT: Non-contact tonometry, NCT local: Non-contact tonometry with local anesthesia, GAT: Goldmann applanation tonometry, IOP: Intraocular pressure)

Age (years)	30.52±9.57 (18-45)
Gender	14 male/17 female
Mean VA	0.97±0.11 (0.5-1.0).
Mean C/D ratio	0.29 ±0.003 (0.2-0.4).
Mean CCT (mikrometer)	553.16±13.25 (498-600)
Mean NCT IOP (mmHg)	16.29±4.53(10-27)
Mean NCT local IOP (mmHg)	16.29±4.03 (9-25)
Mean GAT IOP (mmHg)	13.74±2.31 (9-20)

The mean IOP measurements were statistically significantly different among the 3 measurement groups (p<0.001). IOP measured in NCT and NCT-local groups were similar (p=1.00). Mean difference of IOP between NCT and NCT-local groups was 0.00 mm Hg (95% confidence range of approximately -1.6 to +1.6). The Bland-Altman plots showed that the mean differences between the NCT and NCT-local measurements were not significantly

different from zero, which implies good agreement for IOP (95% LoA -6.9 to +6.9) (Figure 1a). NCT (p=0.007) and NCT-local (P=0.001) measurements overestimated IOP compared to GAT. The mean difference between NCT and GAT (95% confidence range of approximately +0.6 to 4.5 mmHg) and NCT-local and GAT (95% confidence range of approximately +1.0 to +4.8 mmHg) measurements was +2.5 mmHg.

Figure 1a:

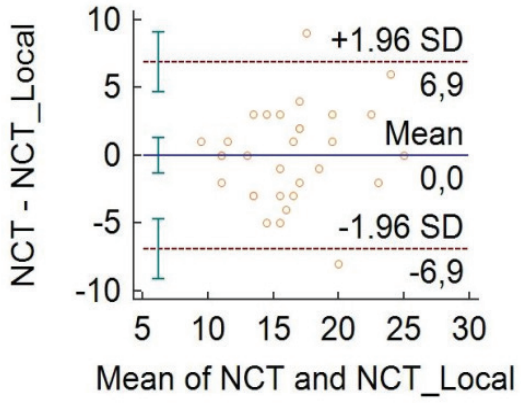

Figure 1b:

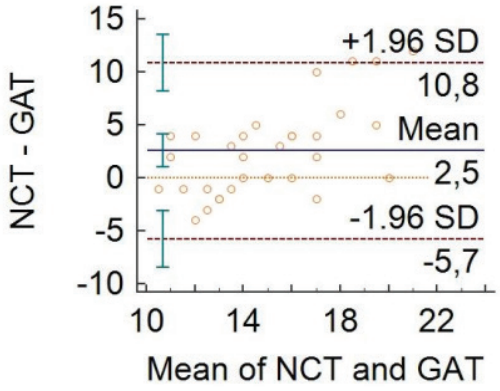

Figure 1c:

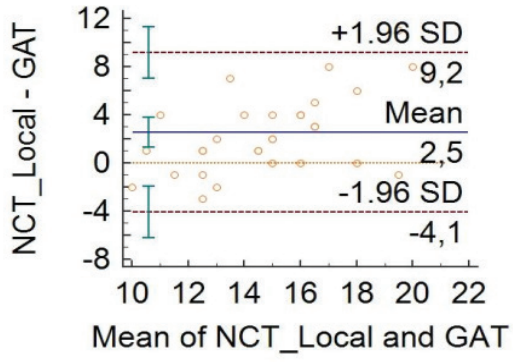

Figure 1: Bland-Altman plots shows the agreement among NCT-NCT local **(Figure 1a)**, NCT-GAT **(Figure 1b)** and NCT local-GAT **(Figure 1c)**. The middle line indicates the mean difference, and the two dashed side lines show the 95% limits of agreement. NCT: Non contact tonometry NCT local: Non contact tonometry with local anesthesia GAT: Goldmann applanation tonometry.

Bland-Altman plots demonstrated that the 95% LoA were broad and different from zero for NCT (95%LoA -5.7 to +10.8) (Figure 1b) and NCT-local (95%LoA, -4.1 to +9.8) (Figure 1c) comparing with GAT, which implies moderate agreement for these tonometers. There were fixed biases between the readings obtained with three different methods since the mean difference lines were straight (Figures 1a,1b,1c).

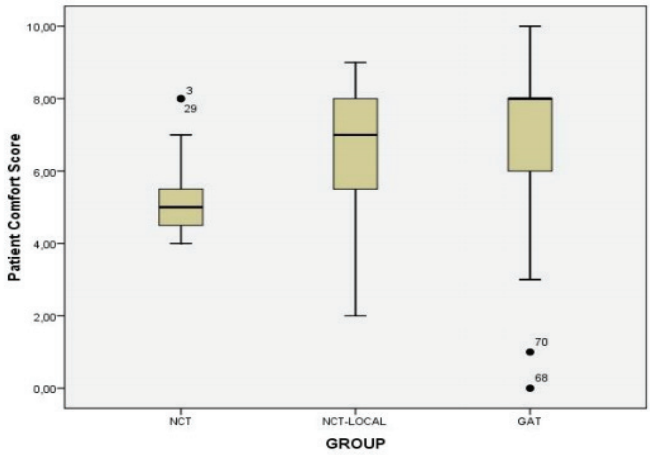

Figure 2: Box-plot showing the distribution of mean patient comfort scores in the NCT, NCT-local and GAT groups. The black lines in the diagram illustrate the medi¬an values of the group. NCT: Non contact tonometry NCT local: Non contact tonometry with local anesthesia GAT: Goldmann applanation tonometry.

A positive but statistically insignificant correlation was found among NCT (r=0.201, p=0.277), NCT-local (r=0.259, p=0.160), GAT (r=0.272, p=0.139) measurements and CCT. There was a significant correlation between NCT and NCT-local (r=0.668, P<0.001), NCT and GAT (r=0.377, P<0.036), and NCT-local and GAT (r=0.546, P=0.001) measurement methods.

Patient comfort was statistically significantly different among groups (p<0.001). Mean patient comfort score in NCT group was 5.25±1.18 [median 25=4, median 50=5, median 75=6 (ranging from 4 to 8)] and in NCT-local group was 6.45±1.67 [median 25=5, median 50=7, median 75=8 (ranging from 5 to 9)] and in GAT group was 7.09±2.27 [median 25=6 median 50=8, median 75=8 (ranging from 0 to10)] (Figure 2). Mean patient comfort score was higher in GAT group than NCT group (p=0.006). Compared with NCT-local, mean patient comfort score was lower in NCT group (P=0.033). Mean patient comfort scores were similar in GAT and NCT-local groups (p=0.615).

DISCUSSION

Patient comfort during IOP measurement may influence the instrument choice at following visits. Ugalahi et al (8) compared patients' comfort and preference with the use of the Icare tonometer and GAT. Majority of the participants in that study indicated that the Icare tonometry was more comfortable compared to GAT. Although the Icare tonometer was found to be more comfortable in this study,

the majority of the patients still preferred GAT for IOP measurement at the following clinic visit. Reasons given for this preference include the idea that GAT was considered to be more reassuring, feeling the contact of the Icare probe and familiarity with the GAT. Instillation of eye drops before GAT measurements were defined as uncomfortable and it was reported by some participants as the reason for preferring Icare tonometry for IOP measurement at the following visit. Similar findings were reported by Pakrou et al (2) and van der Jagt et al (7) compared patient comfort of three portable tonometers, the TGDc-01, the Icare Rebound tonometry and the Tonopen XL. They found that patient comfort was slightly higher for the Icare when compared with the Tonopen. To the best of our knowledge, there has not been any other study comparing the patient comfort between NCT and NCT with local anesthesia and GAT methods in the literature. Contrary to our expectations, the most comfortable measuring method for the patients was GAT. NCT without anesthesia was the least comfortable measuring method for the patients. Adding local anesthesia to NCT measurements increased the patient comfort.

In our study IOP values measured with NCT and NCT with local anesthesia were similar. Adding local anesthetic to NCT did not significantly change the measurement results. We found only one study about the effects of local anesthesia on NCT measurements. Almubrab et al (9) designed a study to investigate the effect of ocular anesthesia on the IOP measurement results. They measured IOP before and two and five minutes after instillation of one drop of oxybuprocaine hydrochloride 0.4% and proparacaine hydrochloride 0.5% with Topcon CT80 non-contact tonometer in healthy subjects. They found significantly lower values of IOP 2 minutes and 5 minutes after the instillation of oxybuprocaine hydrochloride and proparacaine hydrochloride. The average decrease in IOP was approximately 0.8 and 0.9 mmHg with oxybuprocaine and proparacaine, respectively. The authors emphasized that IOP reductions cannot be explained by CCT alterations which were caused by local anesthetic instillation. The effect of topical anesthetics on CCT is unclear. Some studies reported a transient increase in CCT, some reported no change (10,11). We did not compare pre and post instillation CCTs, therefore we cannot make any comment about this issue.

Numerous studies have compared IOPs obtained with NCTs and GAT. Generally, NCT IOP measurement results were 2 to 4 mm Hg higher than those gold standard GAT results in the literature (12-15). Shin Nippon NCT-10 overestimated IOP compared to GAT in our study. Mean difference between Shin Nippon NCT-10 and GAT was +2.5 mm Hg. Similarly, Raina et al have determined 1.96 mmHg overestimated IOP readings with Shin Nippon NCT-10 compared to GAT in children (16).

The effects of CCT on IOP measurements were widely studied. Generally, it was determined that NCTs tend to be more affected by CCT than GAT (3,17). In our study the IOP measurements showed a weak positive correlation with CCT for NCT (r=0.201, p=0.277), NCT-local (r=0.259, p=0.160), and GAT (r=0.272, p=0.139). Since our study population is relatively small, correlations among CCT and NCT, NCT-local and GAT might have not reached statistical significance.

Our study have some limitations. The number of participants is relatively low. However the post hoc power analysis we conducted determined that a cohort size of 31 participants had 85.4% power to detect a difference regarding patient comfort at the 0.05 significance level, which is relatively high. Other limitation of our study was that the participants were healthy adults. Therefore the measurement data may not completely be generalized for glaucomatous and pediatric patients.

CONCLUSION

In conclusion, compared to NCT, IOP measurement with GAT is more comfortable. Performing NCT measurements with local anesthesia increases the patient comfort without changing the IOP values. The measurements with Shin Nippon NCT-10 with or without local anesthesia overestimated IOP compared to the GAT. Therefore Shin Nippon NCT-10 cannot be used interchangeably with the GAT.

Competing interests: The authors declare that they have no conflict of interest.
Financial Disclosure: There are no financial supports.
Ethical approval: The study was conducted in accordance with the Declaration of Helsinki and was approved by the clinical trials ethics committee (approval number: 2018/01/07) and informed consent was obtained from all of the participants.

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REFERENCES

1. Lanza M, Borrelli M, De Bernardo M, et al. Corneal parameters and difference between Goldmann applanation tonometry and dynamic contour tonometry in normal eyes. J Glaucoma 2008;17:460-4.
2. Pakrou N, Gray T, Mills R, et al. Clinical comparison of the Icare tonometer and Goldmann applanation tonometry. J Glaucoma 2008;17:43-7.
3. Mansoori T, Balakrishna N. Effect of central corneal thickness on intraocular pressure and comparison of Topcon CT-80 non-contact tonometry with Goldmann applanation tonometry. Clin Exp Optom 2018;101:206-12.
4. Schiano Lomoriello D, Lombardo M, Tranchina L, et al. Repeatability of intra-ocular pressure and central corneal thickness measurements provided by a non-contact method of tonometry and pachymetry. Graefes Arch Clin Exp Ophthalmol 2011;249:429-34.

5. Yaoeda K, Shirakashi M, Fukushima A, et al. Measurement of intraocular pressure using the NT-4000:a new non-contact tonometer equipped with pulsesynchronous measurement function. J Glaucoma 2005;14:201-5.
6. Tonnu PA, Ho T, Newson T, et al. The influence of central corneal thickness and age on intraocular pressure measured by pneumotonometry, noncontact tonometry, the Tono-Pen XL, and Goldmann applanation tonometry. Br J Ophthalmol 2005;89:851-4.
7. van der Jagt LH, Jansonius NM. Three portable tonometers, the TGDc-01, the ICARE and the Tonopen XL, compared with each other and with Goldmann applanation tonometry. Ophthalmic Physiol Opt 2005;25:429-35.
8. Ugalahi MO, Seidu MA, Olusanya BA, et al. Does patient comfort influence the choice of tonometer for the measurement of intraocular pressure? Int Ophthalmol 2016;36:385-9.
9. Almubrad TM, Ogbuehi KC. Clinical investigation of the effect of topical anesthesia on intraocular pressure. Clin Ophthalmol 2007;1:305-9.
10. Nam SM, Lee HK, Kim EK, et al. Comparison of corneal thickness after the ınstillation of topical anesthetics: proparacaine versus oxybuprocaine. Cornea 2006;25:51-4.
11. Lam AK, Chen D. Effect of proparacaine on central corneal thickness values: An evaluation using noncontact specular microscopy and pentacam. Cornea 2007;26:55-8.
12. Kato Y, Nakakura S, Matsuo N, et al. Agreement among Goldmann applanation tonometer, ICare, and Icare PRO rebound tonometers; non-contact tonometer; and Tonopen XL in healthy elderly subjects. Int Ophthalmol 2018;38:687-96.
13. Bang SP, Lee CE, Kim YC. Comparison of intraocular pressure as measured by three different non-contact tonometers and Goldmann applanation tonometer for non-glaucomatous subjects. BMC Ophthalmol 2017;17:199.
14. Akal A, Adıbelli MF, Yılmaz ÖF, et al. Comparison of the ICARE tonometer with non-contact pneumotonometry and Goldmann applanation tonometer in healthy individuals with different corneal thickness: a prospecitve study. MN-Oftalmoloji Dergisi 2015;22:85-9.
15. Şakalar YB, Keklikçi U, Balsak S, et al. Comparison of different methods for measurement of intraocular pressure and evaluation of effect of central corneal thickness on measurement results. Türk Oftalmoloji Dergisi 2010;40:156-9.
16. Raina UK, Rathie N, Gupta A, et al. Comparison of Goldmann applanation tonometer, Tono-Pen and noncontact tonometer in children. Oman J Ophthalmol 2016;9:22-6.
17. Demirci G, Tanrıverdio C, Erdur SK et al. Comparison of Schiotz, non-contact and Goldmann applanation tonometer measurements in central corneal thickness below and above 550 µm. Glokom-Katarakt 2017;12:42-6.