Int Ophthalmol (2019) 39:697–701
https://doi.org/10.1007/s10792-018-0854-x

CASE REPORT

Corneal perforation after noncontact tonometry in patients with active recurrent herpes simplex keratitis: case report

Napaporn Tananuvat · Atitaya Apivatthakakul · Chulaluck Tangmonkongvoragul

Received: 1 November 2017 / Accepted: 1 February 2018 / Published online: 7 February 2018

Abstract
Purpose To report iatrogenic complications and to review the potential complications caused by noncontact tonometry (NCT) in related literature.
Methods This case report describes two cases of active recurrent herpes simplex keratitis (HSK) on top of a thin corneal scar. The cornea was perforated by the air pulse from the NCT, resulting in an air bubble in the anterior chamber.
Results Both patients were diagnosed with active recurrent necrotizing stromal HSK on top of a thinned corneal scar after previous therapeutic treatment involving tissue adhesive glue with a bandage contact lens (BCL) to treat a perforated cornea. During a follow-up visit, both patients reported similar symptoms of acute pain and fluid exuding from their eyes immediately after undergoing NCT. Slit-lamp examination revealed a perforated cornea with an intracameral air bubble. Treatment involved use of tissue adhesive glue and BCL in both cases.
Conclusion NCT may not be sufficiently safe in patients with active infectious keratitis, particularly in cases where the cornea is relatively thin and necrotic.

N. Tananuvat (✉) · A. Apivatthakakul · C. Tangmonkongvoragul
Department of Ophthalmology, Chiang Mai University, Chiang Mai 50200, Thailand
e-mail: ntananuvat@gmail.com

Keywords Noncontact tonometry · Corneal perforation · Herpes simplex keratitis

Introduction

Goldman applanation tonometry (GAT), the most widely used method, has been recognized as the gold standard for measuring intraocular pressure (IOP). However, this technique involves contact in order to flatten the center of the cornea, which may lead to possible transmission of infectious agents or chemical substances. Another method, the noncontact tonometer (NCT), first introduced by Grolman [1], uses air to flatten the cornea instead of actual physical contact. As a result, some drawbacks of conventional tonometry such as contamination from the tip of the contact tonometer and use of topical anesthesia can be avoided [1–3]. In addition, the technique of NCT is faster and simpler than that of the GAT, making it more reliable and friendly to trained medical personnel. Previous studies revealed no significant differences in the results of IOP measurement between NCT and GAT in normotensive patients; therefore, NCT has become a popular instrument, particularly for glaucoma screening [2, 3].

Herpes simplex keratitis (HSK) is one of the most challenging entities confronting the clinician. A variety of clinical manifestations including infection and immunologic response can affect all levels of the

cornea. Necrotizing stromal keratitis is a rare manifestation of HSK that is thought to result from direct viral invasion of the corneal stroma [4]. The clinical findings are ulceration, dense infiltration, and necrosis of the corneal stroma with an overlying epithelial defect. The severe inflammation may lead to thinning and perforation within a short period of time.

This report describes two cases in which the cornea was perforated after using NCT in patients with active recurrent necrotizing stromal HSK. A review of the literature concerning complications related to the use of NCT is also discussed. This study was approved by the Research and Ethics Committee, Faculty of Medicine, Chiang Mai University (study code: OPT-2559-04048), and written consent was obtained from both patients.

Case reports

Case 1

A 58-year-old man had been diagnosed with multiple recurrent HSK in his left eye, recurrent for 10 years, since 2007. Previously, he had undergone treatment for impending cornea perforation three times. The treatment was carried out using cyanoacrylate tissue adhesive with a bandage contact lens (BCL). Subsequently, his cornea developed a thin paracentral corneal scar with no associated problems for three years prior to this recent attack. One week before the visit, he had symptoms of itching, redness, photophobia, and reduced vision due to ulcerating necrotizing stromal herpetic keratitis (Fig. 1a) and was treated with oral acyclovir (400 mg five times daily) and a prophylactic topical antibiotic. At one-week follow-up after this recent attack, his best corrected visual acuity (BCVA) on the left eye was 20/800. The IOP was measured using NCT (Nidek NT350P, Gamagori, Japan) as a routine eye examination before he was seen by an ophthalmologist. Immediately after undergoing NCT, the patient complained of pain and felt fluid flowing out from his left eye. Slit-lamp examination revealed corneal perforation at the paracentral part of the cornea with iris incarceration (Fig. 1b). The perforation size was about 1.5 mm in diameter. The anterior chamber (AC) was shallow and filled with an air bubble. The Seidel test was positive. The condition was treated with tissue adhesive glue and a BCL on the same day. The outcome, 1 year later, was the presence of a corneal scar with the BCVA of 20/1200 (Fig. 1c). The patient, then, underwent an uneventful triple operation (Fig. 1d) and was given long-term oral acyclovir 400 mg twice a day without topical antiviral drug. Eighteen months after surgery, his BCVA was 20/30 with no evidence of recurrent attack.

Case 2

A 67-year-old woman was referred for ulcerating necrotizing stromal herpetic keratitis in her right eye which had been diagnosed a week before. Her ocular history included a previous referral, 5 years before, for a perforated cornea in her right eye due to active HSK. After undergoing a treatment using tissue adhesive glue and a BCL at that time, she was transferred to an ophthalmologist in her hometown. She informed that on the follow-up day at the eye clinic for her recent attack of HSK, she felt a sharp pain and had fluid flowing immediately after the use of an NCT to measure the IOP in her right eye. The eye examination on this visit showed her right eye VA of hand motion. Slit-lamp biomicroscopy revealed corneal perforation at a paracentral area of the cornea, at the site of the ulceration and stromal necrosis. The wound was about 1 mm in diameter. The AC was slightly shallow and contained an air bubble (Fig. 2a). A treatment was carried out on that day using tissue adhesive glue with a BCL. One month later, the cornea lesion was inactive with residual glue on top of the lesion (Fig. 2b). Her final VA was 20/1200.

Discussions

NCT (or air-puff tonometer) is used to measure IOP via the principles of the Imbert-Fick law [5] based on ejection of a rapid air pulse to the corneal surface. The force produced by the air jet flattens the cornea [2]. When the cornea deforms, a light beam is emitted into a sensor that generates the measurement value. A normal cornea reflects very few rays into the sensor, but the flatted cornea increases the number of detected rays. An electronic clock measures the time from the ejection of the air jet to the reception of the maximum number of rays. The various time intervals are converted to IOP in mmHg [2, 6].

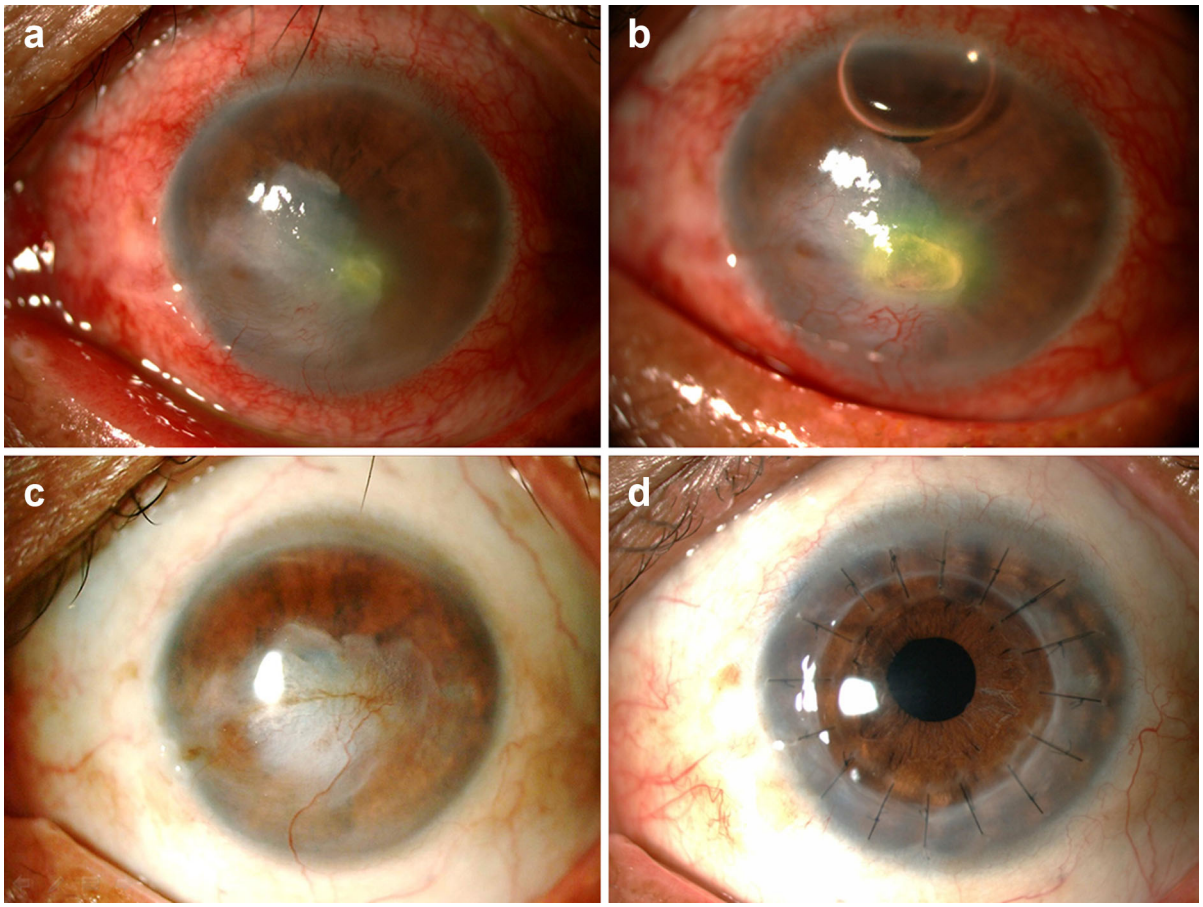

Fig. 1 Color photograph of case 1: 58-year-old man with multiple recurrent HSK; **a** the right cornea with active recurrent HSK at 1 week pre-noncontact tonometry; **b** the cornea with a paracentral perforation with an air bubble in the anterior chamber; **c** the lesion resulted in a corneal scar 1 year later; **d** the cornea at 6 months after triple operation

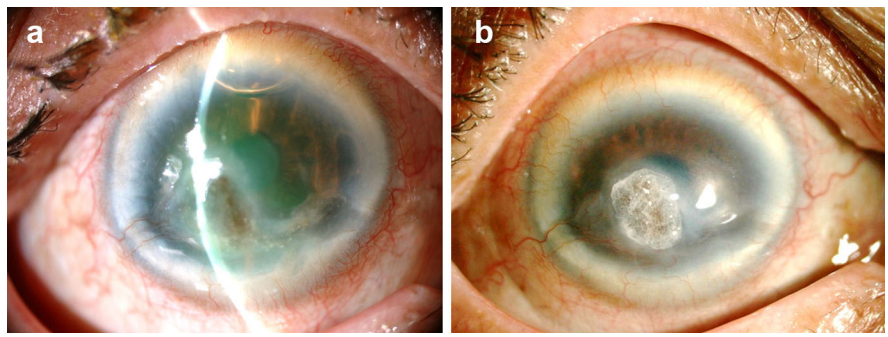

Fig. 2 Color photograph of case 2: 67-year-old woman with recurrent HSK in her right eye **a** necrosis and thinned corneal ulcer involving the paracentral region with an air bubble in the anterior chamber; **b** the cornea 1 month after treatment with tissue adhesive glue

In the human cornea, the stromal layer comprises about 90% of the total corneal thickness and this structure maintains the integrity of the cornea [7, 8]. If an infection extends deep into the stroma and causes stromal thinning, wound healing appears to have long-lasting dynamic remodeling effects on the balance between constructive and destructive processes. As cornea is an avascular tissue, the healing time may take longer than other connective tissues [8]. Besides, in full thickness corneal wounds, the rupture of Descemet's membrane will also decrease structural strength. Even after suturing, the cornea may not

Table 1 Summary of the findings from a literature review of the complications associated with noncontact tonometer

Authors (year)	No. of cases	NCT model	Case (Age/Sex)	Risk factors	Complications	Treatment and results	Final VA
Katz et al. [12]	1	N/A	62 M	18-month post-PK	Wound dehiscence with an AC air bubble	Topical prednisolone acetate and gentamycin/graft rejection	N/A
Linder et al. [14]	2	N/A	74 M	Routine eye examination	Posterior vitreous detachment	Observe	20/20
			67F	Routine eye examination	Posterior vitreous detachment	Observe	20/25
Axer-Siegel et al. [15]	1	N/A	64 M	Routine eye examination	Vitreous hemorrhage and retinal detachment	Scleral buckling procedure with cryotherapy/retina reattached	N/A
Porges and Ophir [10]	1	CT-20 (Topcon, Japan)	26 M	Traumatic corneal laceration	Corneal perforation	Topical antibiotic /spontaneous wound closure	20/20
Kim and Kim [11]	3	Auto Tonometer (Canon, Japan)	64 M	1-month post-PK	Wound dehiscence	BCL/self-sealed wound	N/A
			64 F	7-day post-PK	Wound dehiscence	Resutured with AC washout/wound closed	20/40
			68 F	ECCE with SF- IOL and anterior vitrectomy	Wound dehiscence, gross hyphema, uveal and vitreous prolapse, massive expulsive choroidal hemorrhage	Wound repair, iris reposition, AC reformation, and anterior vitrectomy/suprachoroidal hemorrhage with total hyphema	PL
Vamosi [13]	1	CT-80 (Topcon, Japan)	42 M	2-day post-PK	Wound dehiscence with an AC air bubble	Observe/spontaneous wound closure	20/20
This study	2	NT350P, (Nidek, Japan)	58 M	Recurrent necrotizing stromal HSK	Corneal perforation with an AC air bubble	Tissue adhesive glue with BCL followed by triple operation/clear and quiet graft	20/30
			67 F	Recurrent necrotizing stromal HSK	Corneal perforation with an AC air bubble	Tissue adhesive glue with BCL/corneal scar	20/1200

NCT noncontact tonometer, *AC* anterior chamber, *PK* penetrating keratoplasty, *ECCE* extracapsular cataract extraction, *SF-IOL* transcleral fixation intraocular lens, *BCL* bandage contact lens, *PL* light perception

regain more than 50–70% of its original tensile strength [9]. Wound integrity can also be reduced by ancillary factors such as diabetes mellitus, poor suturing technique, incarceration of uvea or vitreous tissue, and entrapment of the epithelium [8]. In addition, corneal integrity can also be affected by other physical properties such as elasticity and deformability. Both patients in this case report exhibited active recurrent necrotizing stromal HSK on top of a thin and scarred cornea. An air jet from the NCT, which was centrally aimed, distorted the edge of an ulcer, resulting in disruption of the necrotic area and puffing of air bubble into the AC.

In general, an air column from the NCT flattens a circular area of the central cornea 3.0 mm in diameter with an uncertain area of measurement of 0.2 mm. Therefore, a safe distance from the central cornea to the wound edge should be more than 1.7 mm (3.0/

2 + 0.2) [2, 10]. The pneumatic applanation force applied by the NCT is 3 g in 30 mmHg, which is safe for healthy cornea of normal thickness [10]. However, this force may damage a cornea which is very thin and inflamed. In this study, the perforation sizes of the cornea were between 1 and 1.5 mm in diameter, and the distance between the central cornea and perforated edge was less than 1.7 mm, which was not conformed to the safety margins necessary to perform NCT. This postulates that an active inflammation due to necrotizing stromal herpetic keratitis on top of an area of thin cornea can attribute to corneal perforation from using NCT.

However, there have been no studies reporting the safety margin of the residual corneal thickness in each area, making it appropriate to use NCT to measure IOP without complications. The other factors including wound size and the distance from the edge of the wound to the center of the cornea in resistance of central pressure load need to be studied further.

In literature, there have been previous reports concerning complications following NCT (Table 1). Most complications were due to the air puff interfering with wound integrity, resulting in corneal perforation especially in an unhealthy, pathologic thin cornea and in the early postoperative period after corneal or intraocular surgery [10–13]. In addition, NCT could lead to posterior segment complications such as posterior vitreous detachment [14] or even retinal detachment [15]. Besides, significant microaerosol formation after air-puff tonometry was noted by Britt et al. [16]. They suggested that microaerosol droplets, especially from an inferior tear lake, might be contaminated with pathological organisms, and this could be transmitted to other people. Thus, NCT should not be considered as an entire aseptic procedure.

In conclusion, NCT is relatively safe, reliable, and easy to perform in cases involving a normal healthy cornea. However, in cases where there is an active infectious keratitis with a thinned and necrotic cornea, caution should be required and other suitable instruments may be selected instead. There are several factors that should be considered before performing NCT in patients with infectious keratitis, including corneal thickness and size and distance of the lesion from the central cornea. Corneal integrity as regards previous history of perforations and surgical or traumatic corneal wounds must also be included in the assessment. In high-risk cases, the results from a slit-lamp biomicroscopic examination should be evaluated before using NCT as a routine IOP-measuring tool.

Acknowledgement This study was presented in part as a poster presentation at the 5th Asia Cornea Society Meeting, Seoul, Korea (December 9–11, 2016).

References

1. Grolman B (1972) A new tonometer system. Am J Optom Arch Am AcadOptom 49:646–660
2. Forbes M, Pico G Jr, Grolman B (1974) A noncontact applanation tonometer. Description and clinical evaluation. Arch Ophthalmol 91:134–140
3. Kniestedt C, Punjabi O, Lin S, Stamper RL (2008) Tonometry through the ages. Surv Ophthalmol 53:568–591
4. Holland EJ, Schwartz GS (1999) Classification of herpes simplex virus keratitis. Cornea 18:144–154
5. Goldman H, Schmidt TH (1957) Uber applanations-tonometrie. Ophthalmologica 134:221–242
6. Lomoriello DS, Lombardo M, Tranchina L, Oddone F, Serrao S, Ducoli P (2011) Repeatability of intraocular pressure and central corneal thickness measurements provided by a non-contact method of tonometry and pachymetry. Graefes Arch Clin Exp Ophthalmol 249:429–434
7. Kaye GI (1969) Stereologic measurement of cell volume fraction of rabbit corneal stroma. Arch Ophthalmol 82:792–794
8. Soong K, Farjo Q, Sugar A (1999) Late dehiscence of healed corneal scars. Br J Ophthalmol 83:987(**letters to the editor**)
9. Gasset AR, Dohlman CH (1968) The tensile strength of corneal wounds. Arch Ophthalmol 79:595–602
10. Porges Y, Ophir A (2000) Noncontact tonometry in perforating corneal injuries. Cornea 19:407–409
11. Kim EC, Kim MS (2008) Three cases of corneal perforation caused by noncontact tonometry. Cornea 27:1191–1194
12. Katz NN, Byers NT, Bergquist RJ (1983) Inadvertent intracameral air instillation during noncontact tonometry. Am J Ophthalmol 95:708–709
13. Vamosi P (2014) Intracameral air following pneumatic noncontact tonometry in a recently post-perforating keratoplasty patient. Clin Ophthalmol 8:763–765
14. Linder BJ (1993) Posterior vitreous detachment: a possible complication of noncontact tonometry. Ann Ophthalmol 25:54–55
15. Axer-Siegel R, Weinberger D, Weiss Y, Yassur Y (1996) Retinal detachment after noncontact pneumatic tonometry. Retina 16:80–81
16. Britt JM, Clifton BC, Barnebey HS, Mills RP (1991) Microaerosol formation in noncontact 'air-puff' tonometry. Arch Ophthalmol 109:225–228