Author’s response to reviews

Title: Comparison of intraocular pressure measured by ocular response analyzer and Goldmann applanation tonometer after corneal refractive surgery: a systematic review and meta-analysis

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Author’s response to reviews:

Responds to the Reviewer #1:

Comment 1: I suggest the authors to incorporate text to briefly introduce the theories of various IOP measurement methods. This should include how IOPGAT, IOPcc and IOPg were measured and why they were affected by CCT.
Response: Thank you for your instructive suggestions. We have described the measurement principles for Goldmann applanation tonometer (GAT) and Ocular Response Analyzer (ORA), and then explained how they are affected by CCT in the introduction of revised manuscript.

Comment 2: Biomechanical properties of the cornea have a large impact on the IOP measurement, I suggest the authors to elaborate more this point in the Discussion section.
Response: We agree with your opinion and accept your suggestion. Considering that the main purpose of this study is to discuss the influence of CCT changes on IOP measurement after corneal refractive surgery, we added the following content in the discussion section.

“Although this study was focused on the influence of corneal thickness on IOP after corneal refractive surgery, the measurement value of IOP was actually also affected by mechanical properties[1,2]. Corneal Visualisation Scheimpflug Technology (Corvis ST; Oculus Optikgerte GmbH, Wetzlar, Germany) is a new noncontact tonometer characterized with high-speed Scheimpflug technology, which facilitated the measurement of IOP. And the biomechanical corrected IOP (bIOP) [3] is purported to be less dependent on biomechanical properties. At present, there are some researches to further explore and verify the IOP measurement of bIOP in healthy people[4], glaucoma[5] and even keratoconus patients[4]. And it has been proposed[6] that bIOP is able to reduce the known correlation between CCT and IOP readings before and after refractive surgery, such as LASIK and small-incision lenticule extraction (SMILE). However, as Corvis is a newly developed device in recent years, there are few studies on the measurement and comparison of IOP after refractive surgery, so it has not been included in the meta-analysis as ORA and GAT for overall comparison. However, it is believed that
with the increase in the number of related literatures, it is also of great significance to conduct meta-analysis of Corvis and other tonometers after refractive surgery.”

Comment 3: Page 11, Line 21. CCT is an incontrovertible influencing factor for IOPg as it could vary the resistance of the cornea to the air jet indentation. As mentioned above, a more detailed introduction of the theories of various IOP measurement methods could improve the impact of this manuscript.
Response: Thank you for your valuable suggestion after carefully reviewing the manuscript. A more detailed description of various IOP measurement methods is indeed conducive to a more thorough understanding of the article. Therefore, we have added the description of this part in the introduction of the revised manuscript.

Comment 4: Please define abbreviations GAT and ORA when first used in the abstract.
Response: Thank you very much for pointing out the missing abbreviations in the abstract for the first mention of GAT and ORA, and we have added them in the abstract of the revised manuscript.

References


Responds to the Reviewer #2:

Comment 1: The use of language should be improved. There are significant grammatical errors.
Response: Thank you for your careful review. We are very sorry for the grammatical errors in this manuscript. We have corrected the grammatical errors one by one in the revised manuscript with all my might.

Introduction

Comment 2: The principles of Ocular Response Analyzer should be explained more clearly. The terms IOPg, IOPcc and corneal hysteresis need further explanation.
Response: Thank you for your instructive suggestions. We have described the measurement process of Ocular Response Analyzer (ORA), and briefly explained the output parameter of ORA (IOPg, IOPcc CH and CRF) in the introduction section of the revised manuscript. The content is as follows:

“ORA (Reichert, Depew, NY, USA) is a kind of noncontact tonometer. During the measurement process, the amplitude of the air pulse pressure at the corneal apex change over time, and the corneal movement is in response to increased and decreased pressure amplitude. Two air pulse pressure values (P1 and P2) are recorded at the inward and outward applanation events. Due to the indentation of the cornea by an air-puff causing a dynamic time-dependent response, ORA can provide extra information about IOP and corneal biomechanics. In the output parameters of ORA, Goldmann-correlated IOP (IOPg) is the mean of these applanation pressures (IOP g=(P1+P2)/2). Corneal hysteresis (CH) is the difference in applanation pressuresCH=C×(P1-P2)) and is an indication of viscous damping in the cornea. The corneal resistance factor (CRF) captures the overall viscoelastic behavior of the cornea[1]. The correction of IOP according to CH could reduce the measurement of IOP by corneal factors, that is, Corneal-Compensated Intraocular Pressure (IOPcc)[2]. IOPcc is claimed to measure IOP independent of CCT and takes certain biomechanical properties of cornea into account.”

Discussion

Comment 3: Meta-analysis data has shown that there is significant difference between preoperative IOPcc and IOPGAT measurements. As Goldmann applanation tonometry is considered gold standard for calculating intraocular pressure, the significant difference between IOPcc and IOPGAT puts the reliability of the IOPcc results into question, which was not discussed.
Comment 4: Following the statement above, even though it is shown that IOPcc was the least varied measurement following surgery, the postoperative data given by ORA might still be due to preoperative overestimation of intraocular pressure.

Response: We are very grateful for your important questions. For better argument and understanding, we would like to put such two questions together to answer.
Generally, Goldmann applanation tonometry (GAT) has been regarded as the ‘gold standard’ for calculating IOP. But when Goldmann[3] introduced this tonometer to measure IOP, he clearly pointed out the defects of his equipment, which measurement values (IOPGAT) was inevitably affected by CCT. And then some researchers also proposed that GAT could provide a correct value for the IOP when the corneal thickness was about 520 μm[4], furthermore its accuracy would gradually deteriorate when the corneal thickness deviated from this size. The literature data included in this study also showed that IOPcc was indeed less affected by CCT than IOPGAT. Therefore, it is unadvisable to take IOPGAT as the absolute standard to question the results of IOPcc.
Refractive surgery is to correct myopia by cutting a certain thickness of corneal stroma, and CCT changes significantly before and after refractive surgery[5]. However, the real IOP does not change much before and after refractive surgery[6], because the CCT change has no significant effect on the generation and flow of aqueous humor. Based on the assumption that IOP remained basically unchanged before and after refractive surgery, this study also referred to the method of previous research[7], that was, using the difference of pre- and post-operative IOP (ΔIOP) to evaluate which measured IOP was closer to the real IOP after surgery. Our results showed that mean-ΔIOPg > mean-ΔIOPGAT > mean-ΔIOPcc, and mean-ΔIOPGAT was 1.853 times that of mean-ΔIOPcc. Considering the high dependence between IOPGAT and CCT, it is reasonable to speculate that IOPcc may indeed be less dependent on CCT. Therefore, we inferred that IOPcc may be closer to real IOP after corneal refractive surgery than others.

In fact, some studies[8-10] have pointed out that IOP readings made by applanation tonometry were lower than true intracameral IOP in vivo, for example, GAT would be 1.2mmHg[8] lower than true intracameral IOP in patients with retinal disease, and would be 1.7mmHg[9] lower than true intracameral IOP in patients with primary open-angle glaucoma (POAG). In addition, most studies[11-13] have also shown that IOPcc > IOPg > IOPGAT in the normal population, and this might be related to the more objective IOP measurement of ORA. Namely, GAT requires the operator to subjectively align the prisms to determine proper applanation and then read it on the knob scale, while ORA notifies the operator when the tonometer is properly placed and reports the IOP in a digital LCD screen. So far, GAT is still the gold standard for measuring IOP, but measurement values of IOP were indeed affected by the CCT and corneal mechanical properties, and there is still no recognized method and equipment to obtain the actual IOP in vivo.

We are very sorry that we only emphasized the gold standard status of IOPGAT in the introduction and discussion of this article, but did not comprehensively comment on the measurement principle, advantages and disadvantages of GAT, which resulted in some logical loopholes. Thank you very much for your questioning. In the revised version, we have described the measurement principle, advantages and disadvantages of GAT and ORA in the introduction, and added a discussion on the influence of CCT and corneal mechanical properties on IOP measurement in the discussion part.

Comment 5: There is no mentioned gold standard method to compare the post refractive intraocular pressure measurements. Therefore, assuming IOPcc as the closest to actual intraocular pressure due to its unaffected status in postoperative measurements relative to IOPg and IOPGAT is vague.
Response: Thank you very much for your valuable comments. We agree with opinion that there is no mentioned gold standard method to compare the post refractive IOP measurements, the main reason is the measurement values of IOP are indeed affected by the CCT and corneal mechanical properties[14,15]. There is still no recognized method and equipment to obtain the actual IOP in vivo non-invasively. The biomechanical corrected IOP (bIOP) proposed by Corvis, which is said to take into account the mechanical properties of the cornea, has shown good performance in some recent studies, which suggests that it may be a step forward in exploring the possibility of measuring true intraocular pressure after corneal refractive surgery. This aspect still needs to be verified and analyzed with a large amount of clinical data in the later stage. Therefore, as mentioned in the above (response to the Comment 3 and 4), IOPcc is less dependent of CCT, and it is feasible to use ΔIOP (the difference of pre- and post-operative IOP) to evaluate which one is closer the true IOP.

In order to illustrate our views and conclusions clearly, we add the above content in the discussion part.
References


