Improving accuracy of palpation to estimate intraocular pressure

Stanley M. Chan, MD FRSCS\textsuperscript{1,2,*}, Ian Sutanto, MD\textsuperscript{3}, Chad Baker, MD FRSCS\textsuperscript{1,4}, Christopher Hanson, MD\textsuperscript{1}

\textsuperscript{1}Department of Ophthalmology, University of Alberta, Edmonton, Alberta, Canada
\textsuperscript{2}Royal Alexandra Hospital, 10240 Kingsway Avenue, Edmonton, Alberta, Canada
\textsuperscript{3}Department of Family Medicine, University of Alberta, Edmonton, Alberta, Canada
\textsuperscript{4}Alberta Retina Consultants, Suite 400, 10924 – 107 Avenue, Edmonton, Alberta, Canada

*Corresponding author

Email addresses:

SMC: stanley.chan@ualberta.ca
IS: isutanto@ualberta.ca
CB: cfbaker@ualberta.ca
CH: cphanson@ualberta.ca
Abstract

Background

Despite published inaccuracies, palpation is still routinely used to estimate intraocular pressure at the end of intraocular surgery. We evaluated the accuracy of estimating intraocular pressure (IOP) through digital palpation and associated cues. We also assessed whether experience and feedback using a tonometer can improve estimations.

Methods

Prospective case series of one hundred consecutive eyes undergoing cataract surgery were studied over 6 days. Sixty-three eyes were operated on by an experienced surgeon who estimated the IOP at the end of surgery by digital palpation. The ophthalmology resident subsequently measured the IOP using Tono-Pen and informed the surgeon of this value. Thirty-seven eyes were operated on by the resident who estimated the IOP, while the experienced surgeon recorded the Tono-Pen reading.

Results

Of the 100 eyes, estimated IOP was within 3 mm Hg of Tono-Pen IOP in 45% of cases, and within 6 mm Hg in 76% of cases. At the end of surgery, 34 eyes (34%) had pressures measuring outside the range of 10 to 30 mm Hg. The experienced surgeon was somewhat better at estimating the IOP with palpation. Comparing the first 2 days with the last 2 days (out of 6 total days), the percentage of palpation pressures within 20% of the measured Tono-Pen pressure improved from 29.5% to 63.8%.
Conclusions

Digital palpation may be helpful in estimating IOP but cannot be relied upon to consistently measure intraocular pressure with accuracy. With experience and feedback using Tono-Pen measurements, it is possible to significantly improve the accuracy of IOP estimations.
**Background**

Palpation of the eye to detect glaucoma was first described in the European literature by Richard Banister in 1622. With the development and availability of various tonometers, the use of palpation to estimate intraocular pressure (IOP) is now reserved for occasions where a tonometer is either not suitable (e.g. corneal scarring, corneal edema), not available (e.g. remote locales or developing countries where tonometer maintenance or cost is impractical), or felt to be not required (e.g. at the conclusion of intraocular surgery). In these settings, improved estimation of IOP by palpation may have an influence on clinical practice and even surgical outcomes.

The most common setting that palpation is used to estimate IOP is at the conclusion of intraocular surgery, at which time the surgeon confirms that the eye has an acceptable tension and ensures that there is no wound leak. It is known that elevated IOP often occurs between 2 to 7 hours after surgery and may result in corneal edema and/or damage to the optic nerve. Hypotony found in the early postoperative period is also undesirable as it may increase the risk of endophthalmitis due to backflow of ocular surface fluid through the incision. In the absence of other differences, it is assumed that leaving an eye with an elevated IOP greater than 30 mm Hg at the conclusion of surgery would increase the risk of optic nerve damage and corneal edema, possibly due to an IOP spike, while leaving the IOP below 10 would increase the risk of early postoperative hypotony.

Digital palpation has been shown to be fairly inaccurate albeit useful in certain situations such as following penetrating keratoplasty. Experienced surgeons, however, continue to use palpation to approximate IOP at the end of cataract surgery. It has been shown in cadaver eyes that digital palpation accuracy
can be improved. By showing improved accuracy of digital palpation following intraocular surgery, further studies could examine the ability of learning similar techniques in other clinical settings where IOP measurement is beneficial but difficult due to lack of equipment (e.g. remote area emergency rooms, general practice clinics). To our knowledge, this is first study to compare the palpation accuracy of an experienced surgeon to a resident, and the first study to evaluate whether palpation accuracy may be improved with experience and feedback in a clinical setting.

**Methods**

This clinical study was derived from a quality assurance project that included 100 consecutive eyes of patients undergoing cataract surgery at the Royal Alexandra Hospital in Edmonton, Alberta, Canada. The project was conducted over the course of six surgical days during a one month period.

In each surgery, the end goal was to leave the patient with an acceptable IOP of 10 to 30 mm Hg. Sixty-three eyes were operated on by the experienced staff surgeon (SMC). Surgical technique consisted of clear corneal phacoemulsification using the Alcon Infiniti machine through a 2.75 mm main incision, and quick-chop nuclear fragmentation. At the conclusion of the case, the surgeon hydrated the corneal wounds using balanced salt solution, checked the pressure by indenting the peripheral cornea with the side of a 30 gauge bent cannula, and added or removed balanced salt solution as necessary through the paracentesis to achieve an acceptable IOP. Once the wounds were checked to confirm that there was no leakage, the surgeon estimated the pressure by using the 30 gauge bent cannula and by palpating the cornea directly with his index finger. This estimated pressure was recorded. The
ophthalmology resident (CB) then checked the IOP using a Tono-Pen (Tono-Pen XL, Reichert, Depew, NY) and informed the surgeon of this reading. A single Tono-Pen was used in all cases and calibrated at the start of each surgical day or if there was any indication of inconsistency. Only measurements within the 5% confidence interval were accepted.

In 37 eyes, the resident performed the surgery and estimated the pressure, while the staff surgeon measured and recorded the Tono-Pen reading. Surgical technique was identical, with the exception that the resident used a divide-and-conquer nuclear fragmentation technique.

**Results**

Of all 100 eyes, IOP estimations were within 3 mm Hg of the Tono-Pen readings for 45% of the patients and within 6 mm Hg for 76% of the patients (Figure 1). Of the 63 eyes he operated on, the experienced surgeon estimated 47.6% and 79.4% within 3 mm Hg and 6 mm Hg respectively, as compared to the Tono-Pen reading. Of the 37 eyes the resident operated on, 40.5% and 70.3% were estimated within 3 mm Hg and 6 mm Hg respectively, as compared to the Tono-Pen reading. The accuracy of the estimations decreased towards the extremities as high pressures were underestimated and low pressures were overestimated by palpation (Figure 2 and Table 1). Discrepancy between palpation and Tono-Pen varied among four IOP range groups with the least difference in the 10 to 29 mm Hg range as defined by the Tono-Pen (Table 1).

Thirty-four eyes (34%) were measured by Tono-Pen to be outside the acceptable range of 10 to 30 mm Hg (outliers). Of these 34 eyes, 22 (64.7%) had
been estimated to be in the acceptable range and would have been missed. There was a difference between the staff surgeon and the resident in their ability to leave the pressure within the 10 to 30 mm Hg acceptable range. Only 23.8% of the experienced surgeon’s patients fell outside this range and he showed improvement in the last two days in which no patients were outliers. The resident showed little improvement with time and roughly 51.4% of patients were outliers throughout the study period (Figure 3).

Over the 6 operating days, the IOP estimations by palpation improved with decreasing variance from the Tono-Pen measurement (Figure 4). On days 1 and 2 combined, only 29.5% of palpation pressures were within 20% of the Tono-Pen pressure; on days 1 and 6 combined, 63.8% of palpation pressures were within this range.

**Discussion**

Qualitative methods, such as finger palpation or cannula indentation of the cornea, to estimate IOP at the end of cataract surgery remain common practice in order to leave the IOP in an acceptable range postoperatively. In our study, we found that the estimated pressure was generally inaccurate, with 34% of eyes having pressures outside 10 to 30 mm Hg, similar to the 37.7% of eyes outside the acceptable range found in a study by Antao and Kasaby.\(^7\) In the study by Baum et al. that compared palpation by an experienced corneal specialist with Goldmann tonometry, significant errors in palpation accuracy were also found with 43 of 138 measurements (31%) in error by more than 30%.\(^8\) The degree of inaccuracy in our estimations was
somewhat surprising to us, and is likely not appreciated in the majority of cataract surgeons.

During the course of the study, our technique for estimating the IOP evolved. Initially, indentation of the peripheral cornea using a 30 gauge bent cannula was done, with an endpoint of “mild to moderate corneal indentation with some resistance to indentation”. The IOP was assumed to be high if cannula indentation resulted in minimal or no corneal indentation, and displacement of the entire globe. Conversely, the IOP was assumed to be too low if there was little or no resistance to corneal indentation. We discovered that finger palpation on the central cornea was more accurate than using the bent cannula to indent the peripheral cornea, likely since a gloved index finger can actually feel “firmness”, whereas the cannula approach relies on visual cues of “indentibility”. Furthermore, the thickness of the peripheral cornea may be somewhat variable, thus affecting the reliability of this approach. Our rough guidelines to finger palpation on the central cornea were as follows: cornea easily indents – IOP ≤ 10 mm Hg; cornea indents normally – IOP 11 to 22 mm Hg; greater resistance than normal to indentation – IOP > 22 mm Hg. Useful additional visual cues to estimate the IOP were noted during injection of balanced salt solution into the anterior chamber at the conclusion of surgery, and include the following: significant anterior chamber deepening or posterior capsule stretching (e.g. in a high myope) implies IOP of at least 8 mm Hg; pupil dilation implies IOP of at least 8 mm Hg; sudden development of mild corneal edema implies IOP of more than 25 mm Hg. The patient’s refractive status should also be considered, since high myopes tend to have larger anterior segments and larger corneal diameters, giving a perceived IOP that is falsely lower, while hyperopes with smaller corneal diameters may give a perceived IOP that is falsely higher.
By the end of the study, the method that the staff surgeon used to estimate IOP consisted of the following 4 steps: (1) indentation of the peripheral cornea using the side of a 30 gauge bent cannula, (2) digital palpation of the central cornea, (3) repeat corneal indentation using 30 gauge cannula, and (4) repeat digital palpation. The fact that none of the 20 patients operated on by the staff surgeon on the final 2 days had Tono-Pen IOP outside the 10 to 30 mm Hg acceptable range indicates to us that it is possible to improve the accuracy of IOP estimation through feedback from measured Tono-Pen pressures.

Our study also showed a difference between the staff surgeon and resident in his ability to estimate IOP and in his degree of improvement over time (Figures 3 and 4). This may relate simply to surgical experience, but could also be due to the method of estimation and observation of visual cues noted above, since the resident did not refine his method of estimation to as great a degree as the staff surgeon. In any case, it seems clear to us that accurate IOP estimation is not an easy task, and does require particular attention using a reproducible technique.

**Conclusions**

Estimation of intraocular pressure at the end of cataract surgery is often inaccurate, and cannot consistently identify eyes with pressures above 30 mm Hg. In order to consistently achieve an IOP within a set range at the conclusion of surgery, an intraoperative tonometer is required. With increased experience and feedback using Tono-Pen pressure measurements, it is possible to improve the accuracy of IOP estimation. The learned ability to estimate IOP by palpation using Tono-Pen measurement feedback may be a clinically useful skill for cases in which normal
tonometry is unsuitable, impractical, or unavailable. As this study focused on an experienced intraocular surgeon and ophthalmology resident, further studies would have to be performed to show the ability of learning IOP estimation by palpation in a non-surgical, clinical environment with other health care personnel. In learning this skill and keeping it honed with consistent application, this could be a very useful technique in non-ophthalmologic centres as well such as emergency rooms and clinics.

**List of abbreviations**

IOP: intraocular pressure

mm Hg: millimetres of mercury

**Competing interests**

None of the authors have any financial or proprietary interest in any of the products or methods mentioned in this manuscript.

**Authors' contributions**

Contributions of Authors: design of the study (SMC); conduct of the study (SMC, CB); collection, management, analysis, and interpretation of the data (SMC, IS, CB); preparation, review, and approval of the manuscript (SMC, IS, CH).
Acknowledgements

Supported in part by the Patricia Ann Peat Ophthalmic Research Fund of the University of Alberta, Edmonton, Alberta, Canada.

References


Figures

**Figure 1 - Palpation versus Tono-Pen**

Estimated IOP compared with Tono-Pen measured IOP.

**Figure 2 - Bland-Altmann plot of palpation versus Tono-Pen**

Bland-Altman plot showing the difference between estimated IOP (E) and the mean of estimated and Tono-Pen IOP (T).

**Figure 3 - Scatter plot of Tono-Pen IOP**

Scatter plot of the Tono-Pen IOP at the end of surgery in order of surgical case. Range considered acceptable lies between the lines marked at 10 and 30 mm Hg.

**Figure 4 - Scatter plot of palpated IOP as percentage of Tono-Pen IOP**

Scatter plot of estimated IOP, expressed as a percentage of Tono-Pen IOP, in order of surgical case. Solid outside lines show decreasing variance of estimated pressure compared to Tono-Pen measurement. Area within dotted lines shows cases where estimated IOP is within 20% of Tono-Pen IOP.

Tables

**Table 1 - Comparison of palpation and Tono-Pen IOP**

Comparison of palpation and Tono-Pen measurements by classification into pressure ranges.
Figure 1
Table 1. Comparison of Palpation and Tono-Pen measurements by classification into pressure ranges

<table>
<thead>
<tr>
<th>Pressure range* (mm Hg)</th>
<th>No. of eyes</th>
<th>Mean difference † (mm Hg)</th>
<th>Mean absolute difference (mm Hg)</th>
<th>Mean absolute % difference ‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>26</td>
<td>3.38</td>
<td>3.92</td>
<td>67.80</td>
</tr>
<tr>
<td>10 to 19</td>
<td>46</td>
<td>1.09</td>
<td>3.70</td>
<td>27.00</td>
</tr>
<tr>
<td>20 to 29</td>
<td>20</td>
<td>-5.25</td>
<td>5.55</td>
<td>22.50</td>
</tr>
<tr>
<td>&gt;29</td>
<td>8</td>
<td>-16.88</td>
<td>16.88</td>
<td>40.20</td>
</tr>
</tbody>
</table>

*According to Tono-Pen readings
†Palpation minus Tono-Pen
‡Absolute(100-{E/T})