

## EDITORIAL

## Rebound tonometry

# Rebound tonometry: new opportunities and limitations of non-invasive determination of intraocular pressure

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## Age differences in central and peripheral intraocular pressure using ICare, a rebound tonometer

Goldmann applanation tonometry (GAT) has been the gold standard for intraocular pressure (IOP) measurement since its appearance in clinical practice almost 50 years ago.<sup>1</sup> Despite being relatively unchallenged, the last few years have become a continuous search for a new standard method for IOP measurement, mainly for the following three reasons.

1. The demonstrated dependence of GAT accuracy on corneal biomechanics, curvature and thickness.<sup>2-4</sup>
2. The advent of refractive surgery procedures has exponentially increased the number of postsurgical eyes on which GAT has been widely proved to be inaccurate.<sup>3 5</sup>
3. The need for topical anaesthesia to take measurements, mainly in those practices where non-medical personnel are involved in IOP measurement.

Non-contact tonometry seemed to overcome the need for corneal anaesthesia, as well as facilitating the IOP measurement procedure. A series of devices have been marketed and are currently being used in several practices as the default screening test for IOP. Studies comparing the values obtained with pneumotonometry against GAT have shown that the results are comparable when measuring normal eyes<sup>6</sup> versus those with glaucoma.<sup>7</sup> New pneumotonometers even account for the cardiac pulse, detecting it and firing at the same point of the cycle, minimising the variability of the measurements<sup>8 9</sup> However, pneumotonometry readings are still affected by corneal morphometric changes and are underestimated after refractive surgery procedures, although statistical models have been proposed to predict the amount of underestimation.<sup>10</sup>

Dynamic contour tonometry,<sup>11</sup> ocular response analyser,<sup>12</sup> proview phosphene tonometer,<sup>13</sup> TDGc-pra transpalpebral tonometer<sup>14 15</sup> and rebound tonometry

are some of the most recent approaches to the ultimate tonometer. Some of them provide accurate IOP values without topical anaesthesia, are not affected by corneal characteristics (at least not as conventional GAT is affected) and allow the patient to self-evaluate their IOP.

Rebound tonometry has recently appeared in clinical practice after being used for some time in animal research. Its relatively low cost, portability, no need for anaesthesia and ease of use make it ideal for routine clinical practice.

The method includes the processing of the rebound movement of a rod probe resulting from its interaction with the eye. Each disposable probe consists of a magnetised steel wire shaft covered with a round plastic tip at the end that minimises the risk of corneal injury from the probe impact during the acquisition. After pressing the measurement button, the probe hits the eye and bounces back. This movement is detected by a solenoid inside the instrument. Then, the moving magnet induces voltage into the solenoid and the motion parameters of the probe are monitored. The probe bounces faster as the IOP increases and, consequently, the higher the IOP, the shorter the duration of the impact.

The software is preprogrammed for six measurements, discarding the highest and lowest IOP readings and calculating the average IOP value from the rest.<sup>16</sup> Further details on the clinical instrument for use on human eyes are described elsewhere.<sup>17 18</sup>

Experimental studies were carried out to calibrate the early versions of the instrument and evaluate its accuracy in rats<sup>19-21</sup> and mice,<sup>19 22-24</sup> showing good agreement, although a slight overestimation of IOP readings compared with values obtained by GAT or invasive cannulation.

In human eyes, rebound tonometry showed a slight overestimation of IOP when compared with GAT in its conventional and portable versions,<sup>17 18 25-27</sup>

with limits of agreement typically lower than 4 mm Hg, although differences could be as high as 7.7 mm Hg for eyes with high IOP.<sup>25</sup> It has also been reported to be similarly affected by intrasession and intersession variations as other commercial non-GAT tonometers.<sup>25 26</sup>

Portability and no need for anaesthesia are some of the advantages of rebound tonometry, making it suitable for patients with disability and for screening at home, as well as saving space and time in the consulting room. Comparison of rebound tonometry with other portable devices on animal eyes has shown that there is good agreement with optical interferometry tonometry in mice,<sup>24</sup> more accurate and repeatable than electronic tonometry (Tonopen XL) on rat eyes<sup>21</sup> and slightly lower on canine eyes.<sup>28</sup> On human eyes, van der Jagt and Jansonius<sup>15</sup> showed good agreement between ICare and TonopenXL with GAT, and less discomfort with ICare. Garcia-Resua *et al*<sup>18</sup> reached the same conclusions comparing ICare and Tonopen XL with Perkins tonometry. Good agreement was also found against portable pneumotonometry (Pulsair 3000), and less discomfort with rebound tonometry was also highlighted as an important advantage.<sup>16</sup>

Rebound tonometry is yet another way of obtaining repeatable, reliable IOP readings. However, portability, ease of use and good results are what make rebound tonometry different from other commercial tonometers currently in use on the small corneal area used to obtain the measurements. As one of the premises of inventors, rebound tonometry was primarily designed to fit the low scale of eyes of rats and mice.<sup>29</sup> Consequently, the additional benefit of rebound tonometry is the possibility of taking measurements at different corneal locations easily using only a small part of the cornea.

Rebound tonometry seems to be useful to obtain reliable IOP readings even when other tonometry techniques cannot be applied owing to central and paracentral scarring, active inflammatory and infectious processes, as well as other conditions that do not allow the acquisition of IOP measures by applanation techniques over a larger area. However, these potential applications are yet to be explored.

Another potential application of this instrument is the measurement of peripheral IOP readings. Gonzalez-Mejome *et al*<sup>30</sup> (see page xx) have explored this advantage, evaluating the possible influence of ageing in the differences in IOP measurements between the centre and the periphery. The authors document the high correlation between central

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and peripheral readings, and the lack of increase in IOP values despite a marked increase in peripheral corneal thickness. Using a reasonable sample size, divided into three groups by age, the authors have also shown a trend towards lower IOP readings with the ICare associated with ageing. Different interesting hypotheses are considered in this work to explain such behaviour.

Another field to be explored with this instrument is the post-surgical corneas in which peripheral IOP readings could give a reasonable indication of the actual pre-surgical IOP. However, some studies have shown that ICare measurements are weakly correlated with central corneal thickness.<sup>27</sup> So, the relationships between IOP taken with ICare, the central and peripheral corneal thickness and their effect on IOP accuracy on post-surgical corneas are still to be evaluated in clinical trials.

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