



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Bureau
International des
Poids et
Mesures



Metrology in the Fight Against Glaucoma

Together with a European metrology consortium, CMI established a competency center for intraocular pressure metrology to provide hundreds of eye-tonometry calibrations per year

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The Challenge

Glaucoma is a chronic disease that is the leading cause of irreversible vision loss, particularly affecting the elderly. The World Health Organization has named glaucoma as the leading cause of irreversible vision loss, responsible for 37.5 % of blindness worldwide. It has been estimated that approximately 112 million patients will be suffering from this disease by 2040. While a specific total number of intraocular pressure (IOP) tests performed annually in Europe is not explicitly cited in public studies, data indicate that tens of millions of tests are likely performed, driven by high glaucoma prevalence and routine eye care.^{1,2}

In its early stages, the disease has no symptoms and can only be detected by an increase in IOP (aka ocular hypertension), which is caused by fluid build-up within the eye. IOP is the only treatable risk factor for the disease; thus, it is essential that medical instruments that measure IOP are metrologically validated to ensure the correct diagnosis and treatment. This includes eye tonometers, the primary instruments used to measure IOP, that use contact or noncontact methods, such as a puff of air, to measure this pressure.

However, at the start of 2017, Germany's National Metrology Institute (PTB), was the only institute in Europe with state-of-the-art measurement capabilities in IOP metrology. This included the calibrations required to ensure metrological traceability for standard tonometers as well as the research experience needed to adapt to the demands of new technological developments. The scarcity of calibration services for tonometers meant that screening for ocular hypertension fell short, leaving many European citizens at risk of vision loss.

The Solution

Six European NMIs and two universities collaborated to develop a new center for IOP metrology through technology transfer covering all aspects of IOP measurements and tonometer calibrations, including regulatory and legislative aspects. Research and clinical studies pushed the state of the art further by identifying influencing factors in IOP measurements and the effects of non-standard measurement conditions on results.

¹ Meliante LA, Stuart KV, Luben RN, et al. Current burden and future projections of glaucoma in the United Kingdom. *British Journal of Ophthalmology*. 20 January 2026. <https://doi.org/10.1136/bjo-2025-328373>

² Kelsey V. Stuart, Victor A. de Vries, Alexander K. Schuster, et al. Prevalence of Glaucoma in Europe and Projections to 2050: Findings from the European Eye Epidemiology Consortium. *Ophthalmology*, Volume 132, Issue 10, 2025, Pages 1114-1124, <https://doi.org/10.1016/j.ophtha.2025.06.002>

The EMPIR project inTENSE³ brought together European metrology and ophthalmology experts to develop a new center for IOP metrology. This included the NMIs of Austria (BEV), the Czech Republic (ČMI), Germany (PTB), Poland (GUM), Slovakia (SMÚ), and Turkey (TÜBİTAK UME). These were joined by academic partners Palacký University in Olomouc (UPOL) and Slovak Technical University in Bratislava (STU). Working together, the consortium expanded the capabilities of a center originally founded at ČMI in 2007. Experts at PTB transferred knowledge to ČMI staff during four advanced training sessions covering metrological traceability of impression and applanation tonometers, the complex metrological traceability of non-contact tonometers, legislative and regulatory aspects, and modern tonometers such as rebound and contour tonometers. Following this, the new center passed external audits in November 2018 (methods and staff) and in March 2020 (quality system).

In addition, the project's research identified factors that significantly influence IOP measurements with widely used eye tonometers. It was found that IOP readings are primarily influenced by corneal thickness and biometric properties, such as hysteresis and corneal rigidity. The effects of non-standard measurement conditions and short-term physiological stress were also examined, revealing that these factors affect IOP values immediately before measurements and can significantly distort results. Clinical studies were also conducted to examine the effects of hypoxia and head and body position on IOP measurements.

A Quantifiable Impact

In 2020, the inTENSE project⁴ established a competence center for intraocular pressure (IOP) metrology at CMI. A series of advanced training sessions was completed, and CMI passed an external technical review and an external quality management audit. The project introduced the 'smart specialization' concept for IOP, which focuses expertise and knowledge at a single site, ensuring an optimized Central European approach to IOP metrology. The project also published a good practice guide on traceable IOP metrology and a white paper on the smart specialization concept.

An 'artificial' eye (see **Figure 1**) for tonometer calibration was designed, manufactured, and validated in an international metrological comparison. The project team provided input into a new OIML recommendation on non-contact tonometers. The work performed will enable a more uniform approach to IOP metrology throughout Europe, help save the vision of hundreds of European citizens, and reduce the economic and societal costs of glaucoma.

³ EMPIR project 16RPT03 inTENSE, "Developing research capabilities for traceable intraocular pressure measurements" <https://www.euramet.org/research-innovation/search-research-projects/details/project/developing-research-capabilities-for-traceable-intraocular-pressure-measurements>

⁴ EMPIR project 16RPT03 inTENSE, "Developing research capabilities for traceable intraocular pressure measurements" <https://www.euramet.org/research-innovation/search-research-projects/details/project/developing-research-capabilities-for-traceable-intraocular-pressure-measurements>

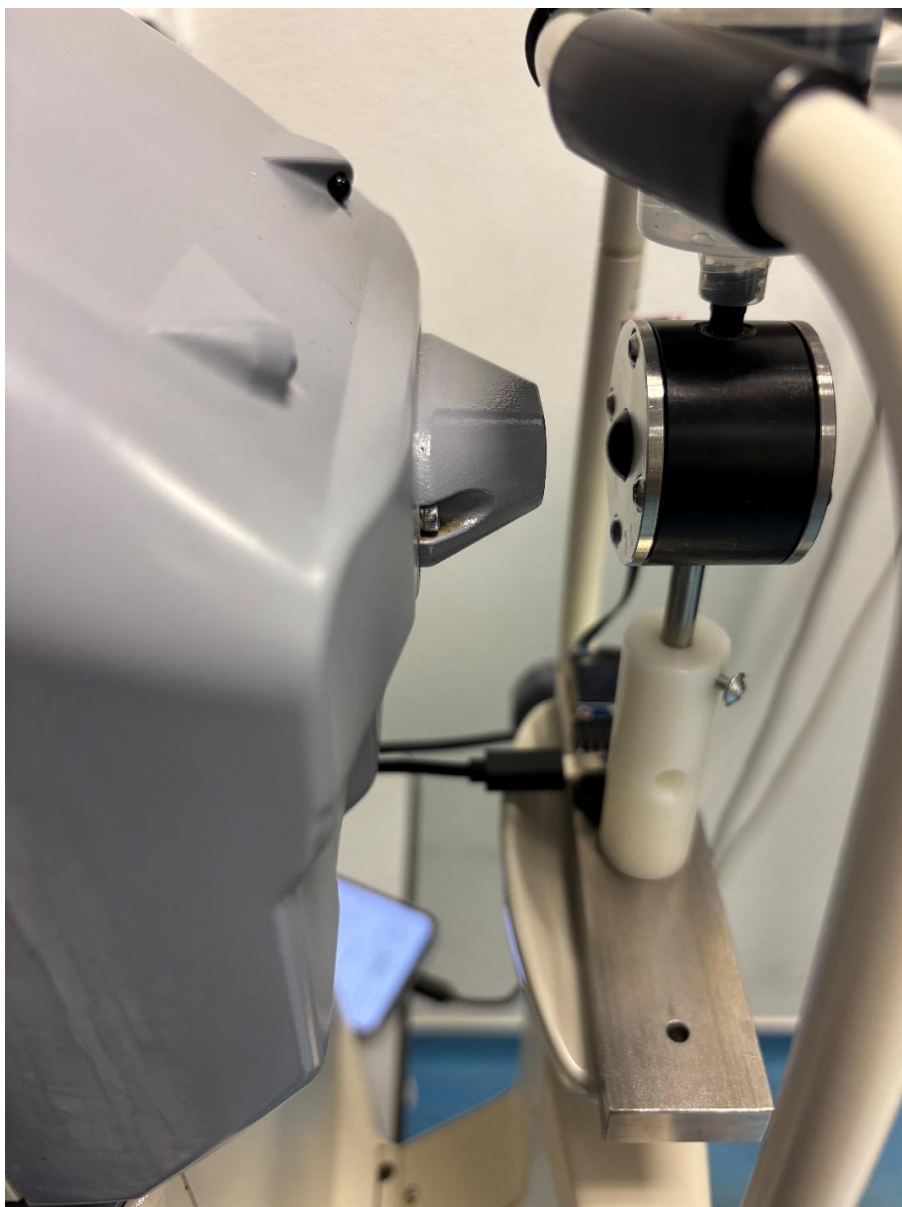


Figure 1. The ‘artificial eye’ device (right) is used to calibrate a tonometer (left).

The now-established IOP center provides metrologically validated services, including calibrations, performing around 500 per year. With a concentration of instrumentation and know-how for IOP metrology unmatched anywhere else in the EU, EFTA, or CEFTA regions, clients are drawn not only from Europe but also from countries such as Israel, Japan, and South Korea. The center also offers training, comparisons, type approvals, and verifications in IOP and can address emerging ophthalmological challenges, including new instruments such as transpalpebral tonometers, designed to allow patients to self-monitor IOP at home.

Through the project, the IOP center at CMI will enable a more uniform approach to IOP metrology across Europe, not only preserving the vision of hundreds of European citizens but also helping reduce the economic and societal costs of glaucoma. This work has continued in EURAMET’s small collaborative project, Development of eye-tonometry in CEFTA countries

(20SCP02 CEFTON). Its aim was to further develop tonometry capability in Central Europe Free Trade Agreement (CEFTA) states, such as Bosnia and Herzegovina, Moldova, and North Macedonia. Their emerging NMIs need to correctly implement IOP metrology in line with the new harmonized approach specified in the Medical Device Regulation (MDR 2017/745). However, they required an experienced partner to provide them with the necessary knowledge transfer. The IOP center at CMI was used to provide this know-how transfer and training. In total, eight participants successfully completed the training in 2022. The participating NMIs (IMBiH, INM, ME BoM) will be able to further develop their expertise in establishing a sound metrological infrastructure for eye tonometry, tailored to their specific needs, especially in the context of the accession process to the EU. In the longer term, they will be able to transfer this newly acquired knowledge to their quality infrastructure frameworks in the CEFTA region. This project has enhanced cohesion for expanding the EU at the metrological level. The center at CMI remains available to all NMIs interested in using it to support their cohesion.

The ‘artificial’ eye (**Figure 1**) was originally developed in collaboration between STU and SMÚ and was designed to simulate IOP and the properties of an ideal human cornea while allowing a full range of variable pressures within it. In 2024, CMI joined the efforts in this field, building its own prototype. Further tests and comparisons of the ‘artificial’ eyes are underway between CMI, SMÚ, STU, and UPOL. Further, in June 2025, a CCM meeting was held in Sèvres, where the project results were presented. This was followed by responses from NIM (China) and KRISS (South Korea), both of which expressed interest in future cooperation.

Acknowledgments. Funding for the research detailed in this case study was provided by the European Metrology Programme for Innovation and Research (EMPIR), co-financed from the European Union’s Horizon Europe Research and Innovation Programme and by the Participating States.

A complete list of participants is provided on the EMPIR Project 16RPT03 inTENSE page.⁵

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⁵ EMPIR project 16RPT03 inTENSE, “Developing research capabilities for traceable intraocular pressure measurements” <https://www.euramet.org/research-innovation/search-research-projects/details/project/developing-research-capabilities-for-traceable-intraocular-pressure-measurements>