

# CORNEAL HYSTERESIS AND INTRAOCULAR PRESSURE MEASUREMENT

**Policy Number:** DIAGNOSTIC 048.15 T2

**Effective Date:** December 1, 2018

[Instructions for Use](#) ⓘ

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## Related Policies

None

## APPLICABLE LINES OF BUSINESS/PRODUCTS

This policy applies to Oxford Commercial plan membership.

## NON-COVERAGE RATIONALE

**The following are unproven and not medically necessary for evaluating and managing glaucoma, corneal and/or other ocular disorders due to insufficient evidence of efficacy:**

- Measurement of corneal hysteresis
- Measurement of ocular blood flow using a tonometer
- Monitoring of intraocular pressure during vitrectomy
- Continuous monitoring of intraocular pressure for  $\geq 24$  hours in persons with glaucoma

## APPLICABLE CODES

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this policy does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by the member specific benefit plan document and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies may apply.

CPT Code	Description
0198T	Measurement of ocular blood flow by repetitive intraocular pressure sampling, with interpretation and report
0329T	Monitoring of intraocular pressure for 24 hours or longer, unilateral or bilateral, with interpretation and report
66999	Unlisted procedure, anterior segment of eye
67299	Unlisted procedure, posterior segment
92145	Corneal hysteresis determination, by air impulse stimulation, unilateral or bilateral, with interpretation and report

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## DESCRIPTION OF SERVICES

Corneal hysteresis (CH) measurement assesses corneal resistance to deformation. CH has been proposed as a possible indicator of the viscoelastic properties in the cornea. The Ocular Response Analyzer® (ORA) is an instrument

that measures CH by using a rapid air impulse to apply force to the cornea. An advanced electro-optical system then monitors the deformation. Two independent pressure values are derived from the inward and outward applanation events. The difference between these two pressure values is CH. Low CH demonstrates that the cornea is less capable of absorbing (damping) the energy of the air pulse. Abnormalities in CH have been detected in a variety of corneal diseases, including keratoconus, Fuchs' dystrophy, and in post-LASIK patients. Glaucoma is another potential indication for CH measurement. The preferred method of measuring intraocular pressure (IOP) is using a contact applanation method such as a Goldmann tonometer (GAT). Corneal compensated IOP, derived from the CH measure has been suggested as a superior measurement of IOP compared to the GAT measurement.

The ocular blood flow (OBF) tonometer measures IOP and pulsatile OBF. It has been proposed that the IOP and OBF test results taken together increase the detection rate for glaucoma when compared to traditional tonometry, which measures only average IOP. The ocular Blood Flow Analyzer (BFA) is an electronic pneumotonometer that measures IOP 200 times per second over a period of 5-15 seconds and automatically measures OBF. The BFA is basically an OBF tonometer, using a pneumatic mode of operation.

IOP monitoring during vitrectomy may be accomplished indirectly by placing disposable blood pressure transducers into the line tubing utilized for vitrectomy infusion. It may also be monitored by inserting a catheter pressure transducer directly into the vitreous by an extra pars plana incision. In either approach, pressure measurements are obtained simultaneously during the various stages of the vitrectomy, including air-fluid exchange and gas-forced fusion. Monitoring IOP during vitrectomy surgery has been proposed to measure fluctuations in IOP that may have an adverse effect on retinal and optic nerve function and visual acuity recovery.

Devices, including contact lens sensors, are being developed to monitor eye pressure for 24 hours or longer in individuals with glaucoma. Currently, the Triggerfish<sup>®</sup> contact lens sensor (CLS) (Sensimed, Lausanne, Switzerland) is the only commercially available device that has been shown to be able to provide 24 hour IOP data. This device has received marketing clearance by the U.S. Food and Drug Administration (FDA). The Triggerfish<sup>®</sup> CLS is a disposable silicone contact lens with an embedded micro-electromechanical system which measures changes in corneal curvature induced by variations in IOP. An antenna, mounted around the eye, receives the data, which are then transmitted to a recorder for analysis. These devices are being studied to determine if they improve detection and allow earlier treatment for individuals with glaucoma.

## CLINICAL EVIDENCE

### **Corneal Hysteresis Measurement**

Susanna et al. (2018) conducted a prospective observational cohort study to investigate the role of CH as a risk factor for development of glaucoma. Two hundred and eighty-seven eyes of 199 individuals suspected of having glaucoma were observed for approximately 4 years. Development of glaucoma was defined as occurrence of 3 consecutive abnormal standard automated perimetry tests during the follow-up period. At baseline and at each visit during follow-up, all participants underwent a comprehensive ophthalmologic examination including IOP measured using GAT, gonioscopy, stereoscopic optic disc examination, visual field testing, and central corneal thickness (CCT) measurements via ultrasound pachymetry. Based on the results of the study, the authors concluded that the decrease in CH measurements represents a risk factor for developing glaucoma. Study limitations included but were not limited to study design (observational versus interventional) as well as uncontrolled confounding by unmeasured factors, such as family history of glaucoma. Future studies, including randomization protocols controlling for treatment strategy, should be performed to further clarify this and other predictive factors.

A 2018 Hayes search and summary report focused on the use of CH for the management and treatment of glaucoma. Nineteen abstracts, including prospective comparative studies, prospective controlled and uncontrolled studies, retrospective comparative studies, retrospective uncontrolled studies, and review articles, were retrieved in the search. Numbers of study participants ranged from 28-323. No clinical trials were identified which studied CH for glaucoma management. It was concluded that while there is sufficient published evidence to evaluate this technology, the study abstracts present conflicting findings regarding the use of CH measurements in the management of glaucoma. Conclusions about the safety and effectiveness of this technology cannot be made until a full assessment has been completed.

Murphy et al. (2017) conducted a cross sectional study with 123 patients (one eye each) to determine if CH differs between patients with glaucoma, ocular hypertension (OHT) and glaucoma-like optic discs (GLD). The secondary aim was to investigate whether corneal resistance factor (CRF) and CCT differ between these patient groups. A One-way Analysis of Covariance (ANCOVA) was conducted to evaluate the mean difference in CH between the 3 diagnostic groups (glaucoma, OHT and GLD), correcting for potential confounding factors, IOP and age. Analysis was repeated for CRF and CCT. There was a significant difference in mean CH across the 3 groups. Mean CH was significantly higher for GLD compared to glaucoma, and significantly higher for OHT compared to glaucoma. Mean CH was slightly lower in patients with GLD than those with OHT but this difference was not statistically significant. A similar pattern was seen

when the analysis was repeated for CRF and CCT. The authors concluded that higher CH in GLD and OHT compared to glaucoma suggests increased viscoelasticity of ocular tissues may have a protective role against glaucoma. Future research in the area of CH should focus on its role in other diseases characterized by altered tissue compliance such as diabetes and hypertension. These areas may reflect a further advantage for the addition of CH measurements into routine ophthalmological examinations.

To determine whether CH and CCT are independent risk factors for glaucoma, Carbonaro et al. (2014) conducted a cross-sectional population-based cohort study with 1754 twin subjects. CH, IOP, and CCT were measured; optic disc photographs were analyzed; and multivariable linear regression analysis was performed. Data were available on 1645 individuals. The authors found no relationship between CH or CCT and quantitative measures of optic disc cupping that suggest CH and CCT are independent risk factors for glaucoma.

Observational cohort studies have been conducted by Medeiros et al. (2013) and Zhang et al. (2016) to investigate the relationship between CH and progressive retinal nerve fiber layer (RNFL) loss/visual progression in patients with glaucoma followed prospectively over time. Medeiros' study group included 114 eyes of 68 patients with glaucoma who were followed for an average of 4 years. Zhang's group followed 186 eyes of 133 patients with glaucoma for an average of 3.8 years. Using the ORA to obtain CH measurements in both a univariable and multivariable models, both studies concluded that the CH measurements to be significantly associated with risk of glaucoma progression and that eyes with lower CH had faster rates of RNFL/visual field loss over time than those with higher CH. While Zhang concludes this study provides further evidence that CH is an important factor to be considered in the assessment of the risk of progression in patients with glaucoma, there is no information that these findings will affect patient management.

Shin et al. (2014) conducted a prospective, cross-sectional, comparative study to evaluate the effects of corneal biomechanical properties on IOP measured with the ICare, and to compare IOP readings obtained with ICare, ORA, and GAT in normal-tension glaucoma (NTG) and normal subjects. IOP was measured with ICare, ORA, and GAT. All subjects had CH and CRF, which were measured with ORA; and CCT, axial length, spherical equivalent, and keratometry. This study enrolled 97 eyes of 97 NTG patients and 89 eyes of 89 normal subjects. CCT, CH, and CRF in NTG patients were significantly lower than those in normal subjects. The difference in IOP between techniques was highly significant in NTG patients, while there was no significant difference in IOP values between techniques in normal controls. ICare readings were significantly lower than corneal-compensated IOP in NTG patients ( $P = .014$ ). CH and CRF were significantly associated with IOP measurements with ICare in NTG and normal subjects ( $P < .001$ ). The greater difference between IOPcc and ICare in NTG patients was significantly influenced by the lower CH ( $P < .001$ ). The author concluded that ICare is a convenient way to measure IOP and is a reasonable option as an alternative tonometer in NTG patients. However, the clinician must consider that the corneal biomechanical characteristics in NTG can cause ICare to underestimate IOP. The findings of this study are further limited by the small size of the study group.

Mansouri et al. (2012a) conducted an observational cross-sectional study to identify whether there is an association between corneal biomechanical parameters and the severity of glaucoma as defined by the visual field and RNFL thickness. CH and CRF were measured using the ORA. CH is assumed to reflect the viscous properties of the cornea as well as its dampening and energy absorption capacity. The CRF seems to be an indicator of the overall "resistance" or elasticity of the cornea. This study included a total 299 eyes of 191 participants (151 suspect and 148 glaucoma eyes), with the mean age of the participants being 68.1 years (range 30–91 years). The authors found only a weak relationship between corneal biomechanical parameters of CH and CRF and measures of structural and functional damage in glaucoma. Prospective longitudinal studies are needed to investigate the relationship between corneal biomechanics and long-term risk of glaucoma progression.

In a systematic review and meta-analysis, Cook et al. (2012) assessed the agreement of tonometers available for clinical practice with the GAT, the most commonly accepted reference device. A total of 102 studies, including 130 paired comparisons, were included, representing 8 tonometers: dynamic contour tonometer (DCT), noncontact tonometer (NCT), ORA, Ocuton S, handheld applanation tonometer (HAT), rebound tonometer, transpalpebral tonometer, and Tono-Pen. The agreement (95% limits) varied across tonometers: 0.2 mmHg (-3.8 to 4.3 mmHg) for the NCT to 2.7 mmHg (-4.1 to 9.6 mmHg) for the Ocuton S. The estimated proportion within 2 mmHg of the GAT ranged from 33% (Ocuton S) to 66% and 59% (NCT and HAT, respectively). Substantial inter- and intraobserver variability were observed for all tonometers. The authors concluded that the NCT and HAT seem to achieve a measurement closest to the GAT. However, there was substantial variability in measurements both within and between studies.

Nessim et al. (2012) analyzed the relationship between measured IOP and CCT, CH and CRF in OHT, primary open-angle (POAG) and NTG eyes using multiple tonometry devices. Right eyes of patients diagnosed with OHT ( $n=47$ ), NTG ( $n=17$ ) and POAG ( $n=50$ ) were assessed. IOP was measured in random order with 4 devices: GAT; Pascal<sup>®</sup> DCT; Reichert<sup>®</sup> ORA; and Tono-Pen<sup>®</sup> XL. CCT was then measured using a hand-held ultrasonic pachymeter. CH and CRF

were derived from the air pressure to corneal reflectance relationship of the ORA data. Compared to the GAT, the Tonopen and ORA Goldmann equivalent (IOPg) and corneal compensated (IOPcc) measured higher IOP readings, particularly in NTG. DCT was closest to GAT IOP and had the lowest variance. CCT was significantly different between the 3 conditions as was CH and CRF. According to the authors, this study suggests that as the true pressure of the eye cannot be determined non-invasively, measurements from any tonometer should be interpreted with care, particularly when alterations in the corneal tissue are suspected.

In a prospective longitudinal observational study, Sullivan-Mee et al. (2013) examined the factors that influence IOP measurement agreement between GAT, ORA, and Pascal DCT. The study included 243 eyes in 243 subjects. The authors identified 5 factors, including CH, by multivariate regression as being independently associated with disagreement in IOP results as measured by different types of instruments. The authors stated that further study is needed to explain the residual disagreements among these instruments.

Kaushik et al. (2012) evaluated corneal biomechanical properties across the glaucoma spectrum and studied the relationship between these measurements and IOP in a prospective cross-sectional study that included 323 participants. Based on the results of the study, the investigators concluded that IOP measurements from the ORA are not interchangeable with, and are unlikely to replace GAT at the present time.

Touboul et al. (2011) estimated the ability of the ORA parameters to aid in the diagnosis of keratoconus in pre-laser in situ keratomileusis (LASIK) patients. The study group comprised 103 eyes and the control group, 97 eyes. CHteresis had a sensitivity of 66% with a specificity of 67%. The authors stated that despite low sensitivity and specificity, some parameters provided by the corneal analyzer offered high negative likelihood ratios and deserve more study with bigger samples.

Schweitzer et al. (2010) evaluated the performance of the ORA in the screening of forme fruste keratoconus (FFKc) in a retrospective comparative study that included 180 eyes. ORA preoperative data were analyzed for 125 normal control eyes (64 patients) undergoing LASIK without corneal ectasia after 24 months of follow-up and 55 case eyes with unilateral keratoconus from a database. All eyes were matched in 4 groups of CCT. CH, CRF, the air pressure curve, and the infrared signal were compared between FFKc and normal eyes in each group. Based on the results of the study, the investigators concluded that the ORA provides additional information in the screening of FFKc, with an accurate analysis of the corneal biomechanical properties according to CCT, air pressure, and infrared curves. According to the investigators, further studies are required to confirm these results and to follow the corneal topography and the ORA parameters over time for both groups.

### ***Professional Societies***

#### **American Academy of Ophthalmology (AAO)**

The AAO Preferred Practice Pattern (PPP) for POAG states that CH, a measure of the viscoelastic dampening of the cornea, has been shown to be associated with the risk of glaucoma progression. (2016)

The AAO PPPs for both POAG and for POAG Suspect (2015) state that low CH is associated with glaucoma progression.

#### **Measurement of Ocular Blood Flow by Intraocular Pressure Sampling**

A prospective, cross-sectional, case-control hospital-based study was conducted with 614 participants to help identify which vascular data can be used as a clinical tool for screening and disease stratification. Patients with POAG, NTG, OHT, glaucoma suspects and healthy volunteers were recruited. Mean ocular perfusion pressure was higher in the glaucoma groups than in controls. Glaucoma groups had lower retrobulbar velocities, higher retinal venous saturation and choroidal thickness asymmetries when compared to the healthy group, in line with the current literature. Named the Leuven Eye Study, the authors concluded that the creation of this vast database may help integrate the vascular aspects of glaucoma into the clinical practice of glaucoma. The trial did not result in definitive information that would affect patient management. (Abegão Pinto, et al. 2016)

In a cross-sectional study, Resch et al. (2011) correlated OBF parameters with parameters of optic nerve head (ONH) morphology and visual field performance. A total of 103 patients with POAG were included. Choroidal and ONH blood flow was assessed using laser Doppler flowmetry. Retinal blood velocities and retinal vessel diameters were measured with laser Doppler velocimetry and a Retinal Vessel Analyzer, respectively. Among all measured ocular hemodynamic parameters, the ONH blood flow was most strongly correlated to structural parameters of ONH damage and visual field loss. Reduced retinal vessel diameters were only slightly correlated with the degree of glaucomatous damage. The authors concluded that reduced blood flow in the ONH was associated with an increasing amount of visual field defect and morphological changes of the ONH. Retinal vessel diameters were only marginally associated with glaucomatous optic nerve damage. According to the authors, based on retinal vessel diameter determination alone, it is not possible to assess whether reduced retinal blood flow is causative or secondary in glaucoma.

Januleviciene et al. (2011) evaluated hemodynamic parameters as possible predictors for glaucoma progression in an 18-month randomized double-masked cohort study including 30 open-angle glaucoma patients. IOP, arterial blood pressure, ocular and diastolic perfusion pressures, color Doppler imaging, pulsatile OBF analysis, scanning laser polarimetry, and Humphrey visual field evaluations were included. The authors concluded that structural changes consistent with glaucoma progression correlate with non-IOP-dependent risk factors. The authors stated that larger group studies with longer followup, standardization of measurement techniques for glaucoma progression, and OBF parameters are required to elicit a clear understanding of vascular risk factors in glaucoma progression.

### **Professional Societies**

#### **American Academy of Ophthalmology (AAO)**

The AAO PPP for POAG does not address measurement of OBF for the evaluation and management of this condition. (2016)

#### **Monitoring of Intraocular Pressure During Vitrectomy**

In a prospective, interventional, consecutive case series, Sugiura et al. (2011) measured ophthalmodynamometric pressure (ODP) during vitrectomy in 75 patients with proliferative diabetic retinopathy (PDR). Multiple regression analysis revealed that ODP had a significant correlation with diastolic blood pressure, presence of rubeosis iridis, and severity of PDR. There is no evidence from this study that this information will affect patient management.

Moorhead et al. (2005) conducted a clinical study of 10 patients to directly measure dynamic IOP during vitrectomy and to determine whether disposable pressure transducers placed in the infusion line can indirectly measure with accuracy the dynamic IOP during vitrectomy. The directly measured IOP varied between 0 and 120 mm Hg during vitrectomy. During fluid flow, the indirectly measured IOP, calculated from the infusion line pressures, accurately corresponded with the directly measured IOP. The investigators concluded that closed vitrectomy causes wide fluctuations in IOP. The IOP can be accurately measured during fluid flow with inline sensors. According to the authors, the physiologic significance of these findings requires further study.

There is limited evidence to support that intraoperative IOP monitoring will improve health outcomes in patients undergoing vitrectomy. Additional clinical trials are necessary to determine its benefit.

#### **Monitoring of Intraocular Pressure for 24 Hours or Longer**

Hayes performed a search and summary of peer reviewed literature published in the last 5 years studying the Sensimed Triggerfish (Switzerland) and glaucoma. 18 abstracts, including prospective studies, a retrospective study, and a systematic review were included, with numbers of participants ranging from 9-50. Various forms of glaucoma were studied, including NTG, POAG, primary angle-closure glaucoma, and glaucoma in general. Five studies received funding from the manufacturer, and there was considerable overlap of authors in the peer-reviewed abstracts. It was determined that while there is sufficient published evidence to evaluate this technology, the study abstracts presented overall conflicting findings regarding the use of the Sensimed Triggerfish System for continuous IOP monitoring in patients with glaucoma. Therefore, conclusions about the safety and efficacy of this technology cannot be made until a full assessment has been completed. (2017)

Mansouri et al. (2012b) examined the safety, tolerability, and reproducibility of IOP patterns during repeated continuous 24-hour IOP monitoring with the Triggerfish CLS. Patients suspected of having glaucoma (n = 21) or with established glaucoma (n = 19) were included in the study. Correlation between the 2 sessions was moderate, suggesting good reproducibility of the IOP recordings. There was also no difference in adverse events or survey scores for tolerability between those with established glaucoma compared with those with suspected glaucoma. Main adverse events were blurred vision (82%), conjunctival hyperemia (80%), and superficial punctate keratitis (15%). The authors concluded that repeated use of the contact lens sensor demonstrated good safety and tolerability. According to the authors, the recorded IOP patterns showed fair to good reproducibility, suggesting that data from continuous 24-hour IOP monitoring may be useful in the management of patients with glaucoma. However, this study did not translate abstract research data into clinical guidelines that can be used to improve physician decision-making and patient care.

In a prospective, observational cohort of 15 patients, Mansouri and Shaarawy (2011) reported their initial clinical results with the Sensimed Triggerfish for continuous IOP monitoring in patients with open angle glaucoma. A signal was recorded in all patients. Thirteen (87%) patients completed 24 hour IOP monitoring: one patient discontinued IOP monitoring due to device intolerance, and incomplete recordings were obtained in a second patient due to technical device malfunction. In 9/13 (69%) patients, the highest signals were recorded during the nocturnal period. No serious adverse events were recorded. According to the authors, the device shows good safety and functionality to monitor IOP fluctuations in patients over 24 hours. The significance of this study is limited by small sample size.

There are multiple clinical trials evaluating the Sensimed Triggerfish System. Additional information is available at [www.clinicaltrials.gov](http://www.clinicaltrials.gov).

On January 20, 2004, the Ocular Response Analyzer® (ORA) by Reichert Inc. received FDA clearance for the intended use to measure intra-ocular pressure of the eye and the biomechanical response of the cornea for the purpose of aiding in the diagnosis and monitoring of glaucoma. More information is available at: [http://www.accessdata.fda.gov/cdrh\\_docs/pdf3/K032799.pdf](http://www.accessdata.fda.gov/cdrh_docs/pdf3/K032799.pdf). (Accessed March 7, 2018)

On October 21, 2002, the Blood Flow Analyzer (BFA) received FDA marketing clearance. More information is available at: [http://www.accessdata.fda.gov/cdrh\\_docs/pdf2/k023245.pdf](http://www.accessdata.fda.gov/cdrh_docs/pdf2/k023245.pdf). (Accessed March 7, 2018)

On March 4, 2016, the Triggerfish® contact lens sensor (CLS) received FDA marketing clearance. More information is available at: [https://www.accessdata.fda.gov/cdrh\\_docs/reviews/den140017.pdf](https://www.accessdata.fda.gov/cdrh_docs/reviews/den140017.pdf). (Accessed March 7, 2018)

## REFERENCES

The foregoing Oxford policy has been adapted from an existing UnitedHealthcare national policy that was researched, developed and approved by UnitedHealthcare Medical Technology Assessment Committee. [2018T01337]

Abegão Pinto L, Willekens K, Van Keer K, et al. Ocular blood flow in glaucoma - the Leuven Eye Study. *Acta Ophthalmol.* 2016 Sep;94(6):592-8.

American Academy of Ophthalmology (AAO). Primary open-angle glaucoma. Preferred Practice Pattern Guidelines. October 2010. Updated 2015.

American Academy of Ophthalmology (AAO). Primary open-angle glaucoma suspect. Preferred Practice Pattern Guidelines. October 2010. Updated 2015.

Carbonaro F, Hysi PG, Fahy SJ, et al. Optic disc planimetry, corneal hysteresis, central corneal thickness, and intraocular pressure as risk factors for glaucoma. *Am J Ophthalmol.* 2014 Feb;157(2):441-6.

Cook JA, Botello AP, Elders A, et al. Surveillance of ocular hypertension study group. Systematic review of the agreement of tonometers with Goldmann applanation tonometry. *Ophthalmology.* 2012 Aug; 119(8):1552-7.

Hayes, Inc. Search and Summary. Continuous Intraocular Pressure Monitoring for Glaucoma Using the Sensimed Triggerfish System (Sensimed AG). Lansdale, PA: Hayes, Inc.; April 13, 2017.

Hayes, Inc. Search and Summary. Corneal Hysteresis for Management of Glaucoma. Lansdale, PA: Hayes, Inc.; April 12, 2018.

Janulevičiene I, Ehrlich R, Siesky B, et al. Evaluation of hemodynamic parameters as predictors of glaucoma progression. *J Ophthalmol.* 2011; 2011:164320.

Kaushik S, Pandav SS, Banger A, et al. Relationship between corneal biomechanical properties, central corneal thickness, and intraocular pressure across the spectrum of glaucoma. *Am J Ophthalmol.* 2012 Feb 4.

Mansouri K, Leite MT, Weinreb RN, et al. Association between corneal biomechanical properties and glaucoma severity. *Am J Ophthalmol.* 2012 Mar;153(3):419-427.

Mansouri K, Medeiros FA, Tafreshi A, et al. Continuous 24-hour monitoring of intraocular pressure patterns with a contact lens sensor: safety, tolerability, and reproducibility in patients with glaucoma. *Arch Ophthalmol.* 2012 Dec 1;130(12):1534-9.

Mansouri K, Shaarawy T. Continuous intraocular pressure monitoring with a wireless ocular telemetry sensor: initial clinical experience in patients with open angle glaucoma. *Br J Ophthalmol.* 2011 May;95(5):627-9.

Medeiros FA, Meira-Freitas D, Lisboa R, et al. Corneal hysteresis as a risk factor for glaucoma progression: a prospective longitudinal study. *Ophthalmology.* 2013 Aug;120(8):1533-40.

Moorhead LC, Gardner TW, Lambert HM et al. Dynamic intraocular pressure measurements during vitrectomy. *Arch Ophthalmol.* 2005 Nov;123(11):1514-23.

Murphy ML, Pokrovskaya O, Galligan M, et al. Corneal hysteresis in patients with glaucoma-like optic discs, ocular hypertension and glaucoma. *BMC Ophthalmol.* 2017 Jan 10;17(1):1.

Nessim M, Mollan SP, Wolffsohn JS, et al. The relationship between measurement method and corneal structure on apparent intraocular pressure in glaucoma and ocular hypertension. *Cont Lens Anterior Eye.* 2012 Dec 14.

Resch H, Schmidl D, Hommer A, et al. Correlation of optic disc morphology and ocular perfusion parameters in patients with primary open angle glaucoma. *Acta Ophthalmol.* 2011 Nov;89(7):e544-9.

Schweitzer C, Roberts CJ, Mahmoud AM, et al. Screening of forme fruste keratoconus with the ocular response analyzer. *Invest Ophthalmol Vis Sci.* 2010 May;51(5):2403-10.

Shin J, Lee JW, Kim EA. The effect of corneal biomechanical properties on rebound tonometer in patients with normal-tension glaucoma. Am J Ophthalmol. 2014 Oct 13.

Sugiura Y, Okamoto F, Okamoto Y, et al. Ophthalmodynamometric pressure in eyes with proliferative diabetic retinopathy measured during pars plana vitrectomy. Am J Ophthalmol. 2011 Apr;151(4):624-629.

Sullivan-Mee M, Lewis SE, Pensyl D, et al. Factors influencing intermethod agreement between Goldmann Applanation, Pascal Dynamic Contour, and Ocular Response Analyzer tonometry. Journal of Glaucoma 2013 Aug;22():487-95.

Susanna CN, Diniz-Filho A, Daga FB, et al. A Prospective Longitudinal Study to Investigate Corneal Hysteresis as a Risk Factor for Predicting Development of Glaucoma. Am J Ophthalmol. 2018 Mar;187:148-152.

Touboul D, Bénard A, Mahmoud AM, et al. Early biomechanical keratoconus pattern measured with an ocular response analyzer: curve analysis. J Cataract Refract Surg. 2011 Dec;37(12):2144-50.

Zhang C, Tatham AJ, Abe RY, et al. Corneal hysteresis and progressive retinal nerve fiber layer loss in glaucoma. Am J Ophthalmol. 2016 Mar 3. pii: S0002-9394(16)30084-8.

## POLICY HISTORY/REVISION INFORMATION

Date	Action/Description
12/01/2018	<ul style="list-style-type: none"><li>Simplified non-coverage rationale (no change to guidelines)</li><li>Archived previous policy version DIAGNOSTIC 048.14 T2</li></ul>

## INSTRUCTIONS FOR USE

This Clinical Policy provides assistance in interpreting UnitedHealthcare Oxford standard benefit plans. When deciding coverage, the member specific benefit plan document must be referenced as the terms of the member specific benefit plan may differ from the standard plan. In the event of a conflict, the member specific benefit plan document governs. Before using this policy, please check the member specific benefit plan document and any applicable federal or state mandates. UnitedHealthcare Oxford reserves the right to modify its Policies as necessary. This Clinical Policy is provided for informational purposes. It does not constitute medical advice.

The term Oxford includes Oxford Health Plans, LLC and all of its subsidiaries as appropriate for these policies. Unless otherwise stated, Oxford policies do not apply to Medicare Advantage members.

UnitedHealthcare may also use tools developed by third parties, such as the MCG™ Care Guidelines, to assist us in administering health benefits. UnitedHealthcare Oxford Clinical Policies are intended to be used in connection with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.