

Ocular Response Analyzer in Glaucoma

In the last decade, the association between ocular biomechanics and glaucoma has seen a remarkable renaissance of interest.

****Central Corneal Thickness****

Independent predictor of POAG

- **Development (OHTS)**
- **Progression (EMGT)**



Gordon MO et al. The Ocular Hypertension Treatment Study: Baseline factors that predict the onset of Primary Open-Angle Glaucoma. Arch Ophthalmol 2002;120(6):714-720.)

Leske MC et al. Predictors of long-term progression in the early manifest glaucoma trial. Ophthalmology. 2007 Nov;114(11):1965-72.

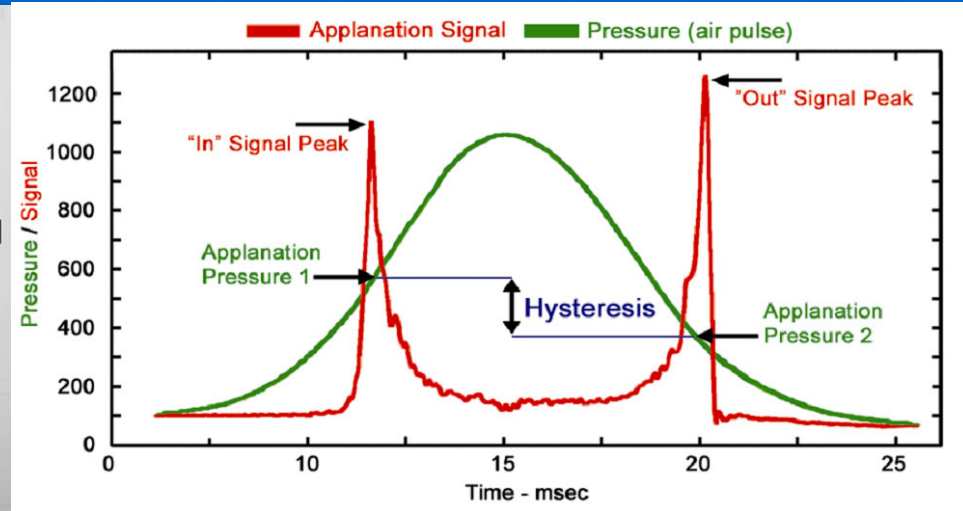
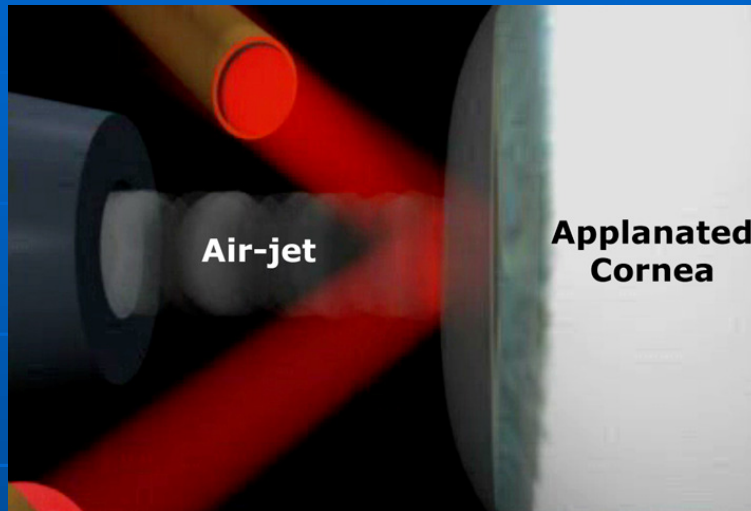
However, although CCT is helpful, its diagnostic precision is relatively poor

- **Patients with > 600um CCT have glc**
- **Patients with < 500um CCT do not**

*****OHTS: ~15% thin vs 5% thick CCT*****

So, the question arises: Do corneal properties beyond central thickness provide better diagnostic/ prognostic precision than CCT ?

What is corneal hysteresis ?



Corneal hysteresis (CH) is a measure of:

- A. Corneal damping capacity**
- B. Visco-elasticity**
- C. Energy absorption capability of cornea**

CH is NOT a measure of ocular rigidity/stiffness

Mean Corneal Hysteresis differs between glaucoma and non-glaucoma groups.

In 298 consecutive right eyes, CH differed between diagnostic groups
(Sullivan-Mee et al. OVS 2008)

	POAG	OH	GS	NML
CH (mm Hg)	*8.1 ±1.5 (5.0, 11.9)	8.9 ±1.3 (6.1, 12.6)	8.9 ±1.4 (5.3, 12.7)	*9.7 ±1.5 (6.2, 12.8)
CCT (µm)	541 ±41 (465 to 657)	*566 ±36 (454 to 639)	547 ±36 (462 to 630)	546 ±33 (464 to 636)

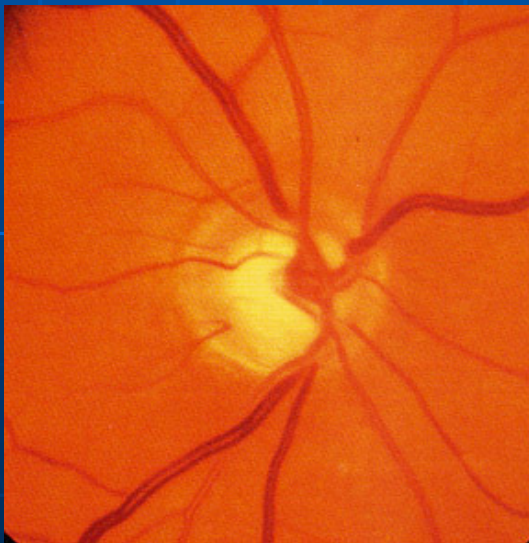
- **Retrospective study at Wilmer (n=367): Congdon et al (Arch Ophthalmol 2005) reported:**

Corneal hysteresis was independently associated with subjects that demonstrated progressive visual field loss

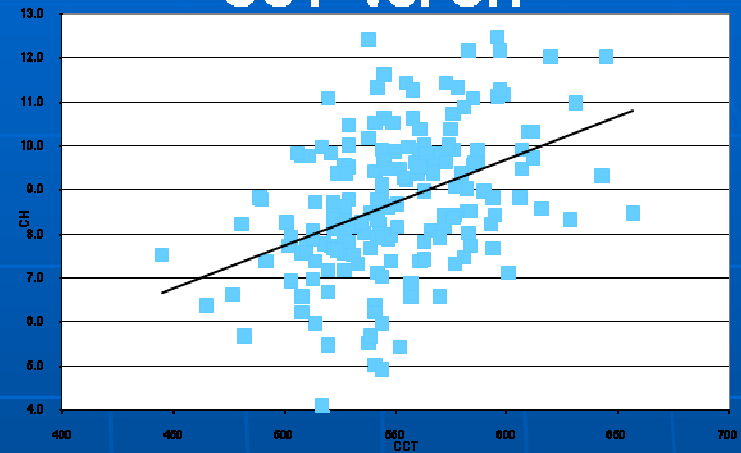
Congdon N et al. Central corneal thickness and corneal hysteresis associated with glaucoma damage. Arch Ophthalmol 2006.

So HOW is CH related to Glaucoma ?

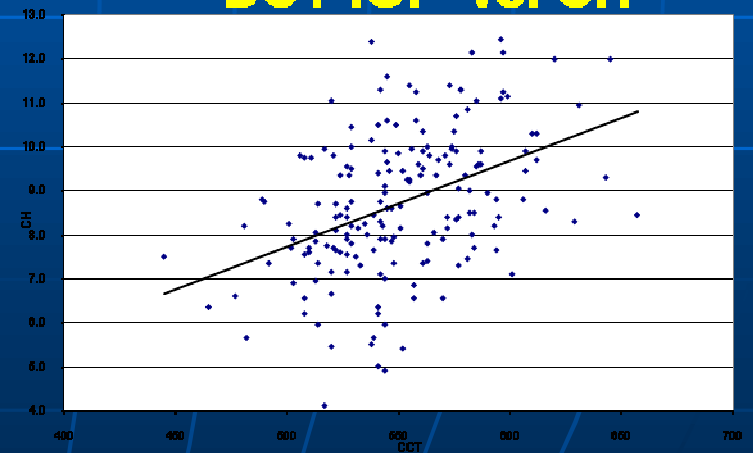
IOP effect
CCT relationship
Corneal damping
Optic nerve susceptibility



CCT vs. CH



DCT-IOP vs. CH



Toubol D et al. Correlations between corneal hysteresis, intraocular pressure, and corneal central pachymetry. J Cataract Refract Surg 2008
Johnson CS et al. Role of corneal elasticity in damping of intraocular pressure. IOVS 2007.
Liu J, He X. Corneal stiffness affects IOP elevation during rapid volume change in the eye. IOVS 2009

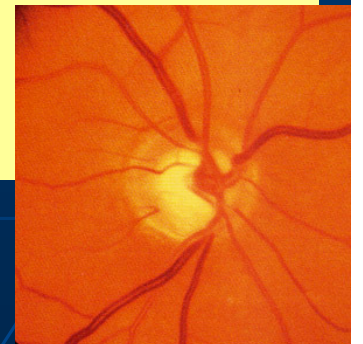
CH and Glaucomatous optic neuropathy ?

Wells et al (IOVS 2008) reported that optic nerve compliance is associated with CH in patients with glaucoma

- **Greater CH associated with more bowing of lamina with IOP elevation**

Bochmann et al reported that corneal hysteresis was lower in glaucomatous eyes with acquired pit of the optic nerve (APON) vs glaucomatous eyes without APON.

Graefes Arch Clin Exp Ophthalmol. 2008



Clinical use of ORA

**Mean CH lower in glaucoma
--but 95% CI fairly wide**

**Mean CRF higher in OH
--but 95% CI fairly wide**

Mean CH and CRF vary with IOP
CH inversely related to IOP and age
CRF directly related to IOP and age

Mean CH and CRF vary with CCT
CH directly related to CCT
CRF directly related to CCT

PURPOSE

To compare ORA-derived anterior segment biomechanical properties between glaucoma and glaucoma suspect after creation of central corneal thickness subgroups

165 subjects; split into 3 equal CCT subgroups (55 each group)

Within each subgroup, separated by diagnosis: definite glaucoma vs glaucoma suspect (OH and GS)

Descriptive Statistics

THIN CCT 445-537um	<u>DX</u>	<u>N</u>	<u>AGE</u>	<u>GMED</u>	<u>CD</u>	<u>NFL</u>	<u>MD</u>	<u>PSD</u>
	no glc	26	63.2	0.31	0.63	91.8	-0.22	1.80
	glc	29	66.9	0.55	0.78	66.8	-5.17	5.55
	t-test		0.12	0.07	0.00	0.00	0.00	0.00
INTERMED CCT 536-566um	no glc	35	61.4	0.29	0.62	93.0	-0.23	1.81
	glc	20	75.1	0.75	0.76	65.1	-4.93	5.67
	t-test		0.00	0.00	0.01	0.00	0.00	0.00
THICK CCT 568-634um	no glc	39	60.3	0.28	0.53	96.1	0.07	1.67
	glc	16	66.8	0.75	0.73	65.5	-5.39	5.99
	t-test		0.01	0.00	0.00	0.00	0.00	0.00

Descriptive Statistics

	<u>DX</u>	<u>N</u>	<u>CCT</u>	<u>IOPCC</u>	<u>IOPG</u>	<u>DCT</u>	<u>DCT-GAT</u>
THIN CCT 445-537um	no glc	26	517	18.3	15.6	18.19	3.18
	glc	29	512	17.9	14.5	16.74	2.63
	t-test		0.22	0.74	0.34	0.18	0.19
INTERMED CCT 536-566um	no glc	35	549	17.7	15.8	17.46	2.20
	glc	20	552	19.7	16.6	18.16	2.49
	t-test		0.26	0.10	0.46	0.48	0.66
THICK CCT 568-634um	no glc	39	596	19.9	19.4	19.77	1.69
	glc	16	581	20.3	18.4	18.70	2.42
	t-test		0.01	0.80	0.51	0.41	0.09

Pearson correlations with DCT:

AVCHCRF: $r = 0.17$ ($p=0.03$)

CH: $r = -0.25$ ($p=0.002$)

CRF: $r = 0.49$ ($p<0.001$)

**AVCHCRF (mean of CH and CRF values):
Less affected by IOP variation**

Biomechanical Statistics

THIN CCT 445-537um	DX	N	AGE	CRF	CH	AVCRFCH
	no glc	26	63.2 ±9	8.72 ±1.5	8.37 ±1.3	8.54 ±1.2
	glc	29	66.9 ±9	7.91 ±1.5	7.80 ±1.1	7.85 ±1.1
	t-test		0.12	0.05	0.08	0.03
INTERMED CCT 536-566um	no glc	35	61.4 ±9	9.32 ±1.6	9.01 ±1.6	9.17 ±1.4
	glc	20	75.1 ±7	8.61 ±0.9	7.87 ±1.4	8.24 ±1.0
	t-test		0.00	0.07	0.01	0.01
THICK CCT 568-634um	no glc	39	60.3 ±7	11.17 ±1.5	9.90 ±1.3	10.54 ±1.2
	glc	16	66.8 ±9	9.88 ±1.6	8.75 ±1.5	9.32 ±1.2
	t-test		0.01	0.01	0.01	0.00

Multivariate regression analyses

Independent variables

Thin CCT group

AVCHCRF

$r^2=0.08$

**Intermediate
CCT group**

AVCHCRF

Age

$r^2=0.38$

Thick CCT group

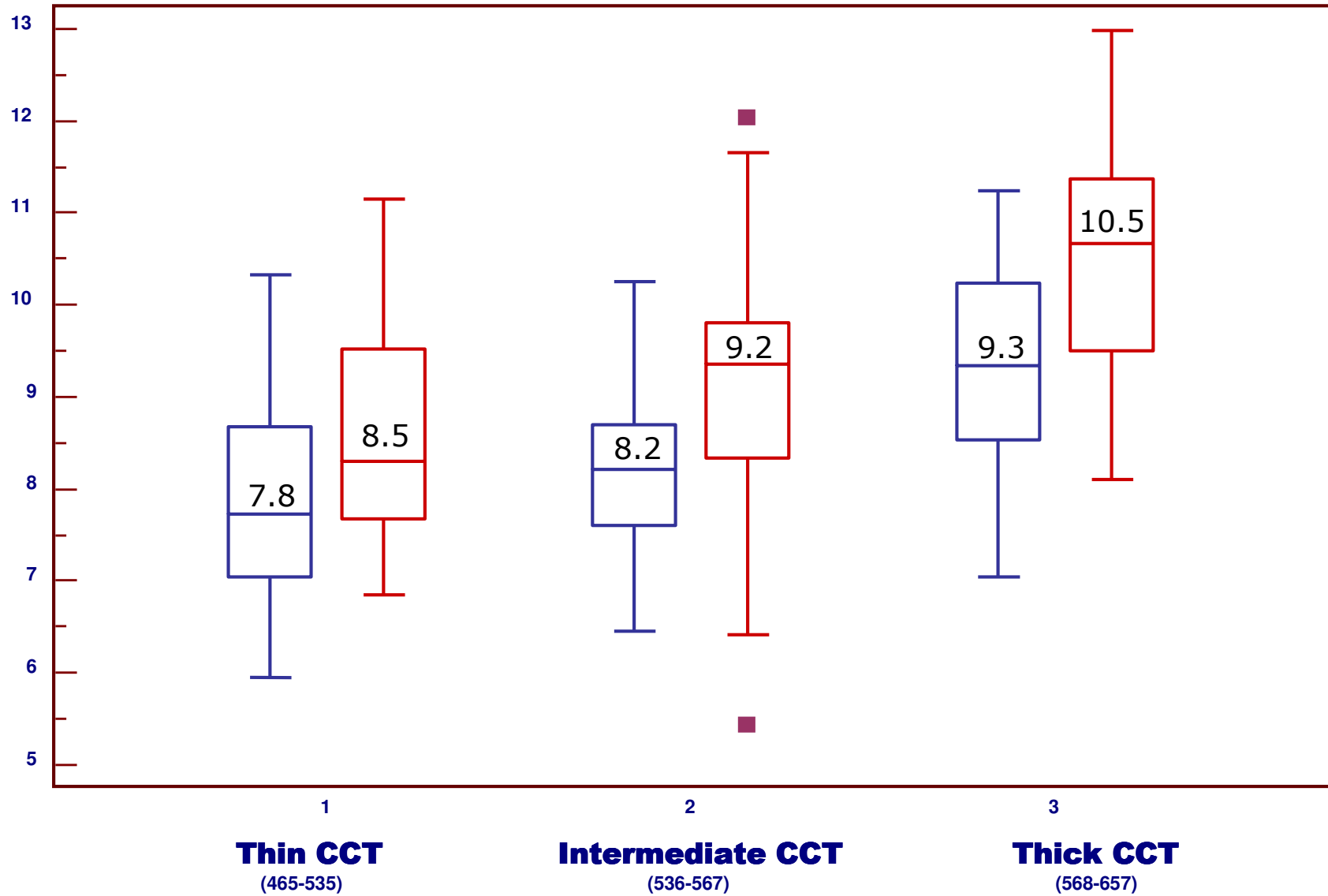
AVCHCRF

Age

CCT

$r^2=0.31$

AVCRFCH: Glaucoma (blue) vs. Glaucoma suspect (red)



SUMMARY

Research to date indicates that ORA-derived biomechanical properties provide unique insight into glaucoma.....

..... And that they have great potential to improve risk analysis, decision-making and outcomes in glaucoma

THANK YOU