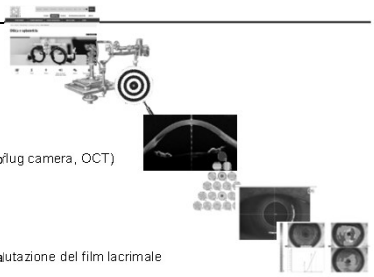
Valutazione del segmento oculare anteriore nella pratica optometrica moderna

Fabrizio Zeri
Giulia Rizzo

Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca
Optics and Optometry Research Center (COMiB), Università degli Studi di Milano-Bicocca

Key points



- Intro CdL e Comib
- Biomicroscopia
- Topografia Corneale
- Tomografia (Scheimpflug camera, OCT)
- Aberrometria
- Pupillografia
- Sistemi integrati di valutazione del film lacrimale

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Università degli Studi di Milano-Bicocca

- 14 Dipartimenti
- 33 Corsi di Laurea Triennale (di cui 11 di area scientifica)
- 40 Corsi di Laurea Magistrale (di cui 17 di area scientifica)

1° anno

- Anatomia e Istologia Umana e Oculare
- Chimica
- Fisica I
- Fisiologia Generale ed Oculare
- Istituzioni di Matematica I
- Ottica Geometrica e Oftalmica con Laboratorio
- Sistemi Ottici e Oftalmici con Laboratorio

2° anno

- Fisica II
- Istituzioni di Matematica II
- Laboratorio Ottica della Contattologia
- Laboratorio Tecniche Fisiche per l'optometria
- Ottica della Contattologia Generale
- Percezione Visiva
- Tecniche Fisiche per l'optometria Generale

3° anno

- Interazione Luce Materia
- Optometria Avanzata con Laboratorio
- Principi di Patologia Oculare
- Storia della Fisica Moderna e degli Strumenti Ottici

+ TIROCINIO
+ PROVA FINALE

Sito del Dipartimento di Scienza dei Materiali

E-learning

Didattica
e-mail: didattica.ottica@animib.it
tel. 02 6448 6556

OTTICA E OPTOMETRIA

Ricerca

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OPTICS AND OPTOMETRY RESEARCH CENTER
UNIVERSITY OF MILANO BICOCCA

- Alessandro Borghesi
- Alessandro Duse
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- Erika Ponzini
- Giulia C. Rizzo
- Riccardo Rolandi
- Silvia Tavazzi
- Fabrizio Zeri

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Pubblicazioni peer-review COMiB (2014-oggi)

Centro universitario di ricerca in ottica e optometria Milano - Bicocca (COMiB)

Costituito nel 2015 presso il Dipartimento di Scienza dei Materiali dell'Università di Milano-Bicocca per creare un collegamento tra il mondo accademico e le attività produttive su tutto il territorio nazionale. In sinergia con ricercatori esterni di altri dipartimento quali Scienze Sociali, Psicologia, Medicina e Statistica.

https://comib.unimib.it/

Ambiti d'azione:

- ✓ Ricerca (Ottica, optometria, lenti a contatto, percezione visiva, scienza dei materiali) anche in collaborare con aziende.
- ✓ Screening e analisi visiva (effettuare analisi visive in collaborazione con la Medicina del Lavoro dell'Università, fornire un servizio al territorio [UFYE])
- ✓ Formazione (tirocini studenti, corsi di formazione avanzata e aggiornamento professionale in collaborazione con aziende e/o associazioni di professionisti)

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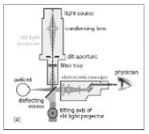
Lampada a fessura

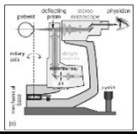
WHY

•Valutazione delle strutture oculari (anteriori: cornea, congiuntiva, palpebre, film lacrimale, cristallino)



•Valutazione delle lac (integrità strutturale, bagnabilità, …)

•Valutazione relazione lente-occhio: posizione, movimento, immagine fluoroscopica (lac RGP, Sclerali).



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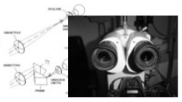
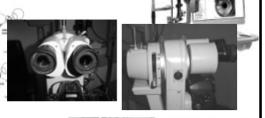
Lampada a fessura: componenti

10

•Sistema di osservazione (biomicrosco

-stereomicroscopio
-ingrandimenti da 5x a 40x





•Sistema d'illuminazione: lampada a fessura

-fascio di luce sezionabile, orientabile e disassabile (tilting)
-filtri (diffusore, rosso privo, cobalto..)

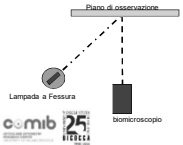
•Sistema meccanico

-coassialità tra i due sistemi
-movimento sincrono
-favorisce un preciso dislocamento del paziente

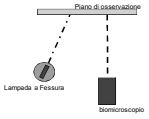
Lampada a fessura: tecniche

11

•Diretta (si guarda ciò che s'illumina)
- Diffusa
- Sezione Ottica
- Parallelepipedo
- Ampio fascio
- Fascio Conico
- Riflessione Speculare
- Obliqua (radente)



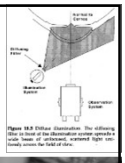
•Indiretta
- Diffusione sclerale
- Retroilluminazione
  - Diretta
  - Indiretta
- Adiacente o prossimale



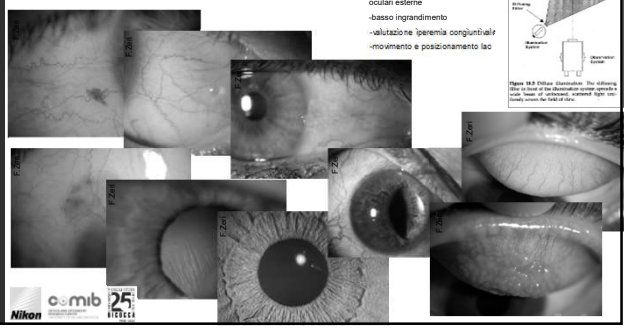
Lampada a fessura: tecniche

•Diffusa

-veduta d'insieme delle strutture oculari esterne
-basso ingrandimento
-valutazione iperemia congiuntivale
-movimento e posizionamento lac



•Dirette



•Dirette

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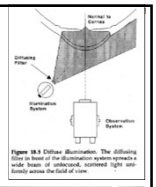
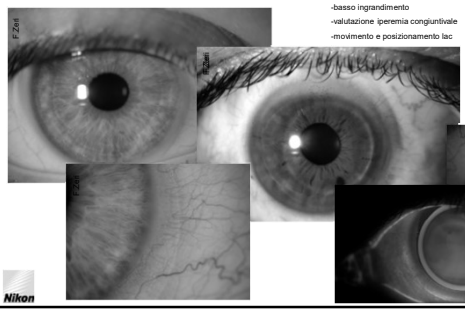
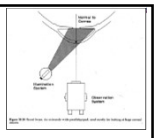
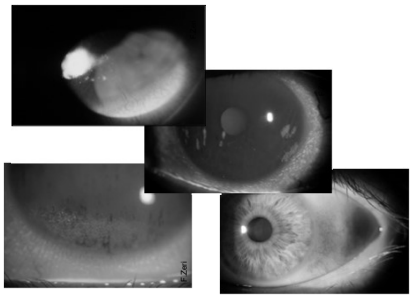




•Dirette

Lampada a fessura: tecniche

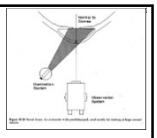


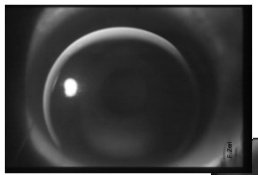


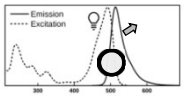
•Ampio fascio
-fascio ampio (1-5 mm)
-ridurre la luminosità reostato
-ampie opacità cornea, pterigio, detriti sotto le lac, pattern fluoresceinico…

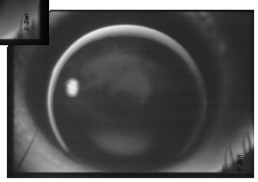
•Dirette

Lampada a fessura: tecniche







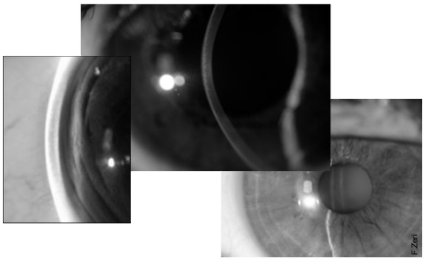


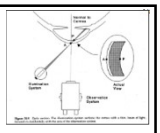
il filtro giallo

•Ampio fascio
-fascio ampio (1-5 mm)
-ridurre la luminosità reostato
-ampie opacità cornea, pterigio, detriti sotto le lac, pattern fluoresceinico…

Lampada a fessura: tecniche

•Dirette





•Sezione Ottica

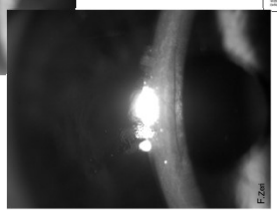
-fascio sottile (0,02-0,1mm)

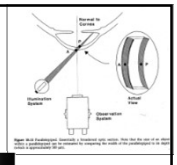
-angolo tra i 2 sistemi 30-60°

-corpi estranei, haze stromale, strie solchi etc…

Lampada a fessura: tecniche

•Dirette





•Parallelepipedo

-fascio sottile

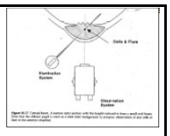
-angolo tra i 2 sistemi 30-60°

-corpi estranei, haze stromale,

strie solchi, staining, vascolarizzazione…

Lampada a fessura: tecniche

•Dirette



•Fascio Conico

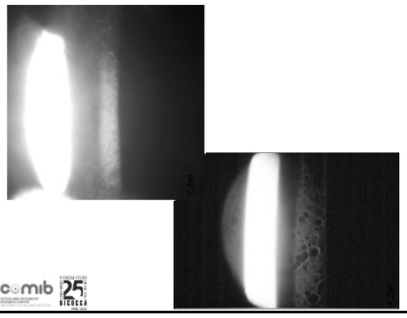
-sezione molto piccola (1-2mm)

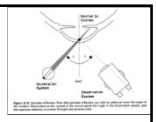
-focalizzazione in camera anteriore

-corpi in camera anteriore

Lampada a fessura: tecniche

•Dirette





•Riflessione Speculare

-uguale angolo tra i due sistemi rispetto alla bisettrice

-superficie strutture

-endotelio, film lacrimale (interferenza)

- Alto ingrandimento (40X)

Lampada a fessura: tecniche

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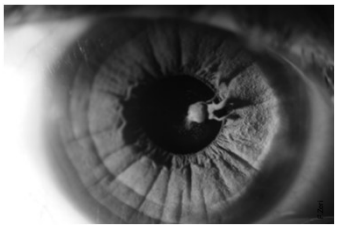
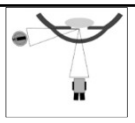
•Dirette





•Obliqua o radente

-ampio fascio

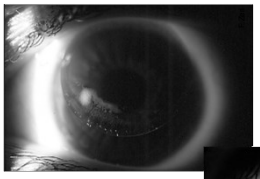
-angolo a 90°

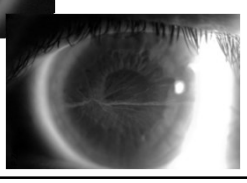
-visibili rilievi di una superficie

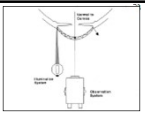
-trama iridea, depositi su di una lac

Lampada a fessura: tecniche

•Indirette







•Diffusione Sclerale

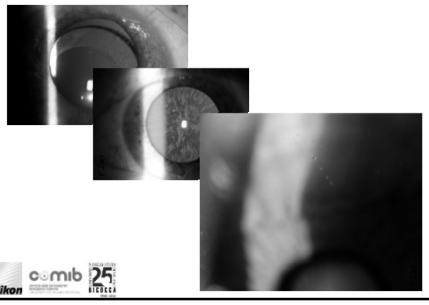
-fascio di luce diretto al limbus

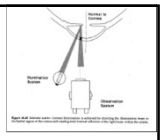
-riflessione totale all'interno della lamina corneale

-opacità corneali (edema, CCC, haze..)

Lampada a fessura: tecniche

•Indirette



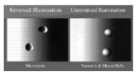


•Retroilluminazione diretta

-fascio diretto sull'iride, la retina o il cristallino che lo riflettono e consentono alla cornea di essere illuminata da dietro

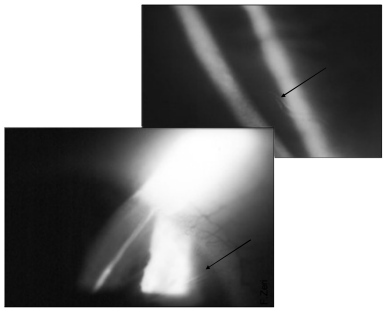
-l'oggetto appare su uno sfondo illuminato (nero su sfondo chiaro)

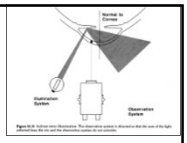
-microcisti, vacuoli , mucin balls, infiltrati….



Lampada a fessura: tecniche

•Indirette





•Retroilluminazione indiretta

-fascio diretto sull'iride, la retina o il cristallino che lo riflettono e consentono alla cornea di essere illuminata da dietro

-l'oggetto appare su uno sfondo scuro

-microcisti, vacuoli, mucin balls, infiltrati….

Key points

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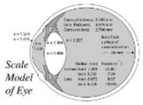
Topografia Corneale

WHY

- La struttura oculare con il più alto potere refrattivo. $F_{cornea}=2/3\ F_{total\ eye}$
- Le astigmatismo e le aberrazioni della superficie anteriore corneale prevalgono sull'astigmatismo e sulle aberrazioni delle altre strutture oculari interne.



BUT

- È estremamente complessa
- È caratterizzata da un'ampia differenza inter-personale

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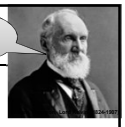
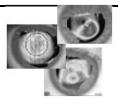
Topografia Corneale

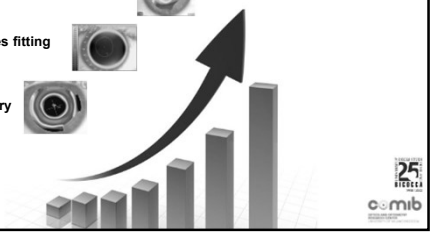


- **Knowledge about normal cornea and corneal disease**



- **Develop Contact Lenses fitting**

- **Develop Corneal surgery**



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Topografia Corneale: un po' di storia

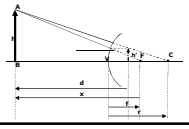
Spheres

Father Christoph Scheiner (1619)
First measure of shape.
He compared reflection of objects on the cornea and on glass spheres with known curvature

Keratometer

von Helmholtz (1854) first keratometer for clinical use (ophthalmometer)

Javal and **Schiotz'** keratometer (1881)



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Topografia Corneale: un po' di storia

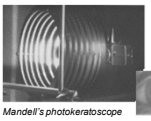
Keratoscope

-Cuignet (1820)
-Henry Goode (1847)
-Antonio Placido (1880)

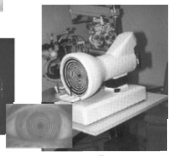
Klein keratoscope

Photokeratoscope

Quantitative analysis of keratoscopy
(1896) Allvar Gullstrand



Mandell's photokeratoscope



Rowsey e coll 1981
CorneaScope (Kera Corporation)

Nikon

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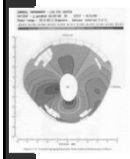
Topografia Corneale: un po' di storia

Computerized Videokeratoscope (CVK)



Doss (1981)
algorithm to calculate corneal shape from a photokeratoscopy.

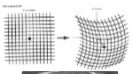
Klyce (1984)
computerized procedure to build and plot corneal shape.

Maguire et al *(1987)*
colour-coded contor map

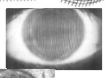
Projection-based System

Slit Photography

Scheimpflug Camera



Rasterstereophotography



Moire' Interference

Laser Interferometry

Corbett, Rosen O'Brat, 1999

Nikon

30

Topografia Corneale: un po' di storia

Reflection based systems: the most prevalent option

Stephen Klyce
Corneal Topography. In Efron The Cornea. (2001)

Table 6.1 Corneal topographers

Manufacturer	*Model(s)*	*Method*
Alcon Surgical	EyeMap EH-290	Placido
Allianze Medical Mkts	Keratron CT; Scout	Placido
B & L Surgical	Orbscan II	Scanned slits and Placido
B & L Surgical	Orbshot	Placido
Dicon	CT-200	Placido
Euclid Systems	ET-800	Fluorescein profilometry
Eyetlys/Premier	Eyetlys 2000; Vista	Placido
Eyetek	CT2000	Placido
Humphrey Instruments	Atlas 991, 992	Placido
Kera Metrics	CLAS-1000	Laser holography
Medmont	E300	Placido
Oculus	Keratograph	Placido
PAR Vision Systems	CTS, Actagrid	Fluorescein profilometry
PAR Vision Systems	Intracap, CTS	Fluorescein profilometry
Sun Contact Lens Co.	SK-2000	Placido
TechnoMed Technology	C-SCAN	Placido
Tomey Technology	AutoTopographer	Placido
Topcon America Corp.	CM-1000	Placido

Nikon

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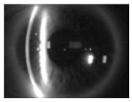
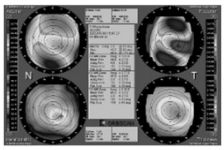
Topografia Corneale: un po' di storia

Integrated systems:

Placido-based CVK + scanning slit beam technology (Orbscan, B&L)





Nikon

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Topografia Corneale: un po' di storia

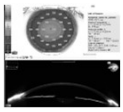
Integrated systems:

Pure rotating Scheimpflug camera system + Pupillography

Pentacam, Oculus

Integrated systems: Placido-based CVK + Scheimpflug Camera + Pupillography + Dry Eye Assessment

Sirius, CSO



Tomographic representation

Thickness (map)

Anterior chamber depth

Anterior chamber angle

Nikon

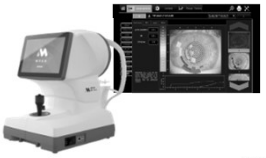
33

Topografia Corneale: un po' di storia

Integrated systems:

Placido-based CVK + Optical biometer + Pupillography + Tear film assessment

Aladdin, Topcon



Myah, Topcon

Nikon

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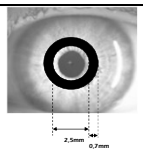
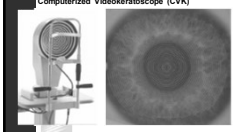
Topografia Corneale: caratteristiche

Keratometer



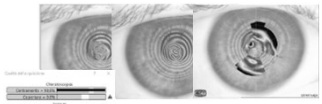
versus

Computerized Videokeratoscope (CVK)



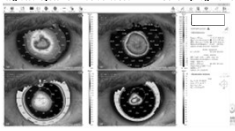
- Up to 95% of coverage of corneal surface (up to 11 mm of diameter)
- Up to 38 rings
- Over 6000 points of measurement (can reach more than 10000)

Computerized Videokeratoscope (CVK)



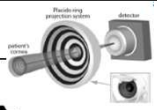
versus

Integrated systems: Placido-based CVK + Scheimpflug Camera



Nikon

Topografia Corneale: funzionamento



Keratoscope

Digital video-camera acquires keratoscopic image

1 Capturing

Specific software analyses digital image

2 Processing

Output on monitor

3 Visualization

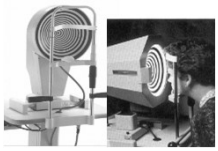
Nikon

Topografia Corneale: caratteristiche

1 *Capturing*

Keratoscope

Large-diameter Placido disc
(long working distance, less sensitive to misalignement, eclipsis problems)



Small-diameter Placido disc
(short working distance, automatic alignement and focusing, no problem of eclips or shadow)

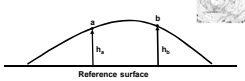
Nikon

Topografia Corneale: caratteristiche

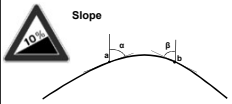
Processing

2

Height or elevation

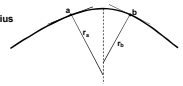


Slope

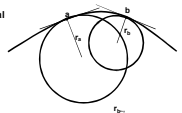


Curvature

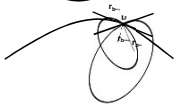
- Axial radius



- Tangential radius



- Gaussian



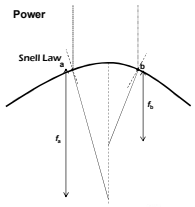
Nikon

Topografia Corneale: caratteristiche

Processing

2

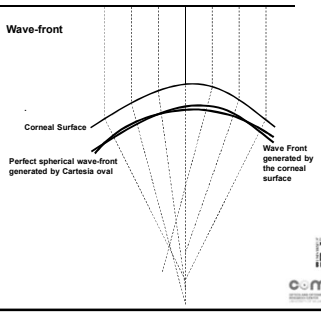
Power



Radius of curvature can be converted in Diopters

$$F = \frac{n' - n}{r}$$

Wave-front



Nikon

Topografia Corneale: caratteristiche

Visualization

3

- **Keratoscopic image (raw)**

- **Color-coded map**

- **Cross Sections**

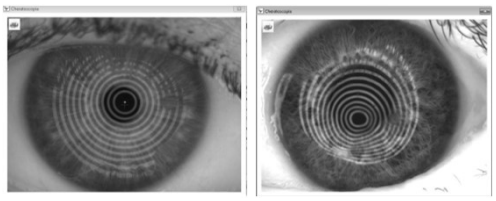
- **Numeric and statistical displays**

Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Keratoscopic image (raw)



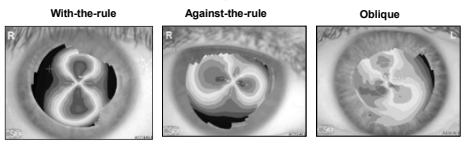
Analisi qualitativa

Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded maps
They provide a rapid method for clinical diagnosis

Regular Astigmatism

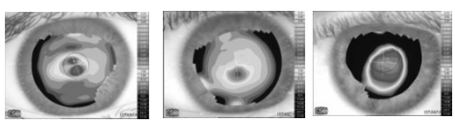


Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded maps
They provide a rapid method for clinical diagnosis

Keratoconus

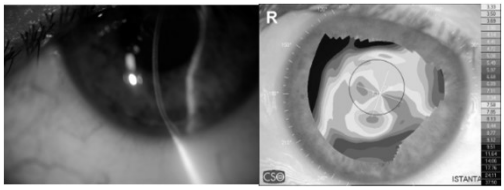


Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded maps
They provide a rapid method for clinical diagnosis

Pellucid marginal degeneration



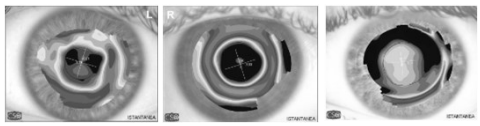
Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded maps
They provide a rapid method for clinical diagnosis

Post Refractive Surgery

PRK **Lasik High Myopia** **PRK Hyperopia**



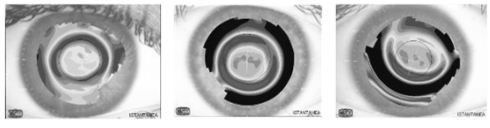
Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded maps
They provide a rapid method for clinical diagnosis

Orthokeratology

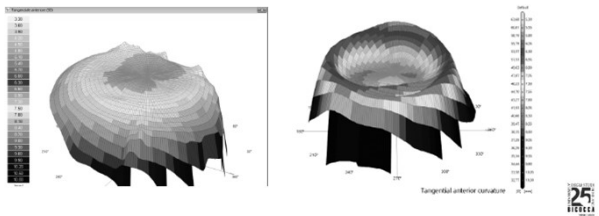
Well centred **Slightly decentred** **Extremely decentred**



Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded map: 3D

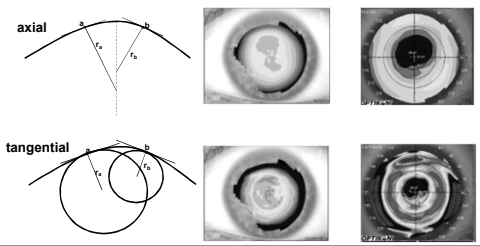


Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded map: algorithm



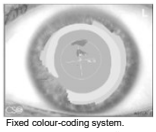
Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded map: scale

Absolute
(standardised)

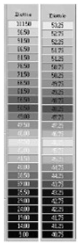


Fixed colour-coding system.

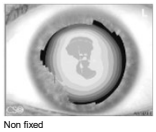
Absolute scales can be different among manufacturers.

-Klyce-Wilson scale (1.50D step).

-26 steps of 1.50D between 35.5 and 50.5D and 5.00 D above and below from 9.0 to 101.50D



Normalized
(relative)



Non fixed

Adaptable scale self-adjusted to the range of powers of a given cornea

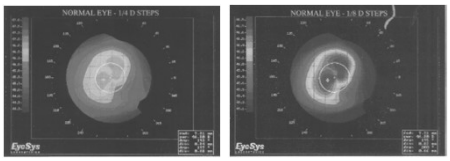
Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Color-coded map: scale

Adjustable scale

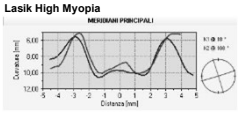


Topografia Corneale: caratteristiche

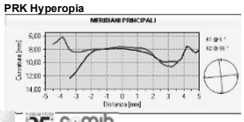
3 *Visualization*

Cross Sections

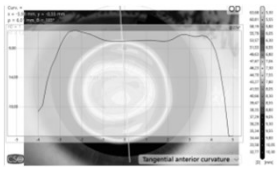
Lasik High Myopia



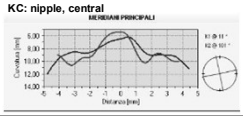
PRK Hyperopia



Ortho-K Myopia



KC: nipple, central



Topografia Corneale: caratteristiche

3 *Visualization*

Numeric and statistical displays

Cursor box

Numerical m_{ap}

Basic Topographic Indexes
(SimK, Asphericity, LSA, Average corneal power)

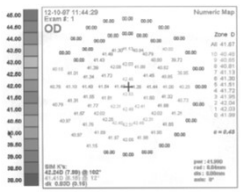
Indexes for Corneal Optical Quality
(SRI, SAI, RMS, MTF)

Keratoconus Indexes (AK, AGC, I-S value, KPI)

Topografia Corneale: caratteristiche

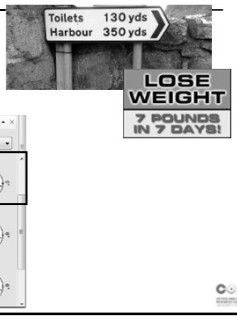
Cursor box

Numerical map



Topografia Corneale: caratteristiche

Basic topographic indexes: SimK



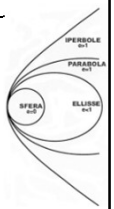
Topografia Corneale: caratteristiche

Basic topographic indexes: Asphericity

Normal Corneal Asphericity		
4.5mm	e=0.31±0.24 (-0.46/0.73)	p=0.86±0.12 (0.47/1.21)
8.0mm	e=0.51±0.14 (-0.22/0.93)	p=0.72±0.13 (0,14/1.05)

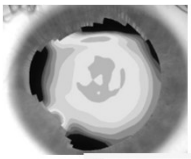
ASFERICITÀ

Meridiani principali (4.5 mm)		
Ro =	7,72 mm @ 165°	e = 0,45
Ro =	7,47 mm @ 75°	e = 0,47
Ro(AVG) =	7,60 mm	e = 0,46
Meridiani principali (8 mm)		
Ro =	7,68 mm @ 165°	e = 0,72
Ro =	7,45 mm @ 75°	e = 0,62
Ro(AVG) =	7,56 mm	e = 0,67

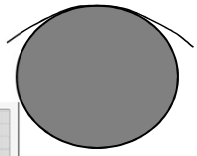


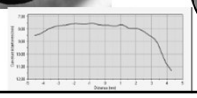
Topografia Corneale: caratteristiche

Centrally, Normal Cornea has a slightly prolate asphericity that increases towards periphery.



Normal Corneal Asphericity	
4.5mm	p=0.86 (0.47/1.21)
8.0mm	p=0.72 (0.14/1.05)

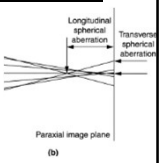




Topografia Corneale: caratteristiche

Basic topographic indexes: LSA (longitudinal spherical aberration)

p	e	LSA (3mm)	LSA (5mm)	LSA (7mm)
0,8	0,45	+0,30	+0,84	+1,70



Topografia Corneale: caratteristiche

Basic topographic indexes: SRI

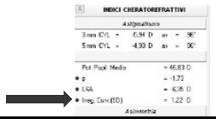
SRI= Surface Regularity Index

Index of central corneal optical quality.

RMS of curvature with respect to a best fit aspherical surface

SRI=0 indicates a perfect smooth surface

High correlation between SRI and BCVA (Wilson and Klyce, 1991)



Topografia Corneale: caratteristiche

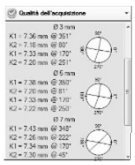
3 *Visualization*

Indexes for Corneal Optical Quality: SAI

SAI= Surface Asymmetry Index

The mean difference between the tangential curvature along two opposite semi-meridians on each meridian.

SAI=0 indicates a cornea with a perfect symmetrical optical zone

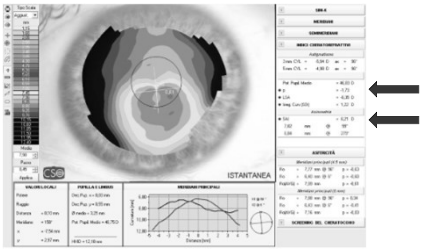


Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Basic topographic indexes: Asphericity, LSA, SRI, SAI

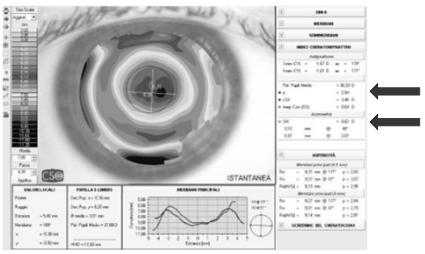


Nikon

Topografia Corneale: caratteristiche

3 *Visualization*

Basic topographic indexes: Asphericity, LSA, SRI, SAI



Nikon

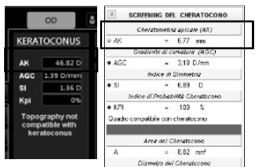
Topografia Corneale: caratteristiche

Keratoconus Indexes

AK= Apex Keratometry/Curvature

Tangential curvature at corneal apex (point of maximum curvature)

Central K (Rabinovitz, 1989)



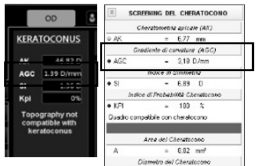
	Normal ± 2SD	Suspect Between 2 and 3 SD	Pathological >3 SD
AK (D)	<48	≥48; ≤ 50	>50

Topografia Corneale: caratteristiche

Keratoconus Indexes

AGC= Apical Gradient of Curvature

Average dioptrical variation of curvature for a certain corneal distance (slope)



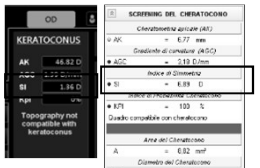
	Normal ± 2 SD	Suspect Between 2 and 3 SD	Pathological >3 SD
AGC (D/mm)	<1.5	≥1.5; ≤2	2

Topografia Corneale: caratteristiche

Keratoconus Indexes

SI= Symetry Index

Difference between average tangential curvature of two symmetric area placed superiorly and inferiorly to the corneal vertex



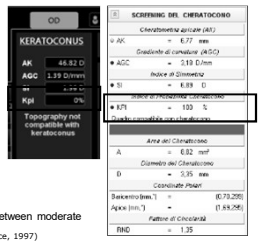
	Normal ± 2 SD	Suspect Between 2 and 3 SD	Pathological >3 SD
SI (D)	<1,5	≥1,5; ≤2	2

Topografia Corneale: caratteristiche

Keratoconus Indexes

KPI= Keratoconus Prediction Index

It provides an estimation of possibility to have keratoconus.

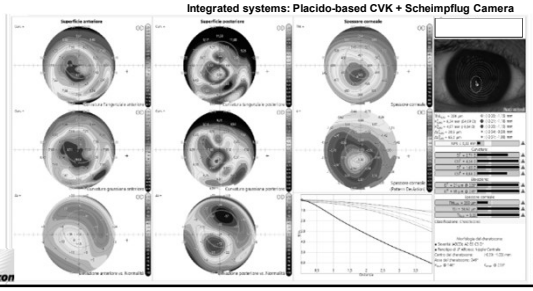


KPI is not a good index to distinguish between moderate and severe keratoconus (Smolek and Klyce, 1997)

Topografia Corneale: caratteristiche

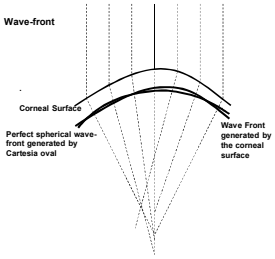
Keratoconus Indexes

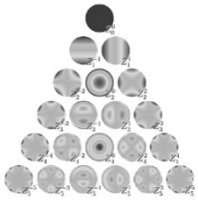
Integrated systems: Placido-based CVK + Scheimpflug Camera

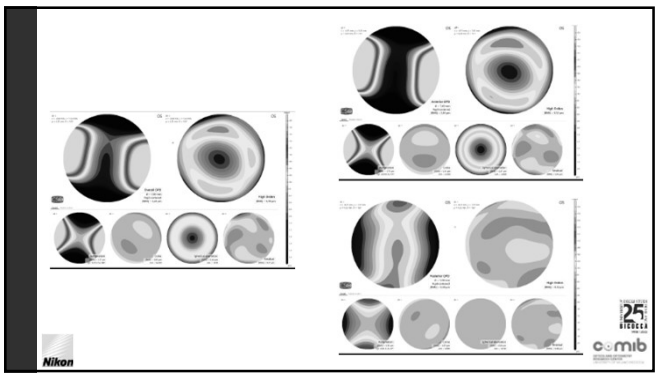


Topografia Corneale: caratteristiche

Aberrazioni corneali

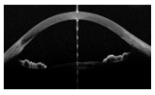






Key points

- Intro CdL e COMiB
- Biomicroscopia
- Topografia Corneale
- Tomografia (Scheimpflug camera, OCT)
- Aberrometria
- Pupillografia
- Sistemi integrati di valutazione del film lacrimale



Sistemi a riflessione vs sistemi a scansione

- Sistemi a riflessione (es topografo): presentano una miglior accuratezza nella rappresentazione della cornea anteriore
- Sistemi a scansione (es Scheimpflug): ampia copertura, mappe curvatura e elevazione posteriori, pachimetria etc

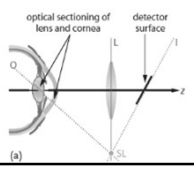
Sistemi combinati

Tomografia: tomos = taglio + grapho = scrivere/registrare (greco)

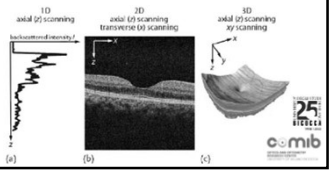
WHAT?

Tecnica di imaging che consente di ottenere immagini dettagliate di una sezione specifica del corpo o di un oggetto tridimensionale. Questa tecnica è ampiamente utilizzata per visualizzare gli strati interni in modo non invasivo.

Scheimpflug tomography

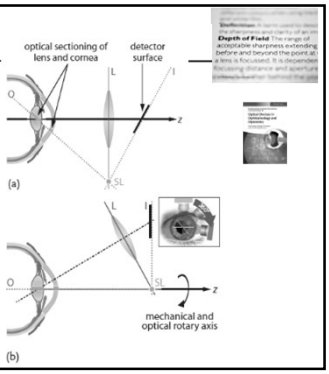


Optical Coherence Tomography



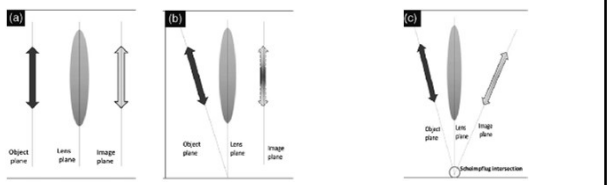
Scheimpfulg camera

Theodor Scheimpflug (1865-1911):
Capitano dell'esercito austriaco che mise a punto uno strumento per correggere le distorsioni dovute alla prospettiva nella fotografia aerea.



Scheimpfulg camera

WHY

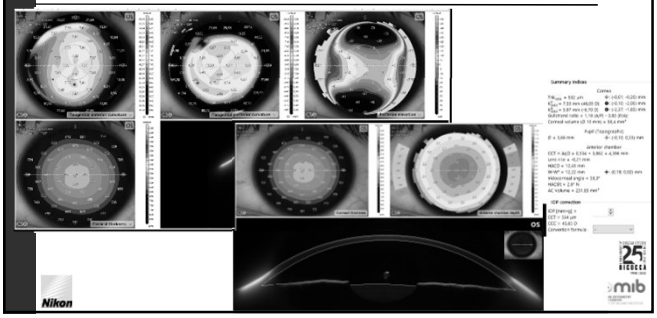


Normally, the lens principal plane and the image plane of a camera are parallel (a). If the object plane is not parallel to the lens, the image will be sharp only along a line where the image intersects the plane of the detector (b)

Scheimpflug condition: The detector plane and the lens plane meet at a line through which also the object plane passes. With this condition, the image of a planar object that is not parallel to the detector plane can be completely sharp.

* a) b) c) Non in scala

Scheimpfulg Tomographer + Reflection Topography



Optical Coherence Tomography

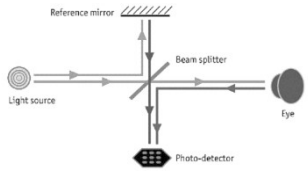
La tomografia a coerenza ottica (Optical Coherence Tomography, OCT) applicata all'occhio è una tecnica diagnostica non invasiva nata negli anni Novanta del Novecento.

Year	Milestone
1991	Demonstration of OCT *in vitro*
1993	First *in vivo* images of the retina
1994	Carl Zeiss (Humphrey Instruments) acquired OCT technology
1995	Clinical studies with first prototypes
1996	First commercial TD-OCT system introduced (ZEISS OCT 1)
1999	Approximately 200 units sold
2000	Improved commercial system ZEISS OCT 2
2001	Approximately 400 units sold
2002	Second generation TD-OCT system introduced (ZEISS Stratus OCT™)
2005	OCT becomes a standard of care
2006	Approximately 6000 units of ZEISS Stratus OCT sold
2006	Multiple companies enter ophthalmic market with FD-OCT devices
2009	Worldwide OCT revenues exceed US$ 250 million
2010	US Medicare reimbursed OCT procedures exceed 8 million
2010	Worldwide reimbursement payments exceed US$ 1 billion
2012	ZEISS Cirrus™ HD-OCT reaches 10 000 installations
2012	Inventors of OCT receive Antonio Champalimaud Vision Award

Optical Coherence Tomography

- L'OCT fornisce immagini trasversali (x,y), ma anche sezioni tomografiche ((x,z) e (y,z)) della retina o del segmento anteriore dell'occhio.
- La tecnica OCT misura l'intensità della luce retro-diffusa o riflessa e il ritardo dell'eco. La misura del tempo di ritardo permette di misurare le distanze.
- L'OCT impiega radiazione elettromagnetica (tipicamente nel vicino IR) con cui è possibile ottenere una risoluzione spaziale tipicamente pari a 3-5 µm in direzione assiale (z) e 15-20 µm trasversalmente (x,y).

Optical Coherence Tomography



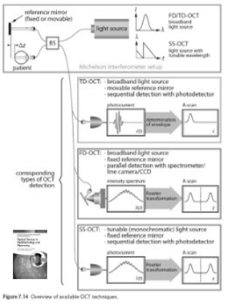
Schema generico basato su interferometro di Michelson

Optical Coherence Tomography

I primi OCT erano di tipo **Time Domain** (Specchio mobile).

Gli strumenti moderni sono di tipo **Fourier Domain**:

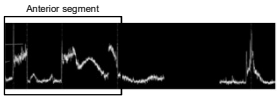
- Spectral Domain OCT (*SD-OCT*): lo specchio di riferimento è fisso (riduzione della probabilità di artefatti) e il rivelatore è uno spettrometro (es CCD) che rivela radiazioni di frequenza diversa. È più sensibile di un TD OCT. I tempi di acquisizione sono inferiori.
- Swept Source OCT (*SS-OCT*): l'informazione in frequenza si ottiene impiegando una sorgente che emette radiazione di lunghezza d'onda variabile. Esistono SS OCT che impiegano intervalli di lunghezza d'onda tra 1000 e 1300 nm; ciò permette la visualizzazione di strutture più profonde rispetto al caso delle lunghezze d'onda più corte.

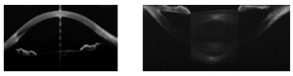


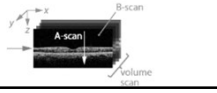
Optical Coherence Tomography

I risultati si rappresentano nelle forme:

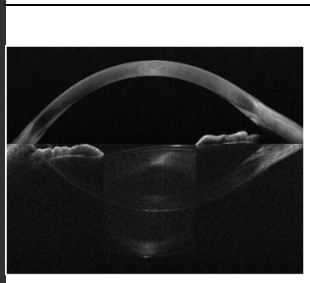
- A-scan 1D: riflettività delle strutture alle varie profondità (z) lungo un singolo raggio luminoso (es. misura della lunghezza oculare)
- B-scan 2D: insieme di A-scan acquisiti muovendosi lungo una linea (x oppure y) trasversale
- C-scan 3D: insieme di B-scan acquisiti con una scansione completa lungo x e lungo y

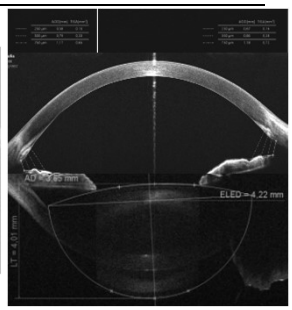






Anterior segment OCT: AS – OCT





Quale impiego dell'AS-OCT in Contattologia?

- **Assessment of anterior segment structures (ocular surfaces)**
  - Corneal thickness
  - Volume (TMV), tear meniscus height (HMT) and turbidity
  - Sagittal depth (for a specific chord)
- **Assessment of CLs**
  - CL thickness
  - Edge form (shape and thickness)
- **In vivo characterization of contact lens fitting and interaction with the ocular surface**
  - Blood vessel compression on the landing zone in Scleral CL
  - Vault thickness and fluid reservoir (FR) turbidity in Scleral CL
  - Epithelial thinning and peripheral thickening in orthokeratology

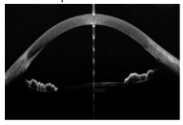
Quale impiego dell'AS-OCT in Contattologia?

- **L'AS-OCT nella misura delle strutture oculari**

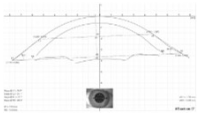
Immagini acquisite con **AS-OCT MS-39** (CSO)

Tear meniscus height

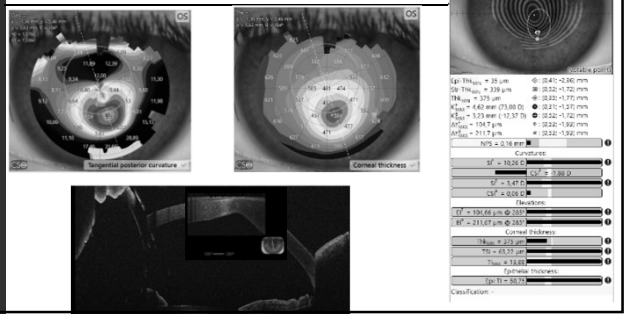
Lo spessore corneale



La stima della sagitta della superficie corneale anteriore



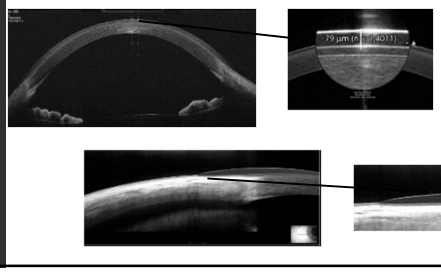
AS-OCT



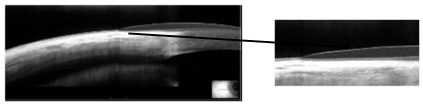
Quale impiego dell'AS-OCT in Contattologia?

- **L'AS-OCT nella valutazione del design delle LAC**

Immagini acquisite con **AS-OCT MS-39** (CSO)



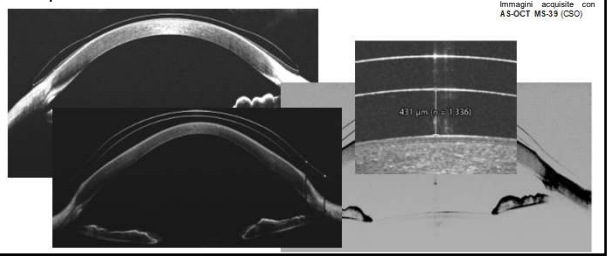
Attenzione all'indice di rifrazione

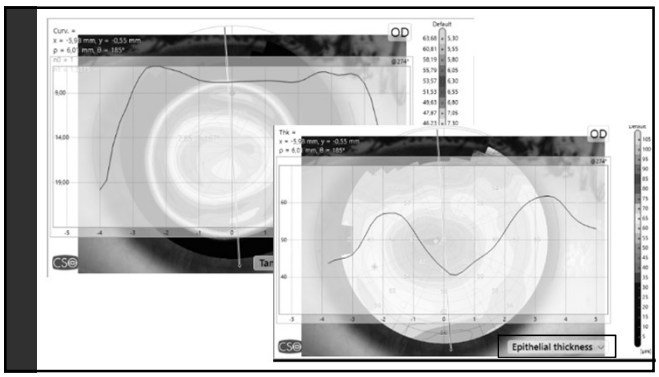


Quale impiego dell'AS-OCT in Contattologia?

- **Caratterizzazione in vivo dell'applicazione e interazione della LaC con la superficie oculare**

Immagini acquisite con **AS-OCT MS-39** (CSO)





Scheimpflug vs AS - OCT

Pro

Cons

Scheimpflug Tomography

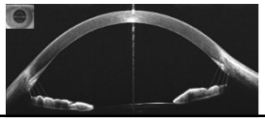
PRO
- Costi più contenuti
- 'Facilità' d'uso?

CONTRO
- Minor risoluzione
- Deformazione prospettica

AS-OCT

PRO
- Imaging ad alta risoluzione
- Maggior 'penetrazione' delle strutture

CONTRO
- Costi elevati
- Maggior collaborazione del soggetto?



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- Pupillografia
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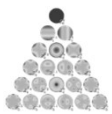
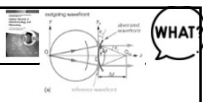
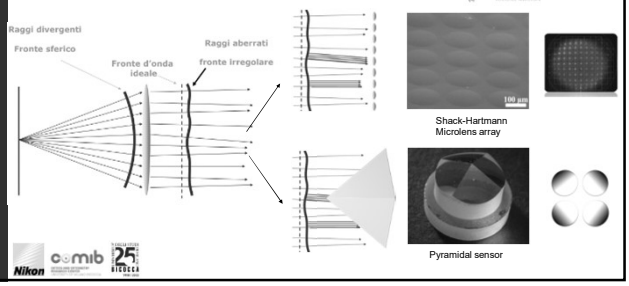


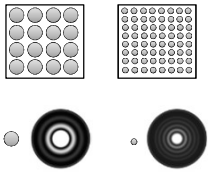
Aberrometria oculare





HSS vs WFP

Campionamento segnale e risoluzione strumento

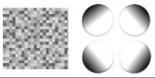


- Nel sistema Hartmann-Shack il fronte d'onda viene campionato da un array di lenti, la risoluzione dipende:
  - dal numero delle lenti (> numero > risoluzione)
  - dalla dimensione (< diametro > diffrazione)

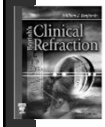
  Risoluzione spaziale media 250-125 micron

- Nel sistema PWS il fronte d'onda non viene mai campionato finche non arriva sul sensore.
  - il numero di campioni di questo sistema è «rappresentato» dal numero di pixel del CCD che vengono illuminati da una delle 4 sub-pupille.

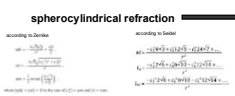
  Risoluzione spaziale media 41 micron

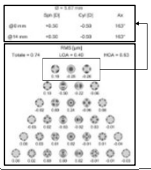


Aberrometry: Wavefront refraction



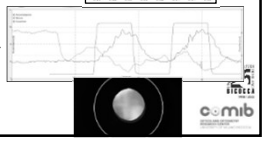
spherocylindrical refraction





wavefront aberration measurements

accommodation

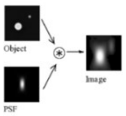


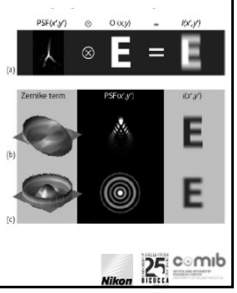
Definition

…wavefront refraction is defined as the process of deriving a conventional spherocylindrical result from wavefront aberration measurements using methods that take into account the amount and type of higher-order aberrations present in an eye to optimize optical quality or vision.

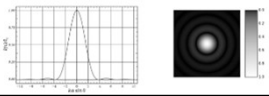
Aberrometria metriche: Point Spread Function (PSF)

La PSF è una funzione che ci dice quale sarà l'immagine prodotta da una lente o, più in generale, da un sistema ottico quando l'oggetto è un punto. L'effetto è dovuto a diffrazione, aberrazioni e possibili difetti.





Se la PSF è dovuta solo a diffrazione si ha:

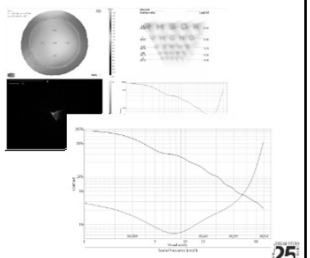


Aberrometria metriche: Modulation Transfer Function (MTF)

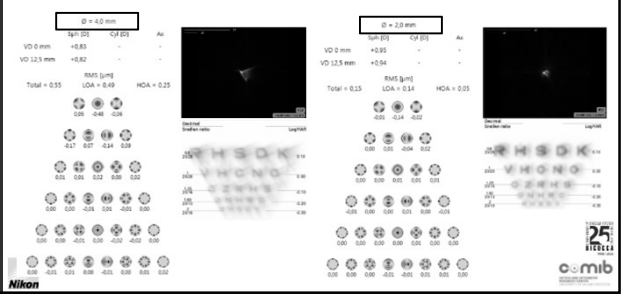
Dalla misura del contrasto (modulation M)...

... alla misura della trasformazione del contrasto da parte di un sistema ottico (modulation transfer MT)...

... alla misura della dipendenza della trasformazione del contrasto dalla frequenza spaziale (modulation transfer function MTF).

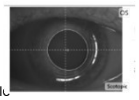


Aberrometria: importanza della pupilla



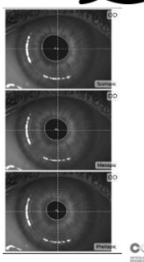
Key points

- Intro CdL e COMiB
- Biomicroscopia
- Topografia Corneale
- Tomografia (Scheimpflug camera, OCT)
- Aberrometria
- Pupillografia
- Sistemi integrati di valutazione del film lacrimale



Pupillografia

Valutazione qualitativa e quantitativa (pupillometria) della forma, della posizione e della grandezza della pupilla.



Pupillografia: La pupilla

- Diaframma dell'occhio umano
- Dimensioni determinate dall'azione congiunta di 2 muscoli a controllo vegetativo
- Decentramento nasale di 0,5 mm rispetto all'asse visivo (Westheimer, 1970)
- Il centro pupillare può muoversi con il variare della grandezza della pupilla

Pupillografia: La pupilla

Dipende da:

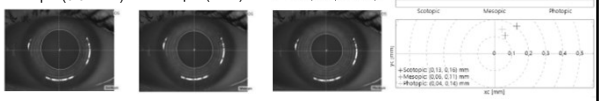
- Livello d'illuminazione
- Visione binoculare e accomodazione
- Età (restringimento e minore reattività con l'invecchiamento)
- Difetto visivo
- Farmaci (miotici: simpaticomimetici o parasimpaticolitici)
- Fattori Psicologici (paura, sorpresa...arousal)

Nikon

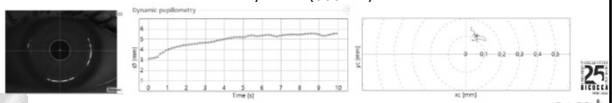
Pupillografia

Static

- Scotopic (0.04 lux*)
- Mesopic (4 lux)
- Photopic (50 lux)



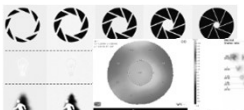
Dynamic (500 lux)



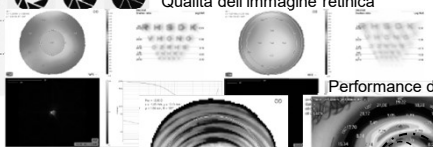
Nikon *al piano della pupilla

Pupillografia

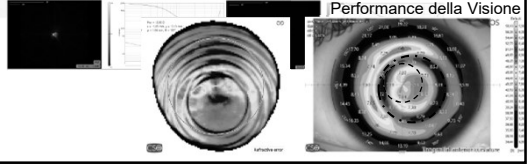
Profondità di fuoco del sistema



Qualità dell'immagine retinica



Performance della Visione



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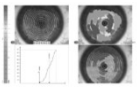


Sistemi integrati di valutazione del film lacrimale

DED definition

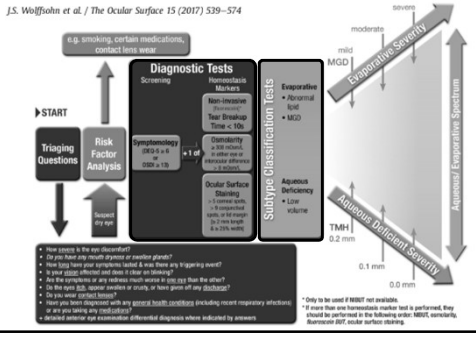
"Dry eye is a multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability, with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and inflammation of the ocular surface"

The definition and classification of dry eye disease: report of the definition and classification subcommittee of the international dry eye WorkShop. Ocul Surf 2007;2007(5):75e92.

"Dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyper-osmolarity, ocular surface inflammation and damage, and neuro-sensory abnormalities play etiological roles."

Craig JP, Nichols KK, Nichols JJ, Caffery B, Dua HS, Akpek EK, et al. TFOS DEWS II Definition and Classification Report. Ocul Surf 2017;15:276e83.

DEWS II proposal for a DED diagnostic test battery



Caratteristiche dei test per la valutazione del DED

- **Covering different aspects**
  - Symptoms
  - Visual Disturbance
  - Tear film stability
  - Tear Volume
  - Tear Composition
  - Damage of Ocular Surface
  - Inflammation of the Ocular surface
  - Eyelids aspects

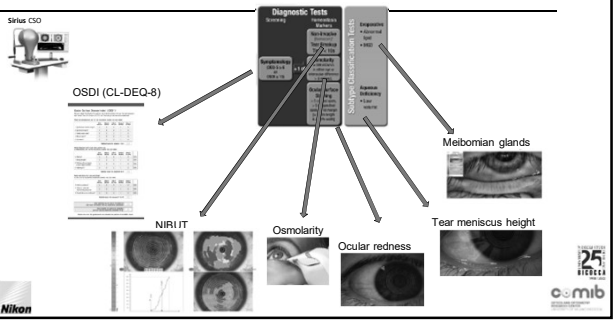
- **Quantitative** versus qualitative assessment

- **Non-Invasive**

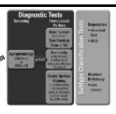

- **Clinically performable**

- **Automated assessment**

Batteria di test disgnostici proposti dal DEWS II per DED

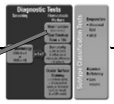


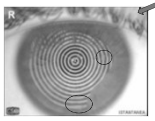
OSDI



- 12-item questionnaire (Schiffman et al, 2000) that measures:
  - -frequency of symptoms
  - -impact of symptoms on the vision related functioning.
  - -environmental triggers
- Strong establishment in the field
- Screening Criteria:
  - Mild 13-22,
  - Moderate 23-32,
  - Severe > 33.

NIBUT

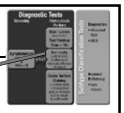




- BUT is the interval of time that elapses between a complete blink and the appearance of the first break in the tear film
- NIBUT (with grid pattern or keratoscope) is generally longer than FBUT
- Healthy population 11.2 ± 6.8 sec
  (Nichols et al, 2002)
- A specific software can automatically assess localized changes in keratoscopic image

Nikon

OSMOLARIMETRIA



L'**osmolarità**: numero totale di molecole e ioni presenti in un litro di soluzione. È definita come il numero di *osmoli* (Osm) per litro (L) di soluzione, dove l'osmole è l'unità di misura del numero di particelle che contribuiscono alla pressione osmotica della soluzione.

Valori <**308 mOsmol/L** sono considerati **normali** (Lemp et al., 2011).
Valori ≥**316 mOsmol/L** indicano **occhio secco** clinicamente rilevante (Tomlinson et al., 2006)

Metodo di misura:
- tear fluid collected directly from the eyelid margin
- impedance measurement to provide an indirect assessment of osmolarity (attraverso una curva di calibrazione)

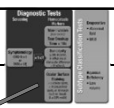
Come viene influenzata durante il porto delle lenti a contatto?

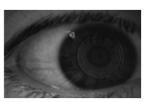
Fase iniziale:
- La LAC viene posizionata sull'occhio -> lacrimazione riflessa + eccesso di soluzione -> riduzione dell'osmolarità

Porto lungo di LaC morbide
- ridotta sensibilità corneale + riduzione della produzione di lacrima -> aumento dell'osmolarità
- rottura del film lacrimale + stabilità del film lacrimale ridotta -> evaporazione eccessiva -> aumento dell'osmolarità

Nikon

Bulbar Redness

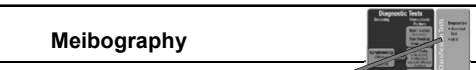


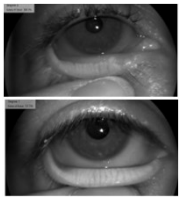


- Conjunctival redness is a clinical sign that is suggestive of ocular surface inflammation
- Useful for diagnosis and documentation of treatment.
- A conjunctival digital picture of the eye is acquired and manually graded with the help of a reference grading scale (Efron, 1988).

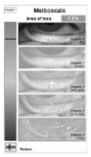
Nikon

Meibography

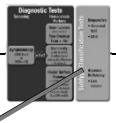


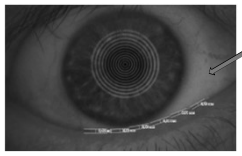


- Infrared illumination LEDs and IR high-sensitive camera captures a gray-scaled image of Meimobian glands (Mathers et al, 1994)
- Glands marking software tool allows to determine the percentage of glands loss
- Final score is computed automatically and it can be verified by comparing the acquired image with a meiboscale (Pult, 2012)



Tear meniscus height





- TMH is the most direct approach to study the tear film volume (Wolffshon, 2017)
- Dry eye 0.15±0.7 mm;
- Normal 0.31±0.2 mm
  Slit-lamp TMH measurement (Ibrahim et al, 2010)

Thank you for your attention!

- Alessandro Borghesi
- Alessandro Duse
- Aziza Obaid
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- Riccardo Rolandi
- Silvia Tavazzi
- Fabrizio Zeri