gonioscopy
Christine Heinrich

Thanks for the photographs
• Peter Renwick
• Stuart Ellis
• Emma Scurrell

gonioscopy – ‘seeing the angle’
from greek
goneo: angle
skopeo: to see
gonioscopy – considerations

- structure of the ICA
- concepts and methods
- methods of angle entrance assessment
  - Width and pectinate ligament
- literature: gonioscopy and glaucoma
  - myth or truth

iridocorneal angle
why is the canine ICA normally invisible?

courtesy J Mould

refraction 1

• when light crosses a boundary between materials with different refractive indices, the light beam will be
  – partially refracted
  – partially reflected

density of the optical media: n2>n1

refraction 2

• if the angle, at which a ray of light strikes the boundary exceeds a certain value, no light passes through and total internal reflection occurs

density of the optical media: n2>n1
total internal reflection

- can only occur if the light passes from a medium of higher refractive index to one with lower refractive index

gonioscopy

- in the dog, rays of light emanating from the area of the ICA exceed the critical angle and thus are (almost) totally internally reflected
overcoming total internal reflection

- optical lenses are used to overcome the 'critical angle'

Direct vs indirect goniolenses

- Direct goniolens
  - observer looks obliquely into the lens and sees opposite drainage angle

- Indirect goniolens
  - observer looks centrally at lens, the image is directed via one or more mirrors

Gonioscopy in the cat

- in the cat, inspection of the entrance to the ICA is possible without a gonioscopy lens
- however, use of a lens provides a better (magnified!) view
direct gonioscopy lenses
- Koeppe
- Lo-vac Barkan
- Franklin
- Troncoso
- Cardona
- Swan Jacob

advantages
- easy to use
  - Lo-vac Barkan and Koeppe most commonly used as leaves both hands for examiner free

advantages
- magnified image
direct gonioscopy lenses

disadvantages

• in fractious patients
difficult to apply
• can be awkward to
see 360 degree of
angle

Koeppe lens

Lovac Barkan
indirect gonioscopy lenses
- Goldmann
- Lovac 6 Mirror
- Posner

advantages
- easy to see 360 degree
- easier to photograph (flat surface)
indirect gonioscopy lenses

advantages
• minimal magnification
• difficult to use in animals (awake)
  – one hand required to hold lens

indirect gonioscopy - technique

advantages
• difficult to use in animals (awake)
• ideally sedated/anaesthetised patient

gonioscopy – practicalities

• usually carried out in conscious patient
• apply local anaesthetic (proxymetacain)
  – wait 25 seconds
• use coupling solution
  – water
  – hypromellose
  – carbomer gel
gonioscopy – practicalities

• experienced handler (or well instructed client) holding patient
• fill lens with coupling solution
• open lids and apply lens to globe
• exert gentle pressure onto lens with fingertip

biggest frustration:
- air bubbles!

how to avoid them
- lens with appropriate fit
- swift application
- firm pressure onto lens during application
- viscous coupling medium

gonioscopy – practicalities

• gently wipe lens surface dry with lint-free swab
• USE MAGNIFICATION TO ASSESS ANGLE
  - ideally slit lamp or retinal camera (10-12x mag)
  - otoscope lamp only provides 2.5x magnification
  - Finhoff and head mounted indirect ophthalmoscope poor alternatives
dynamic/indentation gonioscopy

• briefly, pressure is applied onto the goniolens
• increases IOP and pushes ICA open
• allows to distinguish temporary synechiae/ICA apposition from permanent closure
• technically challenging

indentation gonioscopy

Is this really applicable in our canine patients?

indirect ophthalmoscopy for gonioscopy...

• parts of the ICA may be seen with the indirect ophthalmoscope especially ventromedially
• the observer must stand laterally and look as obliquely possible along iris plane
• "touch method"
  – a 20 D lens is applied to the 'eye' with the convex side onto the cornea
• "no touch method"
  – from observing the peripheral medial fundus through a 20 D lens, the observer moves further medially and in a more anterior plane onto the ICA
gonioscopy: ‘touch’ method

• ‘touch method’
  – a 20 D lens is applied to the ‘eye’ with the convex side onto the cornea

• ‘no touch method’
  – from observing the peripheral medial fundus through a 20 D lens, the observer moves further medially and in a more anterior plane onto the ICA
indirect ophthalmoscopy for gonioscopy…

- advantages
  - time saving
  - in ‘no touch method’ no need for local anaesthesia
  - useful for difficult patients?

- disadvantages
  - poor magnification
  - pressure on cornea may distort ICA appearance
  - limited area visible for inspection

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gonioscopy – what are we looking at

Cornea
Light (limbal) pigment band
Dark pigment band
Pectinate ligament fibres
Iris
Pupil

Flat coated Retriever courtesy of S Ellis

Husky – pigmented iris
gonioscopy – what are we looking at

- Cornea
- Sclera and limbus
- Pectinate ligament fibres
- Iris
- Pupil

Husky - albino

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gonioscopy – criteria for assessment

literature:
- Cottrell and Barnett JSAP 1988
  - Primary glaucoma in the Welsh Springer Spaniel
- Ekesten et al AJVR 1991
  - Correlation of morphologic features of the iridocorneal angle to intraocular pressure in Samoyeds
- Read et al VetOphth 1998
  - PLD and glaucoma in Flat Coated Retrievers. Part I: Objectives, technique and results of a PLD survey
- Bjerkas et al VetOphth 2002
  - PLD ICA associated with glaucoma in the ESS
- Wood et al AJVR 2001
  - Relationship of the degree of goniodysgenesis and other ocular measurements to glaucoma in Great Danes

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gonioscopy – criteria for assessment

- Pectinate ligament morphology
- Angle width

courtesy of S Ellis
morphology of the PL

- if fibres are abnormal
  - extent
  - degree (of 360 circumference)

morphology of the PL

- structure of PL fibres
  - fine, fibrae latae, sheets of tissue

Normal PL - Husky
Fibrae latae

courtesy S Ellis

Thickening at the 9 and 3 o’clock positions

courtesy S Ellis

Occlusio/sheet

courtesy S Ellis
Occlusio/sheet

PL – normal variation in appearance

- Ekesten et al. VO 1998
  - less than 1/16" deemed normal
- Bjerkas et al. VO 2002
  - less than 1/16" deemed normal
- Read et al. VO 1998
  - less than 25° deemed normal
- **ECVO NEW suggested:**
  - >15° < 25° 'undetermined'
  - >25° 'affected'

angle – width assessment

- subjective
  - wide
  - narrow
  - closed
- objective (?)
  - relative width of the ciliary cleft estimation
which zone to evaluate?
Ekesten et al AJVR (1991)
Correlation of morphologic features of the iridocorneal angle to intraocular pressure in Samoyeds

- 203 Samoyeds
- Comparing subjective judgement of width of the anterior opening of the ciliary cleft with measurement (RWOCC)
  - High correlation
  - Varying degrees of narrowness found
  - 6 dogs had closed iridocorneal angle and clinical glaucoma
  - IOP in dogs with closed CC higher than in others
- 25% of dogs had a degree of PLD
- High degrees of PLD were NOT related to increased IOPs

Gonioscopy and glaucoma - the critics

- does gonioscopy allow us an assessment of the patient’s aqueous humour drainage structures?
- can gonioscopy predict a predisposition to glaucoma
  - is PLD associated with glaucoma?
- and if so – what about breeding predictions?
Pectinate ligament and width of ECA – info with gonioscopy
entire ciliary cleft – no info with gonioscopy on inner meshwork
dysplastic pectinate ligament
entire ciliary cleft – no info on inner meshwork with gonioscopy
Chronic Glaucoma in Dogs: Relationships Between Histologic Lesions and the Gonioscopic Diagnosis of Pectinate Ligament Dysplasia.

Abstract

Pectinate ligament dysplasia (PLD) is a common cause of canine glaucoma and the definitive clinical diagnosis is based on gonioscopy. Although the histologic lesions of PLD have been described, it has not been determined whether these changes are specific for PLD or if similar histologic changes can develop as a consequence of secondary glaucoma. The filtration angles of 81 unselected canine glaucoma were evaluated with high myopia by 3 observers who were masked to the clinical history, alignment, and gonioscopic results. A histologic diagnosis of PLD versus no PLD was determined by each examiner based on previously reported morphologic criteria and compared with the clinical diagnosis. When PLD was reported in 50 cases, a histologic diagnosis of PLD was cited by the PLD group with a range of 62.5% to 100%. There was no difference between patient history, alignment, and degree of ICA narrowing (ICA diameter 0.05-0.43). The PLD group was significantly different from the non-PLD group in the degree of ICA narrowing (ICA diameter 0.15-0.43) and the degree of ICA narrowing associated with glaucoma (ICA diameter 0.05-0.15). No clinical or technological features were associated with PLD. The results indicate that the histologic changes proposed to be characteristics of PLD are also noted in canine glaucoma affected with chronic secondary glaucoma. Therefore, using routine histologic evaluation, a histologic diagnosis of PLD is not possible in the face of chronic canine glaucoma.

gonioscopy – what is the point?

…the evidence (selected papers only!)

- Ekesten et al AJVR (1991) – Correlation of morphologic features of the iridocorneal angle to intraocular pressure in Samoyeds
- Bjerkas et al VetOphth (2002) 5, 1, 49-54 – PLD and narrowing of the ICA associated with glaucoma in the ESS
- Wood et al AJVR (2001) – Reassessment of the degree of goniodysgenesis and other ocular measurements to glaucoma in Great Danes
Recent publications….

Survey of the incidence of pectinate ligament dysplasia and glaucoma in the UK Leonberger population
Georgina V. Fricker, Kerry Smith and David J. Gould
Veterinary Ophthalmology, New Forest Vets, Bursledon, Southampton, SO31 6HP, UK

CASE REPORT
Glaucoma associated with uveal cysts and goniodysgenesis in American Bulldogs: a case series
Stephanie S. Pangher,1* Melissa Pimental,1,2 Christopher G. Price1,2 and David R. Newbold
1Veterinary Ophthalmology, New Forest Vets, Bursledon, Southampton, SO31 6HP, UK, 2Chief Ophthalmo-Sequecia, Morgan-Johnson, Inc. (Flinchum), Middletown, DE, USA

AHT team

Pectinate ligament dysplasia in the Border Collie, Hungarian Vizsla and Golden Retriever.
Cline JA,3 Eastwood KL,3 Weatherall CS.
3Author Information

Prevalence of pectinate ligament dysplasia and associations with age, sex and intraocular pressure in the Basset hound, Flatcoated retriever and Dandie Dinmont terrier.
Cline JA,3 Eastwood KL,3 Weatherall CS.
3Author Information

Part 1:
• gonioscopy of
  – 100 normal mixed breed dogs
  – 389 Flat Coated Retrievers
• ICA judged for PLD only
  – broad, thickened fibres & solid sheets noted
  – 7 grades (increments of 12.5%)
  – <25% assumed ‘normal’


• findings on gonioscopy
  – 100 normal mixed breed dogs
    • 6% PLD present
  – 389 Flat Coated Retrievers (16 with glaucoma)
    • 34.7% PLD present
  • Flat Coated retriever predisposed to PLD


<table>
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<tr>
<th>Percentage</th>
<th>Ordinal scale ranking</th>
<th>incidence of glaucoma</th>
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<tbody>
<tr>
<td>&lt;25 (assumed 12.5)</td>
<td>0</td>
<td>0 in 1-3</td>
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<tr>
<td>25.0</td>
<td>1</td>
<td>1 in 4</td>
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<td>37.5</td>
<td>2</td>
<td>1 in 5</td>
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<td>50.0</td>
<td>3</td>
<td>5 in 6</td>
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<td>62.5</td>
<td>4</td>
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<td>7</td>
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- Part 2: statistical assessment of
  - PLD and glaucoma
    - probability that a FCR will have glaucoma is strongly related to its degree of PLD
  - heritability of glaucoma
    - significant positive linear relationship between degree of PLD offspring and parents in FCR
    - heritability values estimated via PLD data high
    - between 0.7-0.9

The relationship between the probability of glaucoma in an individual animal and the degree of pectinate ligament dysplasia in both of its parents.


- current estimated prevalence of glaucoma in FCR 10/1000 (1%)
- if breeding from parents with PLD of 4 or less incidence of glaucoma in offspring reduced to < 2/1000 (0.14%)
Bjerkas et al (VetOphth 2002)

- gonioscopy on 279 ESS
  - 14 with glaucoma
  - assessed both
degree of PLD
  - (present if PL > 1/16th of circumference)
  - 0-4
  
  0 = normal PL
  4 = entire cleft affected with only occ. flow hole
ciliary cleft width
  - relative width of ciliary cleft (RWOCC)
  - 0 = open to 3 = closed

Bjerkas et al (VetOphth 2002)

- prevalence of PLD in ESS 25%
- positive relationship between
  - PLD and RWOCC (p<0.0001)
  - Glaucoma and degree of PLD (p<0.0001)
  - narrowed RWOCC and glaucoma (p<0.0001)
  - relationship between these findings may contribute synergistically / additively / independently to development of glaucoma
- also significant impact of age on RWOCC and PLD
- deduced parent’s status may affect status of offspring
  - normal parents will have predominantly normal offspring

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**Table 2** Effect of parents’ iridocorneal angles on the offspring. Abnormal in this table means either narrowed RWOCC or PLD or both
Wood et al (AJVR 2001)

- original work by Mason
- Gonioscopy on 180 Great Danes
  - 23 of these had glaucoma
- PLD graded by 5 degree steps
- AJVR publication pooled samples due to small numbers of Danes affected with Glaucoma that had been examined
  - 0-50%
  - 60-80%
  - >80%

Wood et al (AJVR 2001)

- show significant correlation PLD and glaucoma in Great Dane
  - impact of age on PLD weak & not statistically significant
- significant association between PLD in offspring and parents
  - \( h = 0.52 \)
- breeding from animals with moderate or low PLD value (below 70%) should reduce prevalence in population

gonioscopy and age

- does the gonioscopic appearance of the iridocorneal angle change with age?
  - if so – what impact does this have on any screening schemes for breeding?
  - one off or repeat testing?
gonioscopy and age

Wood et al (VetOphth 1998)
- examined linear regression for PLD scores on AGE
  - positive and statistically significant
  - BUT intercept and slope of fitted line small – ie dependence of AGE on Goniodysgenesis small
    • even the value of a 10 (1.8) / 20 (3.3) year old FCR would not increase enough to be biologically significant

Wood et al (Gt Dane)
- positive but insignificant impact of age on goniodysgenesis
  • less than 1% of variation of GONIO values explained by AGE
  • expected degree of PLD in Great Dane born clear
    – 40% at 10 years of age
    – 80% at 30 years of age

Bjerkas et al (ESS)
- reports significant impact of age on RWOCC and PLD
  - narrowing of ICA presumed due to
    • anterior displacement of iris due to relative increase of IOP in posterior chamber
    • age related lens size increase
  - higher PLD scores in older dogs
    • subclinical inflammatory changes
    • other secondary changes
gonioscopy and age
Pearl et al VetOphthal 2013
- 96 (39 UK, 57 SWISS) FCRs underwent a second
gonioscopic examination with a mean interval of 5.75
years
- UK – 2 examiners, Swiss – 1 examiner
- presence or absence of PLD was assessed by
gonioscopy using a slit lamp/genesis fundus camera
- 0-3 grades (0 = unaffected, <20° = grade 1, 20-90° =
grade 2, > 90° grade 3)

gonioscopy and age
Pearl et al VetOphthal 2013 ctds
- 39 of 96 (40.6%) dogs demonstrated progression of PLD (P <
0.0001)
- 13 of 96 (13.5%) were classified as mild progression (from either
unaffected to 10–20% or 10–20% to 20–90% ICA affected)
- progression was more extensive in 26 of 96 (27.1%) dogs (P <
0.0001)
  - 12 of 96 (12.5%) went from unaffected to severe PLD of >90% ICA
affected
- 2 dogs had developed glaucoma in 1 eye since the first
examination
  - one of these had originally been unaffected, one mildly affected
‘progression’ of PLD

- SEM studies by Martin, Samuelson and Gelatt showed PL to form from an initially solid sheet through process of rarefaction
  - Initially fibrillar sheet rarefies to strands of intertwining collagenous tissue, progressively encased by trabecular cells confluent with iris base
- PL formed by 8 weeks post-natal
- Bedford suggests clinically that ICA entrance appearance ‘complete’ by 4-5 months

‘progression of PLD’

how can we explain the apparent ‘dysplasia’ developing later in life?

- progressive changes that ‘mimic’ dysplasia
  - progressive cellular depositions around collagenous core
  - progressive pigment deposition
  - inflammatory changes/PIFMs
  - Peripheral anterior synechiae

goniodysgenesis and secondary glaucoma
goniodysgenesis and secondary glaucoma

- 42 Labs (66 eyes) – 199 Non-Labs (314 eyes)
- gonioscopy carried out on roughly 2/3rd of patients
- gonioscopic abnormalities were not associated with an increased risk of postoperative glaucoma in either the Labrador or non-Labrador group.

ICA assessment – what’s next?

- High Frequency Resolution UltraSonography (HFRUS)

courtesy of E Bentley
Abstract no. 06

Ocular cleft morphology in the normotensive fellow eyes of dogs with unilateral overt primary angle closure glaucoma predicts onset of glaucoma

Erling and PA Miller
School of Veterinary Medicine, University of California, Davis

Purpose: To determine if early cleft ocular morphology at high resolution ultrasound (HRUS) differs in the fellow eye to onset of overt glaucoma in the contralateral normotensive fellow eye of dogs with primary angle closure glaucoma (PACG) on prophylactic latanoprost.

Methods: The normotensive fellow eye of 26 dogs with overt PACG in the opposite eye underwent HRUS within 2 months of the diagnosis of PACG. The fellow eye was followed as open (OP) when the cataractous fellow eye could be clinically identified and closed (CL) when it could not be identified or made to affect imaging. The second overt glaucoma in the contralateral fellow eye was confirmed in Kaplan-Meier compared to the time to onset of glaucoma between groups and 3 statics test was compared to the time to onset of glaucoma between groups and a 3-dimension model compared against the data between groups.

Results: Within initial imaging session, 26 dogs had closed (CL) and 20 dogs had open (OP) eyes. There were no significant differences in the time between diagnosis of cataractous fellow eye compared to the control group. Treatment duration of the fellow eye was similar between groups and no significant difference in the cataractous fellow eye. The follow-up was 27 months (range 1-45 months) for the OP group and 6 months (range 3-24 months) for the CL group. Prophylactic NKI (Topik, 2.5 mg/gm) was administered for 4 days and continued for 10-15 months. The follow-up for the CL group was 10.5 months (range 7-14 months) for 10 months followed by 4 months.

Conclusions: In dogs with unilateral overt PACG, careful follow-up is necessary to determine normotensive contralateral eye status at time of initial diagnosis and correlated with high risk of development of PACG. Further studies are necessary on dogs diagnosed with PACG to correlate with high risk of development of PACG.