# Comparative computed tomography anatomy of the lacrimal drainage system in brachycephalic dog breeds

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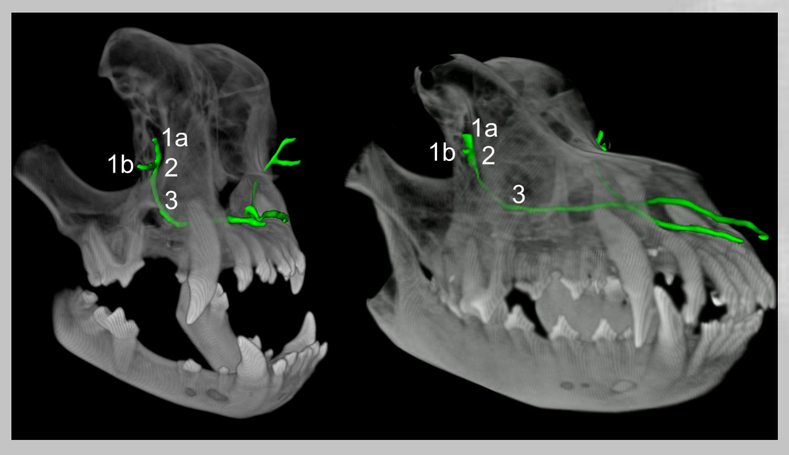
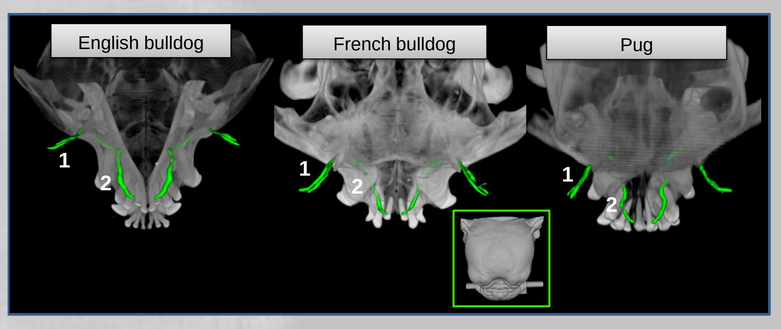



3D-illustration of the NDS of an English Bulldog (left) and a Rhodesian Ridgeback (right) (*3D-Viewer ImageJ);* In the English Bulldog the lacrimal canaliculi and initial part of the nasolacrimal duct (NLD) are directed inversely. The lacrimal canaliculi in the English Bulldog are longer than in the normocephalic dog. In Brachycephalics the NLD crosses beneath the upper canine root before entering the nasal cavity.
1a, upper lacrimal canaliculi; 1b, lower lacrimal canaliculi; 2, lacrimal sac;
3, nasolacrimal duct

## Purpose

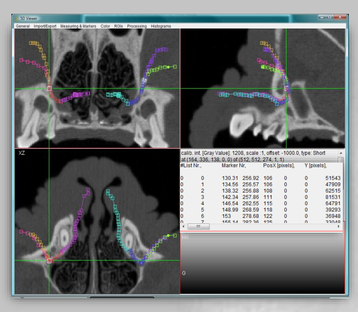
This study evaluates the nasolacrimal drainage system (NDS) in three brachycephalic dog breeds in comparison with normocephalic dogs.




Three-dimensional illustration of the nasolacrimal drainage system (NDS) (*3D-Viewer ImageJ*); The perspective is represented by the head at the bottom of the picture. In Pugs the course of the NDS is more inversely directed than in the French Bulldog and the English Bulldog.
1, lacrimal canaliculi; 2, nasolacrimal duct

## Material and Methods

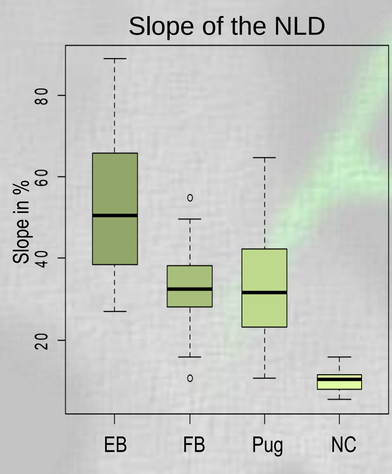
A computed tomographic-dacryocystography (CT-DCG) was performed in 51 brachycephalic dogs, consisting of 23 Pugs, 18 French Bulldogs and 10 English Bulldogs. Six normocephalic dogs of different breeds and body size served as a comparison. Two- and three dimensional images were obtained and evaluated. Several parameters (length, angulation, gradient) were used to describe the nasolacrimal drainage system and to quantify differences between the breeds. Furthermore several additional characteristics were analysed, including the relative position of lacrimal foramen and nasolacrimal ostium, crossing of the nasolacrimal duct underneath the root of the upper canine tooth, the patency of the lacrimal drainage system and the presence of an accessory opening.



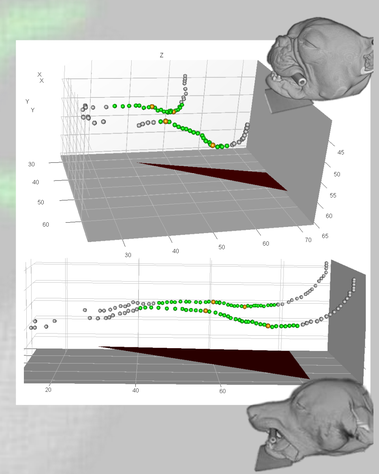
The lengths of the separate parts of the NDS were measured with the program *ImageJ.* The different parts of the NDS were marked along their course. All straight distances between the different markers were added up to the overall length of one segment of the NDS.

| Length in mm | EB | FB | Pug | NC |
|---|---|---|---|---|
| IC | 16,3 | 16,7 | 15,2 | 5,45 |
| SC | 18,2 | 17,0 | 14,4 | $7{,}33_{MD}$ |
| $NLD_{(incl. LC)}$ | 56,4 | 43,5 | 39,5 | 95,7 |
| $IP_{+ED}$ | 19,9 | 14,0 | 13,6 | 35,5 |
| $MP+EP_{NLD}$ | 35,5 | 29,5 | 25,1 | 60,2 |

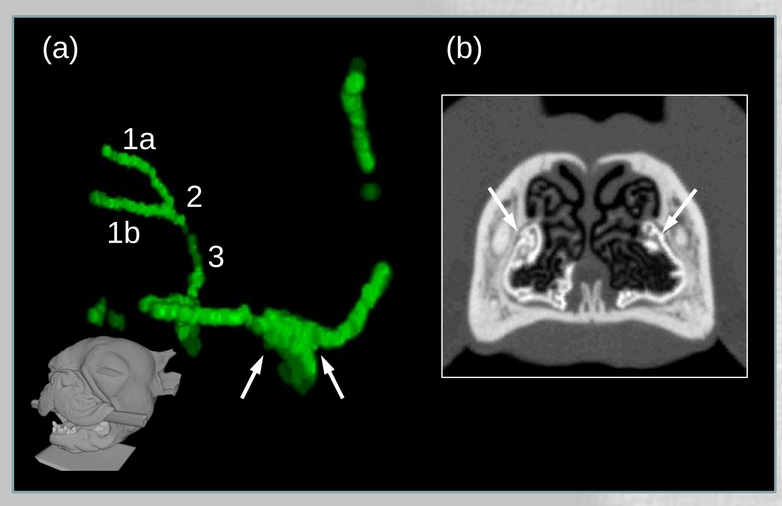
EB = English bulldog; FB = French bulldog; NC = Normocephalics; IC = inferior canaliculi; SC = superior canaliculi; NLD = nasolacrimal duct; MD = Median; IP = initial part of the nasolacrimal duct; MP+EP = middle and end portion of the nasolacrimal duct; LC = lacrimal sac




The gradient was obtained starting from the lowest point of the nasolacrimal duct (NLD) shortly before leaving the osseous lacrimal canal (thus near the accessory opening). The second measuring point is the peak of its middle portion.
EB= English Bulldog; FB= French Bulldog; NC= Normocephalics



Using an application in *Gnu R 2.14.1* the lowest and highest points were determined in relation to the alignment of the hard palate (red triangle) (results unaffected by head positioning). The coordinates of the NLD are illustrated as grey, green and orange dots. The orange dots represent the lowest and highest points.



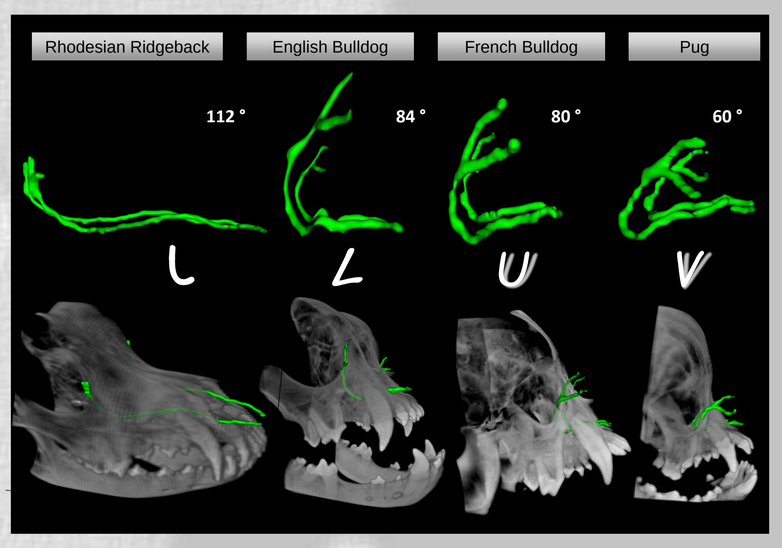

(a) 3D-illustration of the accessory opening (white arrows); The viewing perspective is represented by the head at the bottom of the picture; 1a, upper lacrimal canaliculi; 1b, lower lacrimal canaliculi; 2, lacrimal sac; 3, nasolacrimal duct; (b) transverse CT-image showing contrast agent escaping through the accessory opening (white arrows)
An accessory opening could be identified in all brachycephalics but one French Bulldog. It is located ventromedial to the root of the upper canine tooth, shortly after the NLD exits the bony canal and merges into the membranous middle portion.

## Discussion and Conclusion

While the length of the nasolacrimal duct is substantially reduced in brachycephalic dogs, their lacrimal canaliculi have much larger dimensions than those of normocephalic dogs.

Additionally varying parts of the nasolacrimal drainage system follow an inverse direction in short-headed dogs, giving the nasolacrimal system a characteristic U- or V-shaped appearance.

The nasolacrimal duct in brachycephalic dogs features a much steeper slope than in normocephalic dogs. However, this gradient does not interfere with lacrimal drainage because of a consistently present accessory opening, being the main or only outflow pathway in the brachycephalic dogs examined.

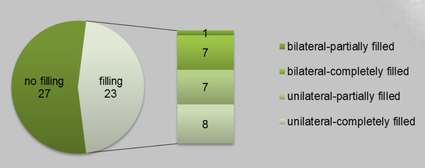



The different shapes of the tear drainage system in a Rhodesian Ridgeback and three brachycephalic dog breeds; The values reflect the angulation of the NDS, measured between the upper lacrimal punctum, the backmost point of the nasolacrimal duct (vertex) and the nasolacrimal ostium.

- The NDS in normocephalic breeds has an obtuse-angled character. As opposed to this, brachycephalic dogs exhibit an acute-angled NDS, with the Pug showing the smallest values.
- These values support the observed inversely directed course of the initial parts of the NDS in brachycephalic dog breeds.
- The very small angle in Pugs shows that the NDS is severely clinched in the vertical plane with the lacrimal canaliculi and end portion of the NLD moving closer together.
- Additionally the different angles quantify the characteristic shape of the NDS, resembling an ‘L’ in normocephalics and a ‘U’ in brachycephalic dogs. The clinched, markedly acute-angled appearance in Pugs resembels a ‘V’ rather than a ‘U’.

Filling of the parts of NLD rostrally to the accessory opening (middle and end portion) in the brachycenphalic dogs;

- in 54% accessory opening only detectable drainage route into nasal cavity (no contrast agent leaves NLD via Ostium nasolacrimale (ONL))
- 7 of 50 cases (14%) additional outflow via ONL




*Either way, in all dogs the accessory opening represents the main outflow pathway for the contrast medium entering the nasal cavity.*

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