NEW ASPECTS OF BRACHYCEPHALIA IN DOGS AND CATS
BASICS: INSIGHTS INTO EMBRYOLOGY, ANATOMY AND PATHOPHYSIOLOGY

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Brachycephalic dogs and cats enjoy increasing popularity in many parts of the world. This is no surprise; animals like Pugs and French Bulldogs show child-like characteristics and most people are instinctively attracted by this. In addition to that most breeds have a very friendly and jolly character. The head of brachycephalic breeds is characterised by a short face, open orbitae and shows various characteristics of young animals (LAURUSCHKUS 1942). This conformation of the skull results in a high incidence of associated diseases.

EMBRYOLOGY

After birth the visceral cranium is undersized in comparison to the neurocranium. Postnatally begins a pronounced growth of the viscerocranium that becomes more prominent than the neurocranium. Furthermore, the development of the viscerocranium has to be seen in close relation to the necessity of sufficient space for the teeth. With the development of the permanent teeth the face gets the characteristic expression.

With CT-analysis and preparation we could show that many of the complex alterations in brachycephaly arise from the highly shortened facial bones and the resulting dislocation of nasal structures caused by the dorsorotation of the teeth. Profound and severe brachycephaly is characterised by a dorsal rotated upper and lower jaw and an abnormal dislocation of conchae with a steep course of intranasal airways and the nasolacrimal drainage system. Severe stages of brachycephalia show a horizontally positioned and dorsally rotated canine tooth (HENNET and HARVEY 1992; NOELLER 2006).

In young animals both frontal sinuses and nasal conchae show a marked postnatal development. However, in brachycephalic animals shape and size of frontal sinuses and nasal conchae differ considerably from normocephalic skulls. In the French Bulldog the frontal sinuses are extremely small and in the Pug they are missing completely.

As a consequence of the hypogenesis of the upper jaw we suspect an aberrant growth of conchae. Impeded in their normal development by a lack of space they grow into free gaps of adjoining structures. We classified them as rostrally growing aberrant conchae (RAC) and as caudally growing aberrant conchae (CAC).

ANATOMY

BAS is a well described combination of upper airway disorders in these breeds. Symptoms can vary broadly as well in intensity as in frequency of dyspnoeic episodes. We examined the anatomical specifics of the brachycephalic nose by computed tomography (CT), 3D-reconstructions, preparations, drawings as well as macerations and compared them to those of the normocephalic nose. The phenotypic appearance of the brachycephalic head depends on the shape of the skull and is strongly related to breed specific skeletal features.

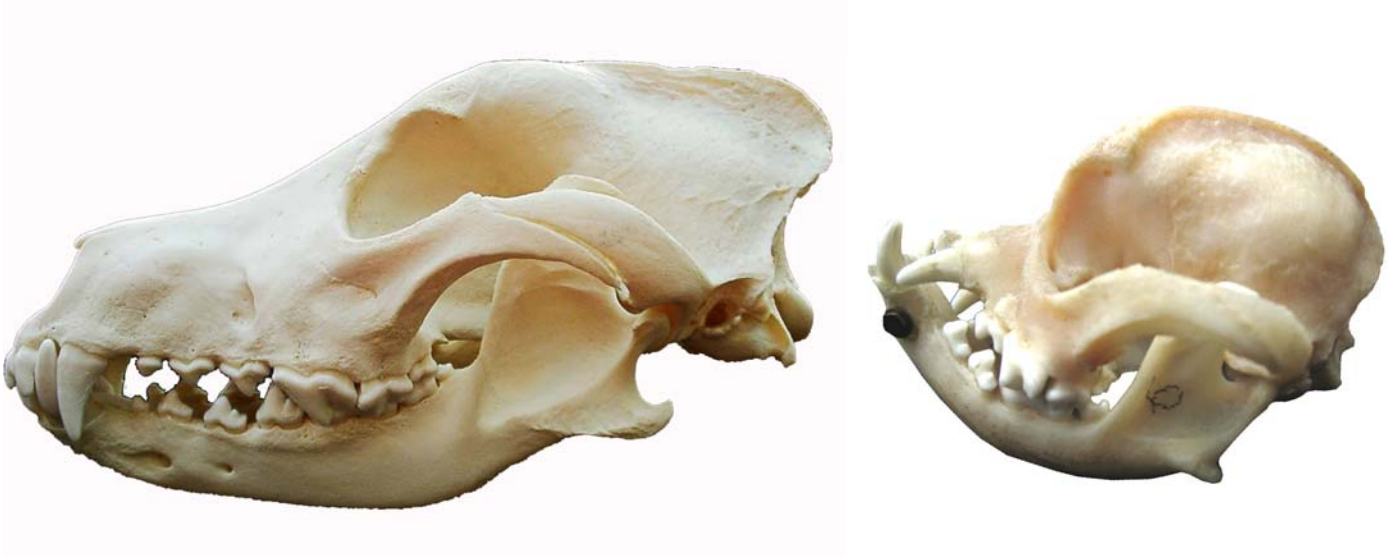

Figure 1: Scull specimens of a German shepherd dog (left) and a Pekinese dog (right). Note the highly shorted facial bones with a summation of the reduction within the area of the nose. No nasal bone and less maxillary bone are visible and the accommodation of all teeth seems impossible. The viscerocranium and the mandible are dorsally rotated and the canine tooth is located in a horizontal position.

Concomitant with increased stages of brachycephaly, the nares and the nasal entry get narrower; the rostral ending of the respiratory duct (Meatus nasi ventralis), the nasal conchae and the whole ethmoidal bone are pushed into an increased upright

position; and the nasolacrimal drainage system is characterized by an increased angle and a steeper course. Conchal material is pushed into the respiratory duct in some animals with higher degrees of brachycephalia and hinders respiratory air flow.

MORPHOMETRIC MEASUREMENTS

Morphometric measurements of the skull revealed characteristic differences among the brachycephalic dog breeds. The pug had an even shorter craniofacial skull than French and English Bulldogs (OECHTERING et al. 2007c).

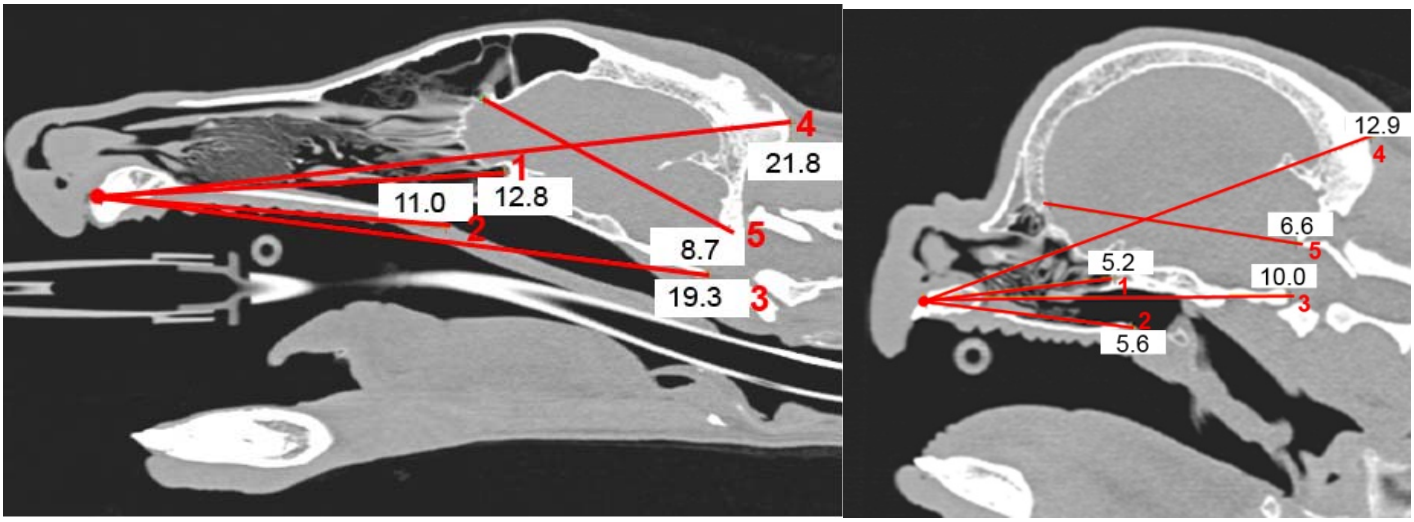

Figure 2: Examples for CT based morphometric measurements of normo- and brachycephalic dogs (OECHTERING et al. 2007c).

PATHOPHYSOLOGY

Typical signs of BAS are laboured breathing and both inspiratory and expiratory stridor. Even with open mouth breathing, the situation does not change for the better. Some dogs lose consciousness and then recover after a while, others die due to asphyxia; the latter being reported in a growing number. If causative conditions improve (i.e. cool surroundings back home after a walk on a hot day), time to full recovery is extraordinary long, up to several hours.

It is known that the nose is the greatest source of flow resistance in the total airway system (OHNISHI and OGURA 1969) particularly in carnivorous species (NEGUS et al. 1970). While closed-mouth breathing, the nasal passage has to be overcome both during ins- and during expiration but only during inspiration while panting (SCHMIDT-NIELSEN et al. 1970). During rest, the dog is an obligatory nose breather (NEGUS 1958; OHNISHI et al. 1972) and it was observed that dogs with bilateral nasal obstruction attempted to breathe through the nose even against a high anatomic nasal resistance (OHNISHI et al. 1972).

With our recent research we could reveal the dimension of intranasal obstruction brachycephalic animals suffer from (NOELLER 2006; OECHTERING et al. 2007b). So far, we developed and evaluated a new technique to re-establish functional intranasal airways by laser assisted turbinectomy [LATE] (OECHTERING et al. 2007a).

Septum deviation seems to have a major influence on hypertrophic or aberrant development of nasal turbinates, at least in man and some brachycephalic dog breeds (MLYNSKI 2005; OECHTERING et al. 2007c). Septum deviation affects amount and quality of nasal airstreams both known as important determinants of conchal size and configuration (MLYNSKI et al. 2001).

Very recent histological examinations of aberrant conchae showed hypertrophic, well vascularised structures that differ widely from physiologic conchae. Respiratory mucosa covering aberrant conchae is rich in venous sinuses. This might be an indication that conchal surface within the nasal cavity is not sufficient to meet the demands, particularly in respect of thermoregulation.

We also looked at the histological alterations of laryngeal tissues. Excised tissue of the ventriculus laryngis revealed a mildly irregular cornified squamous epithelium covering the specimens. Beneath, a markedly oedematous submucosa with moderate lymphangiectasia was present. The collagen fibres were deviated and shortened, but signs of inflammation were missing in most cases. Occasionally very mild infiltration of lymphocytes and plasma cells were seen. Angiopathies as a known potential cause for interstitial edema were not detectable in the excised material. Furthermore, preliminary histopathological examinations of collapsed laryngeal cartilage indicate marked chondrodystrophic changes that require further investigation.

THERMOREGULATION

It is a very well known fact that brachycephalic dogs also suffer from severe heat susceptibility. If it is hot outside, man begins to sweat and the evaporating water will cool the large surface of our skin and with that our blood. Dogs cannot sweat. Nevertheless, they also use the mechanism of evaporation cold - they have their large surface inside the nose: an anatomical marvel of nasal turbinates. Panting is the most important element of thermoregulation in dogs (SCHMIDT-NIELSEN et al. 1970). Both, a patent intranasal airway for inspiration and an undisturbed oral expiration are essential for effective cooling.

Brachycephalic dogs lost their nose, not by chance but due to intentional breeding. With our recent research, we concentrated on the nasal influx and demonstrated severe obstruction of as well the intranasal as the rostral nasopharyngeal airways (Choanae) in

brachycephalic breeds. In the course of our recent investigations, we had strong indications that concurrently there is a substantial impairment of the oral (expiratory) airflow as well. These findings support the assumption, that heat and stress susceptibility in brachycephalic dogs is a primary failure of peripheral thermoregulation and not of central mechanisms. More basic research on brachycephalia is needed to investigate the relation between anatomical malformation and functional impairment.

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