Use of Cone Beam CT for Objective Assessment of BOAS

Summary
The goal of this study was to find an objective diagnostic approach in BOAS cases by using a combination of Cone Beam CT and endoscopic evaluation of the respiratory system in brachycephalic dogs. In the study, we included 22 brachycephalic dogs and as a control group 31 normocephalic dogs. All brachycephalics had at least one of the BOAS symptoms. All patients underwent head and pharyngeal area computed tomography. All patients with brachycephalic syndrome were also endoscopically evaluated. The study looks for a correlation between the length and width of the soft palate relative to the maxillary pharyngeal diameter and compares measurements in brachycephalic and normocephalic dogs.

Preface
Brachycephalic dogs have very unique upper respiratory anatomy which in some cases can lead to upper airway obstruction.\(^1,2\)

The typical anatomic abnormalities are shortened skull, compressed nasal passages, stenotic nares, enlarged tonsils, elongated and hypertrophic soft palate, everted laryngeal sacculae, narrowed rima glottidis and collapse of the larynx and trachea.\(^3\) In most of these dogs a combination of a compressed and shortened structures of upper airways leads to increased negative pressure on inspiration to adequate ventilation.\(^4,5\) The primary component of BOAS are stenotic nares, elongated soft palate and hypoplastic trachea. Secondary components such as everted laryngeal saccules (Fig.1), soft palate thickening (Fig.2), tapering of the larynx, laryngeal collapse and everted tonsils are the result of high negative pressure. The effect of BOAS on gastrointestinal tract, however, is also not negligible.\(^6,7\)

Materials and Methods
A total of 22 brachycephalic dogs which underwent CT imaging of the skull in the time between March 2013 and August 2014 at our Clinic were included in this study. The main indicators of brachycephalic breed was the French bulldog (n 6), followed by pug (n 4), beaver (n 3), English bulldog (n 2), chihuahua (n 2), Boston terrier (n 1), bulldog (n 1), Yorkshire terrier (n 1), Cavalier King Charles spaniel (n 1) and griffon (n 1).

A total of 31 dogs from different breeds were included in the group of normocephalic dogs. They underwent the CT imaging of the skull because of different reasons than respiratory disorders.

Computed tomographic imaging by Cone Beam CT (CBCT) was used (Fig.2). It is a quite new imaging technology which has found its use in veterinary medicine in last three years. In contrast to fan-beam CT, CBCT reaches the image by rotation of one X-ray tube around the patient. Beams passing through the object are caught by dynamic flat-panel detector on the opposite side and the data is processed in a computer. As a conventional CT, transversal, sagittal and dorsal reconstruction of the image are created. In addition, images can be processed into a 3D reconstruction.

The CT scan was performed on all dogs in sternal recumbency in an extended neutral position under general inhalation anaesthesia with isoflurane in oxygen administered via a cuffed endotracheal tube.

The measurements were taken in the mid sagittal images at the level of the deepest point of sela turca. At this projection the length of the soft palate (SPL) from the caudal margin of the hard palate to the tip of the soft palate (Fig.1) and the width of the soft palate (SPW) at the level of sela turca (Fig.2) and the dorsoventral cross-sectional diameter of the meatus nasopharyngeus (MNP) (Fig.3) were measured. The absolute numbers could not be compared directly because of the difference in the breeds present. Therefore the ratio between SP length and MNP diameter and the ratio between SP width and MNP diameter were used. These were summarised as the mean (resp. median) and were compared between the brachycephalic and normocephalic groups.

All the brachycephalic dogs also underwent a retrograde endoscopic examination of nares and larynx, tracheo- and bronchoscopy for further BOAS evaluation.

Results
The most obvious finding in our study is that brachycephalic dogs have significantly thicker soft palates compared to normocephalic dogs. (Tab.1) The majority of the normocephalic dogs have the SPW/MNP ratio under the median value of the brachycephalic dogs. (Tab.2)

Interestingly enough, this was not proven by the length of the soft palate. The majority of the normocephalic dogs have the SPL/MNP ratio above the mean value of the brachycephalic dogs. (Tab.3,4)

Anyway, we could not find any clear line for the objective assessment of the width or the length of the soft palate. This evaluation still remains very subjective and dependent on the surgeon’s experience.

As an incidental finding in the significant part (22.7%) of the examined brachycephalic dogs fluid or solid material in tympanic bulla was found. (Tab.5) (Fig.6) Dogs with other skin disorders and other skin disorders were excluded from this calculation.

Discussion
Our measurements confirm the findings in recent studies in which the soft palate width serve to be a very important component in patients with severe signs of BOAS (Brachycephalic Obstructive Airway Syndrome).\(^10\)

Whether this thickness is a primary abnormality or a secondary event could not be determined. This thickening could be explained by a muscular hypertrophy, mucosal oedema, or both. This modifications could be inducted as an adaptation to the increased intranasal airflow resistance at the level of nares, vestibulum nasi and caudal nares.\(^10,11,12\)

Critical attitude has to be taken in assessment of the soft palate length because the measurements were made on static CT scans on images of soft palate and endotracheal tube so the dynamic features in awake and asleep states with regard to the respiratory phase could not be compared.\(^9\)

Conclusion
Currently, the combination of CT imaging and endoscopy is considered to be a gold standard in evaluation of the severity of BOAS.\(^6,9,10\)

The endoscopy allows to assess the in situ conditions and evaluate the dynamic airway features during the respiratory cycle. By the retrograde endoscopy the nasopharyngeal mucosal and/or lymphatic tissue hyperplasia, caudal abacterian turbinates presenece can be detected.\(^7\) The trachea and bronchi are then observed for the presence of collapse or other abnormalities. Interestingly, the left-side cranial subsegmental branches are affected more often than the right-side branches.\(^13\) It has been recommended by some authors to assess the GI tract during the endoscopy because of the presence of typical gastrointestinal disorders in these breeds. Some evidence-based studies show better evaluation of corrective surgery of BOAS in patients treated simultaneously with antacids and prokinetics.\(^13,14\)

Computer tomography is a non-invasive imaging method that permits a detailed assessment of the entire upper airways. Especially, the structure of soft palate is the key factor that has to be considered.\(^3,15,16\)

On the basis of this examination it is possible to assess critically the severity of BOAS in the concrete patient and schedule the individual plan of treatment and eliminate the risks. Many studies support the suggestion that young immature brachycephalic dogs with BOAS should undergo assessment and, if required, surgery as soon as possible because of severe secondary changes.\(^15,16\)

The conclusion these patients still remain a diagnostic challenge. Despite all known information an objective system for BOAS evaluation is still missing. The assessment is more subjective and a successful outcome is strongly dependent on the surgeon’s experience.