BRACHYCEPHALIC BREEDS: THE COST OF CUTE

HOW DENTISTRY CAN PLAY A ROLE IN ADDRESSING BRACHYCEPHALIC BREATHING PROBLEMS

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"THE BEST TOOL VETERINARIANS CAN HAVE TO PROTECT THE WELFARE OF BRACHYCEPHALIC PETS IS A DEEP KNOWLEDGE OF THEIR ANATOMICAL FEATURES."

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Owners may be initially attracted by what they perceive as cute, but the reality is different, sometimes far different. Owners should understand the pathologies that their pets have, which are falsely perceived as standard for the breed. They also need to be prepared for the financial commitment involved in caring for a flat-faced pet. The challenge, of course, is that many of the people who own and recommend a brachycephalic breed have already prioritized cuteness without fully understanding the multiple health issues.

Veterinarians play an essential role in creating awareness by educating their clients about the health and welfare concerns that brachycephalic breeds face. The best tool veterinarians can have to protect the welfare of brachycephalic pets is a deep knowledge of their anatomical features.

BOAS

Some owners believe that addressing BOAS (brachycephalic obstructive airway syndrome) is all that their pets will need to have a good quality of life, mistakenly believing that one fix will cure everything. Sadly, this is not so. Many owners are unaware that their pet may suffer in silence due to chronic and painful conditions such as traumatic occlusion, oronasal fistula, periodontal disease, or unerupted teeth.

The goal of this article (and others that will follow) is to provide an in-depth review of the following:

1. Skull anatomy
2. Dental conditions
3. Components of BOAS and any other oropharynx, nasopharynx, and pharynx pathologies
4. General recommendations for anesthesia and common emergencies associated with brachycephalic breeds

BRACHYCEPHALIA

The term *brachycephalic* refers to a type of head shape. The head shape is also known as a *cephalic index*. Based on the cephalic index ratio (calculated as the maximum width of the head divided by the head's maximum length and multiplied by 100), the skulls of the dogs may be classified as brachycephalic, mesocephalic, or dolichocephalic.

A better definition describes brachycephaly as a local chondrodysplasia induced by domestication that manifests as alteration so that the cranial length to skull length ratio is greater than 3.44 or the skull width to length ratio is more than 0.81 (see Figure 1).

Neurocranium shape

- Rounded and protruding forehead
- Brain case relatively large
- Cribriform plate anteriorly displaced
- High incidence of keyhole-shaped foramen magnum
- Brain is rotated with respect to its mediolateral axis
- Muscle attachment sites large, providing increased mechanical advantage
- Angulation between the skull base and hard palate
- Short basicranium with increased skull height
- The angle formed by the cranial base and palate quantify the dorsal rotation of the snout; angles greater than 180 degrees characterize airorhynchy
- Up-down-snout or airorhynchy in Boxer and French Bulldog
- Cephalic index of more than 60 indicates a short head

Cranial base length

- Disproportionate to overall body size
- Chondrodysplasia
- Two temporal lines instead of a sagittal crest
- Persistent ventral foramen magnum

Zygomatic arches

- Wide and shallow
- Shallow orbits, ocular proptosis, and widely placed orbits
- Widened skull with wide zygomatic arches

Rostrum

- Shortened
- Frontonasal dysplasias
- Face is shorter, smaller, and wider
- Hypoplasia of the bones of the rostrum and retrognathic upper jaw

Palate

- Flat or convex (rather than concave) oral surface of the palate
- Club-shaped
- Short and wide secondary palate (maxilla and palatine)

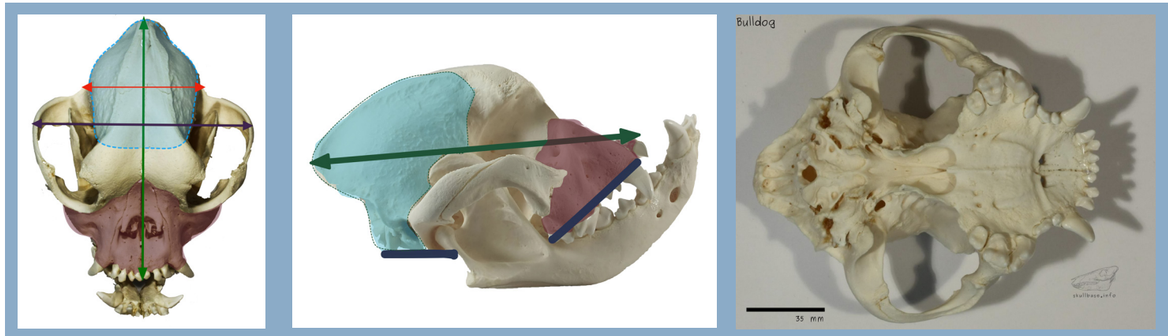

FIGURE 1: Anatomical and morphological characteristics of the brachycephalic skull.

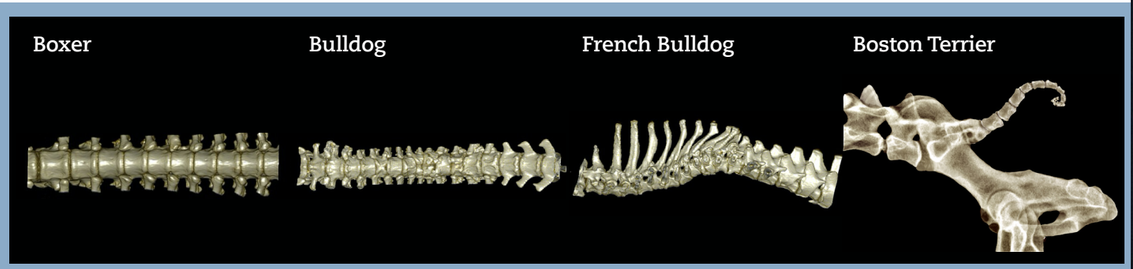

FIGURE 2: Spinal malformations in screw-tailed breeds associated with the *DVL2* gene.

Mandible
- Shorter and wider
- Bowing of mandibular body
- Protruding mandible and prognathic lower jawbone
- Malocclusion class III (underbite)

Disrupted carnassial complex
- Greater variance in carnassial orientation
- Maxilla/palate shape shows medio-lateral widening centre at PM4
- Crowded premolars
- Wide spread of incisors

THE GENETIC COMPONENT OF BRACHYCEPHALIA

Modifications in dog breeds have traditionally been based on breeding for desired phenotypes. However, in just the last couple of decades, we have started to track and identify the specific genes associated with brachycephalism in dogs.

There is new evidence supporting the hypothesis that mutations associated with the skull shape in brachycephalic breeds may be related to a near-homozygous trait (a selective sweep). Also, sequencing the genome of screw-tailed brachycephalic breeds demonstrates a mutation in the *WNT* pathway gene *DISHEVELLED 2* (*DVL2*). Bulldogs, French Bulldogs, and Boston Terriers may show manifestations of the *DVL2* variant in a recessive, variable, and incomplete penetrance for thoracic and caudal vertebral column malformations (see Figure 2).

Various genes and suggested loci have been associated with the phenotypic characteristics of brachycephalia (see Table 1). On the CFA1 chromosome, the *SOMC2* gene for modular calcium binding is responsible for the most profound facial length variation. On CFA5, *DVL2* is associated with the screw tail phenotype and vertebral abnormalities. On CFA32, *BMP3* (bone morphogenetic protein 3) modulates skull shape. On CFA12, *FGF4* reduces neurocranium size.

Two features of brachycephalic breeds are associated with polyglutamine and polyalanine on the transcription factor of *RUNX2*:
1. Dorsal bending of snout (airorhynchy)
2. Midface length

Underdeveloped nasal turbinals

The same genetic mutations responsible for restricting the facial length growth in brachycephalic breeds also affect the development of the turbinals. As the space in the nasal cavity becomes compromised, some of the turbinals develop in abnormal places (aberrant turbinals).

Possible locus (CFA)	Gene	Skull length	Snout length	Mandibular length/ height	Zygomatic arch width	Palate length/ width	Bone density	Suture closure
1	*SOMC2*		*SL*	*ML*				
5 (no pug)	*DVL2*		*SL*					
24	Unknown				*Za*			
30	Unknown					*PL*		
32	*BMP3*	*SkL*	*SL*				*BD*	*SC*
X		*SkL*		*MD-H*	*Za*	*PW*		
	FGF4	*SL*				*SL*		

TABLE 1: Gene loci for phenotypic characteristics of brachycephalia.

FIGURE 3: Placement of the mandibular canal.

Mandible and mandibular canal

Changes on the mandible are not as profound as the change on the maxilla of brachycephalic dogs, but they do exist. The mandible is shorter and is wider in a medial-lateral direction.

The body of the mandible is shorter and has a bowed shape. This is the result of the carnassial tooth and the rest of the posterior teeth being in a more inferior location than in mesocephalic breeds.

The mental foramen is located in the mandibular body approximately halfway ventral to the alveolar edge, with a mild displacement in the posterior and lateral directions. The mandibular foramen is also displaced in an anterior direction. As a result, the inferior alveolar canal is shorter.

The mandibular canal in brachycephalic dogs (see Figure 3) travels from caudal to rostral in a lingual to vestibular direction. The entrance is the mandibular foramen; then the canal reaches the maxilla deep from the alveolar crest at the level of tooth 309/409. Finally, the canal is slightly displaced in the direction of the alveolar crest to reach and exit through the middle mental foramen.

Another factor that determines the shape of the mandible in brachycephalic dogs is their large and strong masticatory muscles. But those changes are not limited to the mandibular body. Another change is that the coronoid process is large and wider with a deep masseteric fossa and the ramus curved ventrally and laterally.

Cribriform plate shape

The cribriform plate (CP) has a remarkable plasticity that allows it to adapt to extreme breed modifications. This plasticity is due to its late ossification, which happens several months after birth. Therefore, variations of the CP are more profound in domesticated dogs than in wild canids.

An example of this is in short-snouted skulls, where the main axis of the CP is flat. Also, the CP is shifted anteriorly. Pugs showed a CP that is remarkably different than in other dogs. Their CP is flatter and the rostra caudally compressed.

Nasal septal deviation

The prevalence of nasal septal deviation has been underestimated and historically has been associated with nasal pathologies. However, recent studies show that there is no difference in the prevalence of nasal septal deviation between healthy and ill dogs.

An example of this is the brachycephalic breeds that may have developmental distortions of the nasal septum due to their increased facial and skull indices. A study evaluating nasal airflow showed that some English Bulldogs may have had disruption of the nasal air flow due to deviation of their nasal septum.

Changes in the carnassial complex

The reduced size of the maxilla in brachycephalic dogs directly affects the position of the maxillary premolars PM4 in relation to the mandibular M1.

A recent study confirmed that the distance between the MX and PM4 is larger and the MX-to-MD carnassial ratios are wider than in other breeds. Also the PM4 shows malocclusion class I as they are rotated. The changes have disrupted the scissoring and shearing functions of these teeth.

Hard palate

There is a remarkable anterior projection and rotation of the PM4 in the hard palate of brachycephalic dogs. These changes are maladaptive and have been perpetuated by selecting breeding. WCV

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