animals

MDPI

Case Report

Changes in the Dentition of Small Dogs up to 4 Months of Age

Gábor Lorászkó [1], Bence Rácz [1] and László Ózsvári [2,*]

[1] Department of Anatomy and Histology, University of Veterinary Medicine, H-1078 Budapest, Hungary; loraszko.gabor@univet.hu (G.L.); racz.bence@univet.hu (B.R.)
[2] Department of Veterinary Forensics and Economics, University of Veterinary Medicine, H-1078 Budapest, Hungary
* Correspondence: ozsvari.laszlo@univet.hu

Simple Summary: National and EU legislation impose age restrictions for the rabies vaccination which is required in the export of dogs. This makes it important to know whether a particular dog is older than three months or not. In veterinary practice, age estimation is mostly based on dentition, although there is no standardized method described in the literature for determining the age of dogs under four months old and we found considerable variation in the references. We observed and recorded the changes in cranial shape and dentition of two Yorkshire Terriers born by caesarean section on 2 March 2018 up to four months of age. At the age of three months, both individuals showed the same characteristics of a wide gap between the upper maxillary incisors (i2 and i3) and the lower maxillary incisor and canine (i3 and c).

Abstract: It is common practice in EU member states to permit the entry of dogs vaccinated against rabies at the age of at least 3 months. In the absence of easily applicable comparative data, subjective disputes emerge around age. The aim of our study was to observe the development of dog teeth. During birth, an abnormally lying Yorkshire Terrier fetus was stuck in the birth canal, which led to a caesarean section, hence, the exact date of birth was known. For the next 4 months, two puppies were examined weekly, and they showed the same development. The dogs were born without teeth. At the age of 4.5 weeks, the canines I appeared, together with the adjacent incisors (i3), and the second incisor (i2) also erupted at the age of 6 weeks. A week later, a first incisor (i1) also appeared. From the age of 2.5 months, the distance between the teeth was increasing, especially on the upper dental arch. At 3.5 months of age, only the bottom front incisors (i1) had not grown in a row, and the significant distance between the top incisors, comparable to the width of the tooth, was striking. Since only two dogs of one breed were involved in this case study, the observations cannot be generalized.

Keywords: age determination; deciduous tooth; dog trade; animal protection; animal welfare

Citation: Lorászkó, G.; Rácz, B.; Ózsvári, L. Changes in the Dentition of Small Dogs up to 4 Months of Age. *Animals* **2022**, *12*, 1417. https://doi.org/10.3390/ani12111417

Academic Editor: Mandy Paterson

Received: 31 March 2022
Accepted: 30 May 2022
Published: 31 May 2022

1. Introduction

It is estimated that there are 74.4 million dogs in the EU member states [1] and of those, 46,000 dogs are traded every month, with an annual turnover of EUR 1.3 billion, directly supporting the incomes of 300,000 people [2]. The link between dog trafficking and crime [3] is regularly addressed by the European Union [4,5] and national authorities [6,7], NGOs [8,9] and the media [10–13], primarily from an animal welfare perspective.

Traditionally, one of the most popular transport destinations from Hungary is Italy, where the relevant legislation is the imprisonment of up to 1 to 3 months and fines of EUR 3000–15,000 for importing animals without the appropriate documentation, which increases if the animal is less than 12 weeks old [14], while the documents accompanying the animals often contain false information [15]. Although the annual incidence of rabies in pets in EU member states has recently fallen to just a few cases, in neighboring Ukraine, the incidence of rabies is two orders of magnitude higher [16]. This underlines the importance of vaccination against rabies, and the associated minimum age for eligibility makes it important to estimate the age of puppies as accurately as possible.

In the past, it was recommended to look at the dentition [17,18] of young and old dogs to distinguish them from each other, and the dentition was also considered the best way to estimate the age of a horse [19] when it was purchased, although its empirical system was described thousands of years later [20–23].

The timeline of tooth development was also used to identify the age of children employed in industrial production [24], a method that is still, after nearly two hundred years, scientifically accepted [25]. After human examinations, medical researchers studying the development of dentition in animals [26] compared the processes in animal species [27], including dogs, and found that nutrient and vitamin supply also have an effect on it [28]. More recent studies identified a wider range of influencing factors that are difficult to separate [29]. Rodents have proved to be the best model animal because of their ever-growing incisors [30].

In veterinary medicine, the changes in horse dentition with age has always been an important piece of knowledge [31] and communications are still issued on age determination based on teeth [32]. This procedure is still used on laboratory animals [33] and wild animals [34], such as fur-bearing animals [35] and wild boar [36].

In the modern era, the first choice for estimating the age of a dog was also its dentition [37]. The role of photographs, which are of a quality that can also be evaluated today, was later taken over by drawings [38]. The names of the teeth [39], their positioning [40], their approximation [41] and their exact structure [42] are described in detail in anatomy textbooks.

X-ray diagnostics may be used to determine the age of dogs on the basis of the appearance of certain tendons [43–46] and the progression of ossification [47–51] and changes in the positioning and structure of certain teeth [52,53]. The age of the dog can be determined by histopathological examination of the cerebellum up to 75 days of age [54] and ophthalmological examination can be used to determine the age of adult animals [55,56]. The age of a dog can only be determined to a limited extent [57–60], or not at all [61], on the basis of specific behaviors (walking, vocalization) [62] appearing from a few weeks of age, EEG examination [63] or neurological examination [64].

In practice, it would be advantageous if age could be recognized without special tests in order to determine whether the dog in question, on the basis of its age, could comply with the border crossing rules or whether the accompanying documents are authentic. There can be substantial variation in the rate of tooth eruption [65,66] but, for example, in the United States, no entry is allowed for any dog under eight weeks old [67] and, for commercial or adoption purposes, only dogs over six months of age are allowed [68], and they consider this determinable on the basis of the teeth [69]. The literature on the subject typically includes data on large and medium-sized dogs, for example, the dentition of 89 medium and large dogs [70] or 107 beagle puppies [71] were recorded; however, Roccaro [65] also studied the dentition of small dog breeds (eight Pomeranian dwarf spitz and two dwarf poodles).

In this case study, we followed the development of canine milk teeth from a known date of birth to 3.5 months of age in two Yorkshire Terriers. The long-term aim was to start collecting data that would be readily comparable retrospectively, and later, on the basis of a sufficient number of samples, to answer the question as to whether, in daily practice, age estimation based on dentition could possibly give acceptable accuracy within a certain breed.

2. Materials and Methods

After a caesarean section performed on a Biewer Yorkshire Terrier (the Yorkshire Terrier is not a separate breed due to a recessive gene defect in the white color), whose whelping was arrested due to lying abnormally on 2 March 2018, the owner presented the two surviving puppies for examination on day 10, 18, 25, 32, 41, 46, 53, 62, 69, 81 and 102 of life. The photos were taken by the following camera and accessories: Canon EOS 600D 1/200 s, ISO 400, Canon EF-S 60 mm f/2.8 and Canon Speedlite 430 EX II EOS.

We used similar marking on the images:

- Age in days and rounded in weeks;
- Dentition characteristics: missing tooth is marked in white, erupting tooth in red, growing tooth in yellow and deciduous tooth in line in green square;
- Graphical representation of the time between birth and four months of age.

For tooth shape and size, the 3.5 month status was used as a reference (Figure 1).

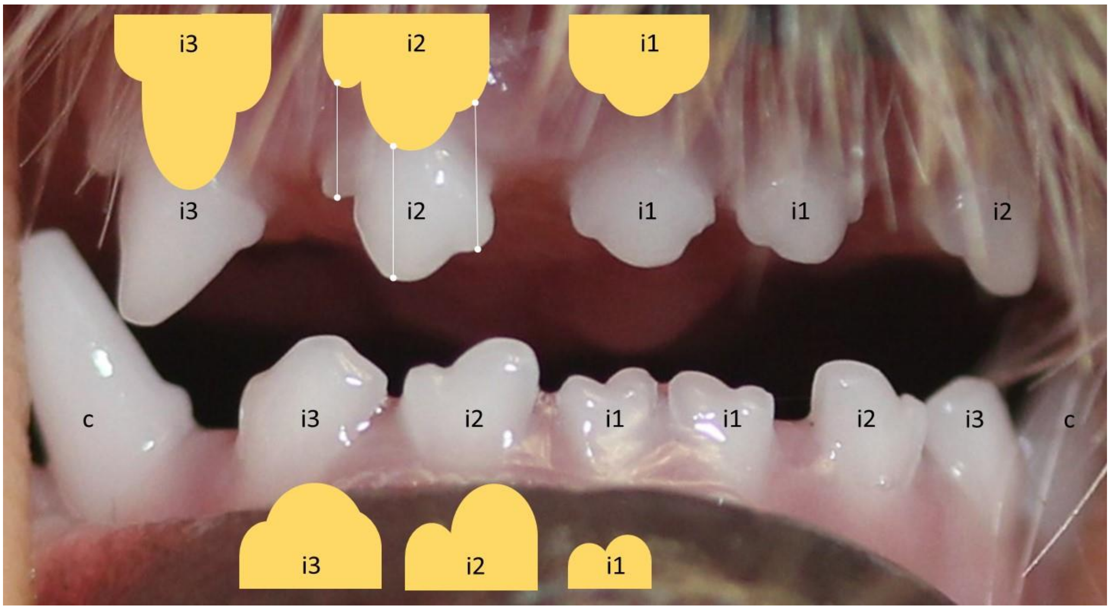
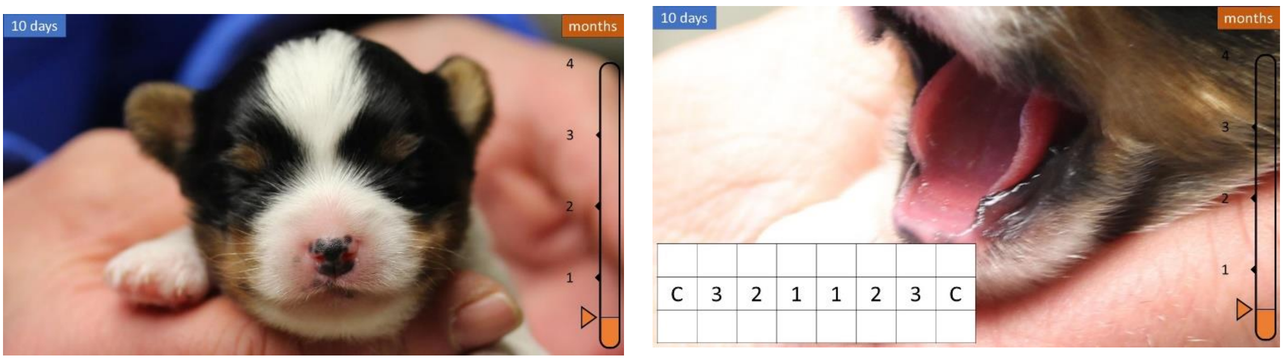


Figure 1. Special shaped incisors of a three-and-a-half-month-old Yorkshire Terrier.

The two puppies developed their teeth at exactly the same rate. All images presented are from one of the dogs.

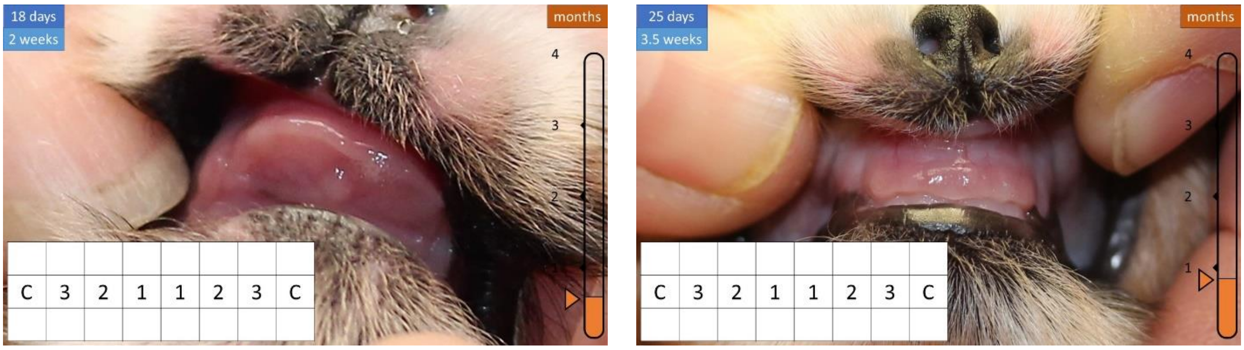
3. Results

During the first few weeks of life, the head is shaped similar to a sphere and has no teeth (Figures 2 and 3).



(**a**) (**b**)

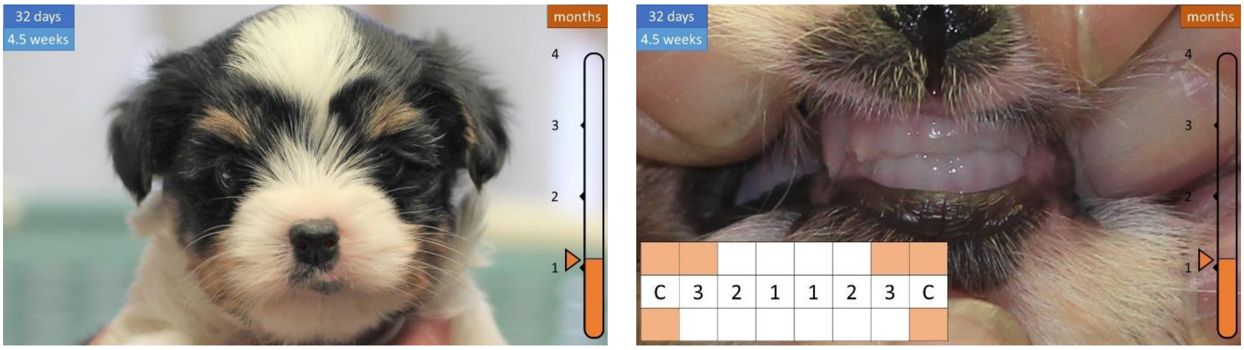
Figure 2. Development of the head and teeth in the first 10 days of life. (**a**) Near-spherical skull. (**b**) There are no teeth.



(**a**) (**b**)

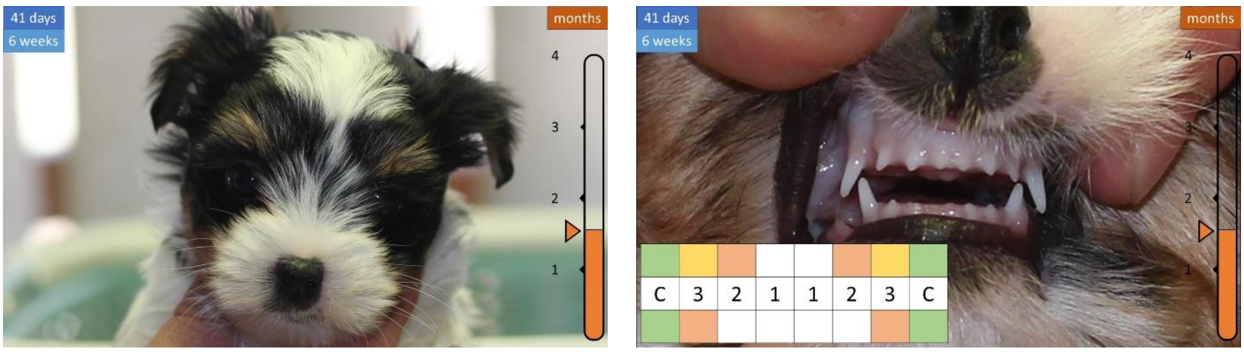
Figure 3. Development of the teeth in the first 18 and 25 days of life. (**a**) There are no teeth. (**b**) There are no teeth.

At four and a half weeks of age, the coat is longer and the canines (c) and the adjacent incisors (i3) on the top (Figure 4) are erupting. At six weeks of age, the coat is even longer, the canine tooth (c) becomes significantly longer, and the second incisor (i2) emerges in the upper dentition (Figure 5).



(**a**) (**b**)

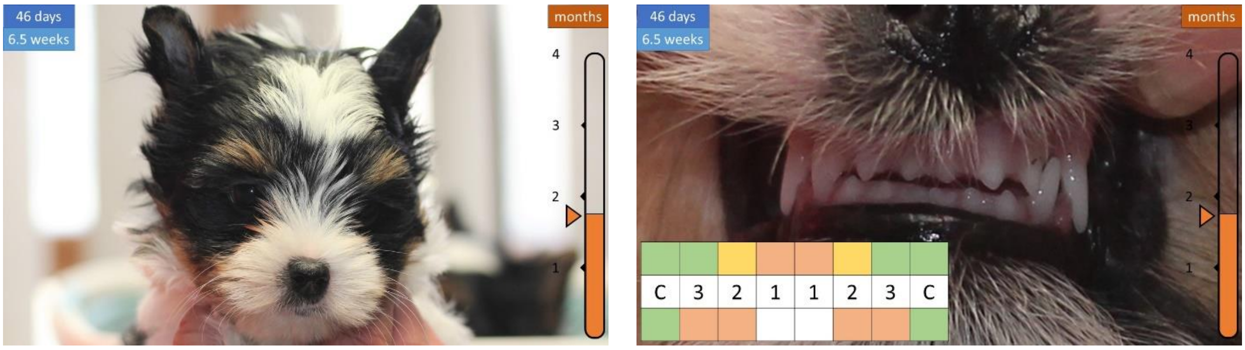
Figure 4. Development of the coat and teeth in the first 32 days of life. (**a**) Longer coat. (**b**) Appearance of the first teeth.



(**a**) (**b**)

Figure 5. Development of the coat and teeth in a 6-week-old puppy. (**a**) Even longer coat. (**b**) Visible canines and new incisors.

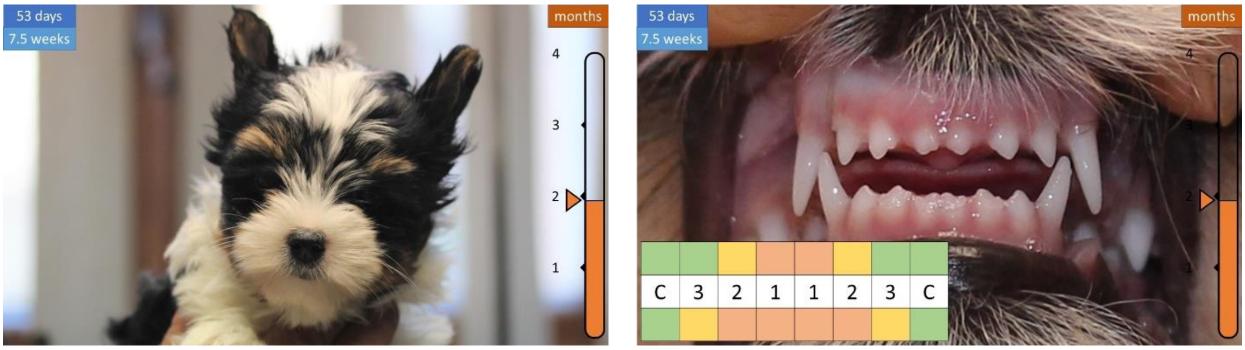
After a few days, the upper first incisor (i1) is also visible (Figure 6).



(**a**) (**b**)

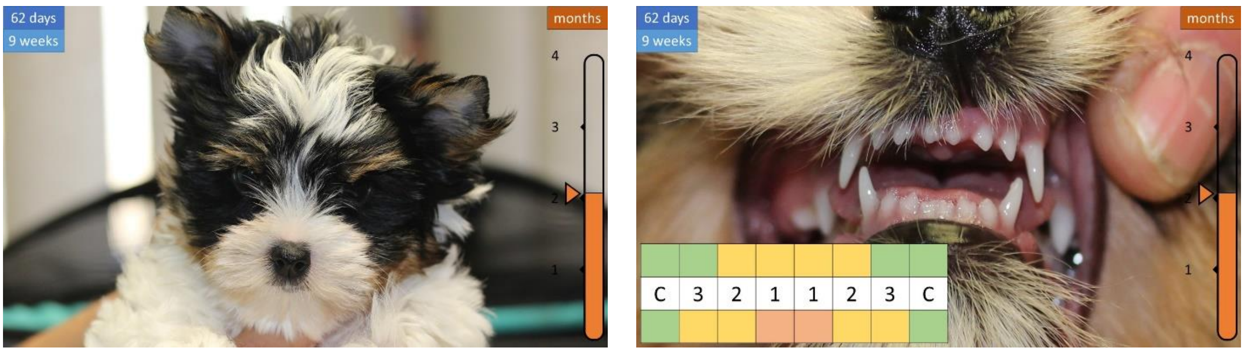
Figure 6. Development of the skull and teeth in a 6-week-old puppy. (**a**) Head shape is no longer spherical. (**b**) Upper dentition completed.

A week later, the face becomes longer and the lower first incisor (i1) appears (Figure 7), then the teeth continue to grow, and the shape of the head becomes more articulated, covered with a longer coat (Figures 8 and 9).



(**a**) (**b**)

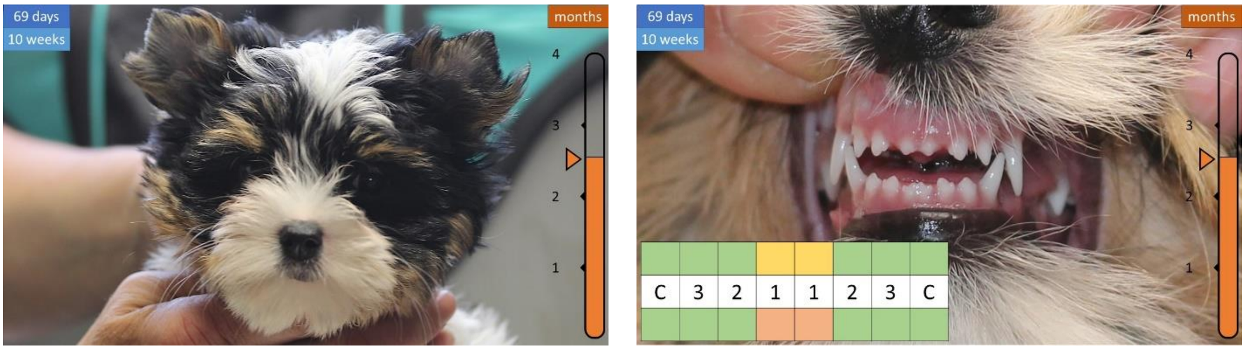
Figure 7. Development of the skull and teeth in a 7.5-week-old puppy. (**a**) An elongated face begins to form. (**b**) All teeth are visible.



(**a**) (**b**)

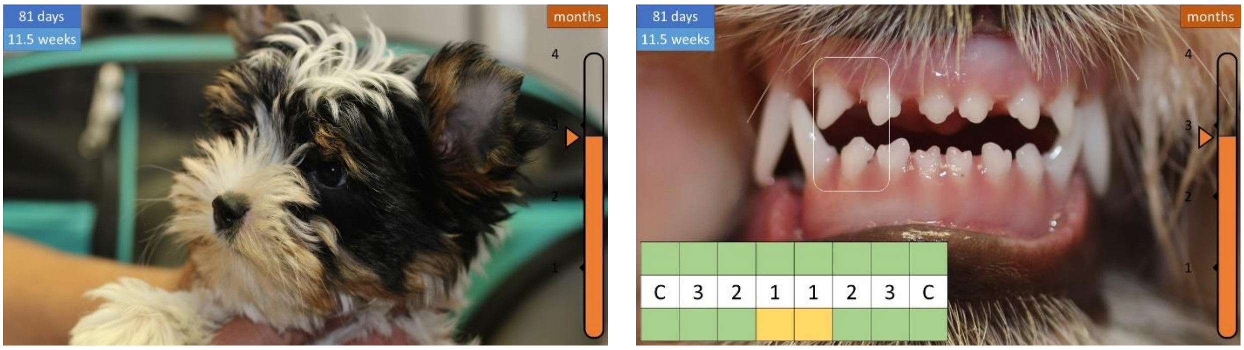
Figure 8. Development of the skull and teeth in a 2-month-old puppy. (**a**) More articulated head. (**b**) Most of the incisors are clearly visible.

At 2.5 months of age, the coat is long and the distance between the teeth is noticeable, more so for the upper dentition (Figure 10).



(**a**) (**b**)

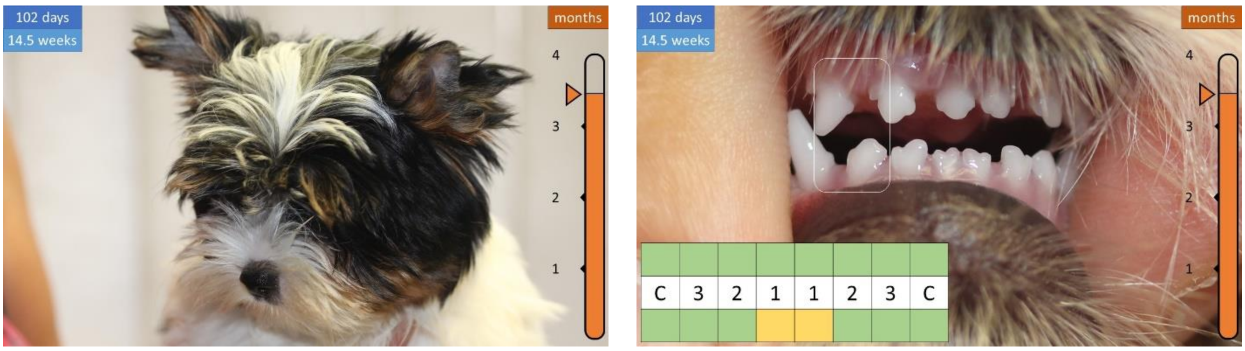
Figure 9. Development of the skull and teeth in a 10-week-old puppy. (**a**) Even more articulated head. (**b**) Teeth grew in a row except for the first incisors.



(**a**) (**b**)

Figure 10. Development of the coat and teeth in a 11.5-week-old puppy. (**a**) Long coat ("tousled"). (**b**) The upper incisors are spaced apart.

By 3 months of age, the coat is long enough to be combed, and the widening gap between the lower teeth can be observed in the bottom dentition, which corresponds with the upper incisors to about half the width of a tooth (Figure 11).



(**a**) (**b**)

Figure 11. Development of the coat and teeth in a 14.5-week-old puppy. (**a**) Long coat that can be combed. (**b**) Distance between the lower teeth.

At 3.5 months of age, only the lower first incisors (i1) have not grown in a row. As the skull grows, the teeth become increasingly spaced apart. Under three months of age, the lower dental arch is barely visible, but after 3 months it is. In the upper dental arch the distance between the two extreme incisors (i2 and i3) is most prominent, and in the lower dental arch, the distance between the incisor (i3) and the canine (c) is the most prominent (Figure 12).

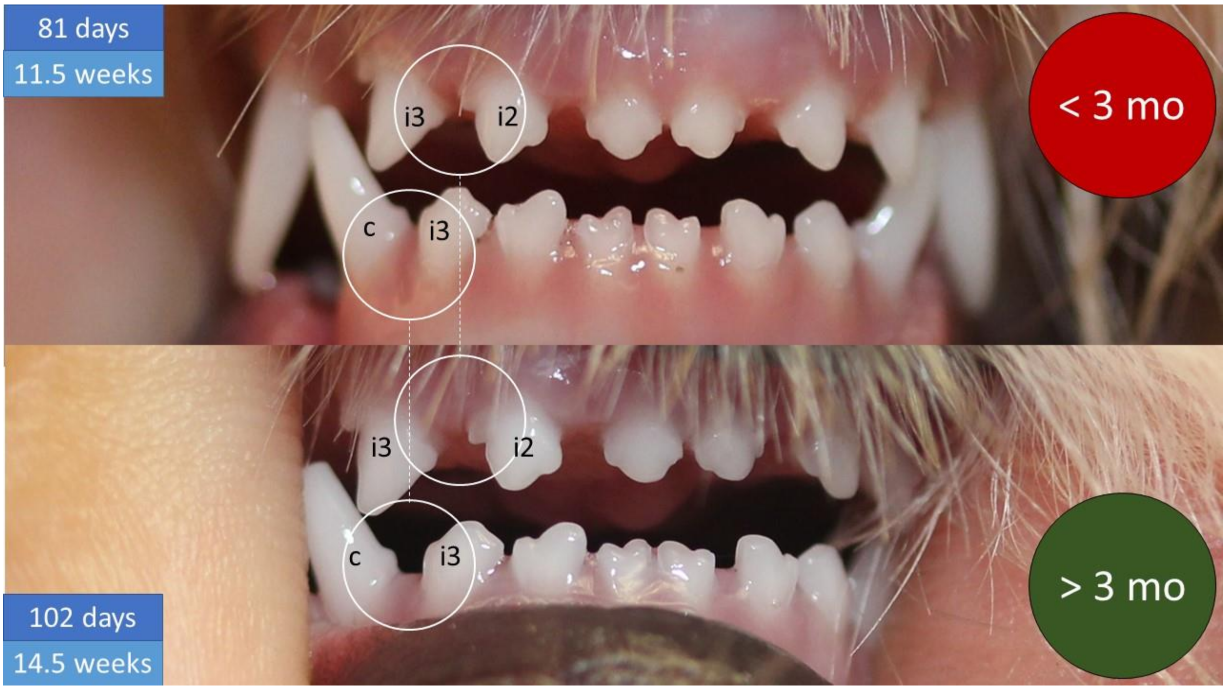


Figure 12. The gaps between the teeth of dogs under and over three months of age show a characteristic (about twofold) difference.

Gaps between the teeth of dogs under three months of age show a characteristic difference.

A specific condition is observed in the studied individuals for the period of time relevant in terms of the dog trade.

4. Discussion

A dog is born without teeth, then at a certain age the milk teeth appear (erupt), emerge, and grow to full size (grow in a row). The emergence and positioning are species specific [72]. The growing tooth mechanically excites the gums, causing them to bite and chew, which aids and accelerates its penetration through the gums [73]. As the body grows larger, the size of the teeth does not follow it, so they become increasingly spaced, and then the deciduous teeth fall out (exfoliate) and larger permanent teeth grow, of a size appropriate to the adult skull [74]. In humans, it is accepted that teeth only appear when there is sufficient space for them, and that tooth germs migrate to the desired location as the cranial bones grow, as a result of bone resorption and new bone formation [75]. For new teeth to erupt, the bones that hold the teeth need to grow properly [76]. The displacement of tooth germs and erupted teeth is aided by the increased local rate of bone formation, which even in adult dogs is three times that of the femur in the case of the jawbone and five times that in the case of the mandible [77]. Within the mandibula, the bone formation in the tooth sockets is 3–5 times faster than in the cortical bone [78]. In puppies, the rate of bone formation in the cortical bone of the jawbone is initially lower than in the femur, but slows down as age progresses, while the rate of bone formation in the jawbone and mandible remains high [79].

The milk incisors (i) and canines (c), which can be easily examined by viewing, appear in the first months of life. For veterinary practitioners, the dental characterization of the second to fourth months is not included in the literature [80]. One of the most prestigious professional bodies [81] in veterinary dentistry does not describe the emergence of milk teeth; instead, it refers in its nomenclature to a book on an anatomy nomenclature, which does not include dental information for the first few months [25]. The World Small Animal Veterinary Association's [82] Global Dental Guidelines [83] contain detailed anatomical descriptions, but data on dentition are missing. The American Animal Hospital Association's (AAHA) guidelines [84,85] for the dental examination and care of dogs and cats do not include the characteristics of dentition; the appearance table of deciduous teeth [86] relates to the period between 3 and 6 weeks of age, with a spread of several weeks for each tooth, and then with a spread of 1 to 2 months for permanent teeth after 4 months of age. In its guidelines describing the life stages of dogs [87], the AAHA discusses the age characteristics of dogs from two weeks of age, but only discusses teeth as a potential health problem. The age of three months cannot be established by using veterinary bulletins [88,89], nor even in the related papers of dental clinics [90], or it is not mentioned at all [91–93]. A world-renowned pet food industry player also provides information on possible age determination from teeth [94], but in stages overarching several months.

Determining age by simple means would have great advantages, but the method to determine age by dentition alone is uncertain as far as we currently know. It is possible that, similarly to the significant differences in ossification between species [75], tooth development may differ between individuals to such an extent that age estimation from teeth is too imprecise. There is little specific literature on any particular breed and even then, there may be considerations that affect the assessment and the final conclusion. In addition to hereditary traits, the time of emergence of human deciduous teeth depends on the composition of the diet [95–98], partly also on the texture of food [99], and therefore the results of the study on the teeth growth of the 107 beagles with the largest number of one breed may have been influenced [71] by the fact that the animals were fed twice daily until 4 months of age and only once thereafter. Today, puppies are fed three times a day up to six months of age in the most age-appropriate formulation and with a feed pellet size that takes into account the size of the breed.

In small dogs, dentition may be delayed [48], which is consistent with our observation that, in the small breed dogs we studied, the change in incisors to permanent teeth occurred much later than would have been expected based on previous experience [66]. Silver [47] described all incisors as erupted at the age of 4 to 6 weeks, whereas in the dogs we studied, mandibular i1 did not appear until the age of 6.5 weeks, only a week later. In the brachycephalic breeds, some teeth are more frequently unerupted than average [99], and although this abnormal cranial shape is not typical of the Yorkshire Terrier, it may have occurred in our case. The position of the growing teeth relative to each other varied from week to week, probably due to the non-uniform growth of the teeth [100].

5. Conclusions

The development of the two puppies' dentition occurred at the same rate and was consistent with our decades of veterinary experience. The main value of the observations is the proven affiliation to a breed that is popular in the dog trade, the certainty of age and the pictures showing the progression of the teeth in relation to each other. Nevertheless, the results need to be extensively validated before any general conclusions are drawn, as only two dogs of one breed were involved in the study and several factors can be involved in the dentition, including individual differences and variability among breeds, especially if airorhynchy and klinorhynchy skulls are considered.

Author Contributions: G.L. conceived and designed the study and made the visualization. G.L., B.R. and L.Ó. contributed to the conceptualization and writing of the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The animal study protocol was approved by the Scientific Research Committee of University of Veterinary Medicine Budapest (TKB/0408-1/2022; 8 April 2022).

Informed Consent Statement: Written informed consent was obtained from the owner of the animals.

Data Availability Statement: The data presented in this study are available on request from the corresponding author without undue reservation.

Acknowledgments: We are indebted to Elisabeth Nagy, the owner of the dogs, for her willingness to present the small dogs for months for mouth examination and photographs, Attila Magyar, Associate Professor at the Institute of Anatomy, Tissue and Developmental Biology, Semmelweis University, for his advice on developmental issues, and Katalin Julia Bikádi and Marietta Máté for their valuable help.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. European Pet Food Industry Federation: More Than 140 Million Cats and Dogs in the EU. Available online: https://www.fediaf.org/component/memberlibrary/memberlibrary.html?id=2156:more-than-140-million-cats-and-dogs-in-the-eu&Itemid=101 (accessed on 28 March 2021).
2. Study on the Welfare of Dogs and Cats Involved in Commercial Practices. Specific Contract SANCO 2013/12364. Available online: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_eu-strategy_study_dogs-cats-commercial-practices_en.pdf (accessed on 28 March 2021).
3. Maher, J.; Wyatt, T. European illegal puppy trade and organised crime. *Trends Organ. Crime* **2021**, *24*, 506–525. [CrossRef] [PubMed]
4. European Parlament: Pet Trafficking: Measures against the Illegal Puppy Business. Available online: https://www.europarl.europa.eu/news/en/headlines/society/20200117STO70506/pet-trafficking-measures-against-the-illegal-puppy-business (accessed on 17 April 2021).
5. EU Political Report: Puppy Smuggling Peaks. Available online: https://www.eupoliticalreport.eu/puppy-smuggling-peaks/ (accessed on 17 April 2021).
6. Ministero Della Salute: Traffico di Cuccioli, Procedure per L'esecuzione dei Controlli nella Movimentazione Comunitaria di Cani e Gatti. Available online: https://www.salute.gov.it/portale/news/p3_2_1_1_1.jsp?menu=notizie&p=dalministero&id=2948 (accessed on 28 March 2021).
7. Bundesministerium: Zoll Stoppt Erneut Welpenschmuggler. Available online: https://www.bmf.gv.at/presse/pressemeldungen/2021/mai/welpenschmuggel.html (accessed on 17 April 2021).
8. Mayhew: The EU Puppy Smuggling Scandal Continues. Available online: https://themayhew.org/the-eu-puppy-smuggling-scandal-continues/ (accessed on 10 January 2022).
9. Organised Crime and Corruption Reporting Project: The Canine Connection: Europe's Illegal Dog Trade. Available online: https://www.occrp.org/en/blog/14263-the-canine-connection-europe-s-illegal-dog-trade (accessed on 10 January 2022).
10. Puppy Smuggling: Rise in Cases Prompts New Welfare Rules: BBC News. Available online: https://www.bbc.com/news/uk-58287850 (accessed on 10 January 2022).
11. The Telegraph: The Shocking Truth about Britain's Illegal Puppy Smuggling Trade. Available online: https://www.telegraph.co.uk/christmas/0/shocking-truth-britains-illegal-puppy-smuggling-trade/ (accessed on 29 May 2021).
12. France 24: Puppy Trafficking in Europe, a 'Well-Organised Mafia'. Available online: https://www.france24.com/en/tv-shows/focus/20210716-puppy-trafficking-in-europe-a-well-organised-mafia (accessed on 10 December 2021).
13. "Kofferraumgeschäfte" mit Hundebabys, Süddeutsche Zeitung. Available online: https://www.sueddeutsche.de/muenchen/ebersberg/markt-schwaben-welpen-schmuggel-infektion-1.5536636?reduced=true (accessed on 10 December 2021).
14. LEGGE 4 November 2010, n. 201. Available online: https://www.gazzettaufficiale.it/eli/id/2010/12/03/010G0220/sg (accessed on 17 April 2021).
15. D'Intino, N.; Messori, S.; Arena, L.; Ferri, N.; Ruggieri, E. Il Trasporto Degli Animali da Compagnia. Available online: https://www.trentagiorni.it/files/1443603530-27-28.pdf (accessed on 29 May 2021).
16. Rabies-Bulletin–Europe. Available online: https://www.who-rabies-bulletin.org/site-page/queries (accessed on 29 May 2021).
17. Aristotle: Natural History of Animals, Book II, 350 BC. Available online: http://classics.mit.edu/Aristotle/history_anim.2.ii.html (accessed on 29 May 2021).
18. Marcus Terentius Varro: Rerum Rusticarum, Liber Secundus, 37 BC. Available online: https://penelope.uchicago.edu/Thayer/E/Roman/Texts/Varro/de_Re_Rustica/2*.html (accessed on 10 December 2021).
19. Seaverns, J.A. *The Art of Horsemanship by Xenophon*, 1st ed.; John Wilson and Son: Cambridge, MA, USA, 1894; Chapter III; pp. 23–26.
20. Erdelyi, V.M. *Darstellung des Zahnalters des Pferdes, Rindes, Schafes und Schweines; Nebst Einem Pferd-Scelette mit den Äusseren Umrissen, Als Beytrag zur Vergleichenden Anatomie und Physiologie, und als Beylage zur Knochenlehre des Pferdes und der Übrigen Haussäugethieren*, 1st ed.; Leopold Grund: Wien, Austria, 1820.
21. Girard, N.F. Età del Cane. In *Ippodonteologia*, 1st ed.; Perelli e Mariani: Milano, Italy, 1845; pp. 182–196.
22. Huidekoper, R.S. *Age of the Domestic Animals: Being a Complete Treatise on the Dentition of the Horse, ox, Sheep, Hog, and Dog, and on the Various Other Means of Determining the Age of These Animals*; F.A. Davis: London, UK, 1891.
23. Pope, W.G. *Determining the Age of Farm Animals by Their Teeth*; U.S. Department of Agriculture: Washington, DC, USA, 1934.
24. Saunders, E. The Teeth a Test of Age, Considered with Reference to the Factory Children. *Am. J. Dent. Sci.* **1847**, *7*, 330–375. [PubMed]

25. Manjunatha, B.S.; Soni, N.K. Estimation of age from development and eruption of teeth. *J. Forensic Dent. Sci.* **2014**, *6*, 73–76. [CrossRef] [PubMed]
26. Mellanby, M. An Experimental Study of the Influence of Diet on Teeth Formation. *Lancet* **1918**, *192*, 767–770. [CrossRef]
27. Mellanby, M. *Diet and the Teeth: An Experimental Study. Part II. A. Diet and Dental Disease. B. Diet and Dental Structure in Mammals Other Than the Dog*; Medical Research Council (H.M.S.O.): London, UK, 1931; p. 94.
28. Mellanby, M. *Diet and the Teeth: An Experimental Study. Part I. Dental Structure in Dogs*; Medical Research Council (H. M. S. O.): London, UK, 1929; p. 308.
29. Marks, S.C., Jr. Tooth Eruption: The Regulation of a Localized, Bilaterally Symmetrical Metabolic Event in Alveolar Bone. *Scanning Microsc.* **1987**, *1*, 1125–1133.
30. Catón, J.; Tucker, S.A. Current knowledge of tooth development: Patterning and mineralization of the murine dentition. *J. Anat.* **2009**, *214*, 502–515. [CrossRef]
31. Clarke, W.H. *Horses' Teeth: A Treatise on Their Mode of Development, Anatomy, Microscopy, Pathology, and Dentistry; Compared with the Teeth of Many Other Land and Marine Animals, both Living and Extinct; with a Vocabulary and Copious Extracts from the Works of Odontologists and Veterinarians*, 3rd ed.; W. R. Jenkins: New York, NY, USA, 1886.
32. Hoopes, K.; Evans, P.; Jack, N. Aging Horses by Their Teeth. *All Curr. Publ.* **2020**, *128*, 1–5.
33. Habermehl, K.H. Die Altersbestimmung beim Fleischfresser. In *Altersbestimmung bei Haus- und Labortieren*, 2nd ed.; Paul Parey: Berlin, Germany, 1975; pp. 152–171.
34. Habermehl, K.H. *Altersbestimmung bei Wild-und Pelztieren*; Paul Parey: Hamburg, Germany, 1985; pp. 122–129.
35. Röttcher, D. Beiträge zur Altersbestimmung bei Nerz, Steinmarder und Iltis, Gießen. Ph.D. Thesis, Justus Liebig-Universität Giessen, Veterinarmedizinische Fakultat, Giessen, Germany, 1965.
36. Wittemann, S. Zur Altersbeurteilung beim Wildschwein (Sus Scrofa, Linné, 1758) mit Hilfe von Merkmalen an den Zähnen unter Besonderer Berücksichtigung der Canini. Ph.D. Thesis, Justus Liebig-Universität Giessen, Veterinarmedizinische Fakultat, Giessen, Germany, 2004.
37. Boenisch, F. Beitrag zur Altersbestimmung des Hundes nach den Schneidezähnen. Master's Thesis, Tierarztliche Hochschule zu Berlin, Berlin, Germany, 1913.
38. Barton, A. Age Determination in Dogs. *Iowa State Univ. Vet.* **1939**, *2*, 18–19.
39. Constantinescu, G.M.; Habel, R.E.; Hillebrand, A.; Sack, W.O.; Schaller, O.; Simoens, P.; De Vos, N.R. *Illustrated Veterinary Anatomical Nomenclature*, 4th ed.; Enke Verlag: Stuttgart, Germany, 2018.
40. Budras, K.-D.; McCarthy, P.H.; Horowitz, A.; Berg, R.; Wünsche, A.; Reese, S.; Fricke, W.; Richter, R. *Anatomy of the Dog*, 5th ed.; Schlütersche Verlagsgesellschaft mbH & Co. KG: Hannover, Germany, 2007.
41. Evans, H.E.; DeLahunta, A. *Guide to the Dissection of the Dog*, 7th ed.; Saunders Elsevier: Philadelphia, PA, USA, 2009.
42. DuPont, G.A.; DeBowes, L.J. *Atlas of Dental Radiography in Dogs and Cats*, 1st ed.; Saunders Elsevier: St. Louis, MO, USA, 2009.
43. Wood, A.K.; McCarthy, P.H. Radiologic and anatomic observations of plantar sesamoid bones at the tarsometatarsal articulations of greyhounds. *Am. J. Vet. Res.* **1984**, *45*, 2158–2161.
44. Wood, A.K.; McCarthy, P.H.; Howlett, C.R. Anatomic and radiographic appearance of a sesamoid bone in thetendon of origin of the supinator muscle of dogs. *Am. J. Vet. Res.* **1985**, *46*, 2043–2047.
45. McCarthy, P.H.; Wood, A.K.W. Anatomical and radio-logical observations of the sesamoid bone of the popliteus muscle in the adult dog and cat. *Anat. Histol. Embryol.* **1989**, *18*, 58–65. [CrossRef] [PubMed]
46. Broeck, V.D.B.; Stock, E. The sesamoid bone in the long abductor muscle tendon of the first digit in the dog. *Anat. Rec.* **2021**, *305*, 37–51. [CrossRef] [PubMed]
47. Silver, I.A. The ageing of domestic animals. *Sci. Archaeol.* **1969**, *70*, 283–302.
48. Dennis, R.; Kirberger, R.M.; Barr, F.; Wrigley, R.H. Appendicular skeleton. In *Handbook of Small Animal Radiology and Ultrasound. Techniques and Differential Diagnoses*, 2nd ed.; Elsevier Ltd.: London, UK, 2010; pp. 51–83.
49. Evans, H.E.; de Lahunta, A. The skeleton. In *Miller's Anatomy of the Dog*, 4th ed.; Elsevier Inc.: St. Louis, MO, USA, 2013; pp. 80–157.
50. Thrall, D.E.; Robertson, I.D. *Atlas of Normal Radiographic Anatomy & Anatomic Variants in the Dog and Cat*, 2nd ed.; Elsevier Inc.: St. Louis, MI, USA, 2016.
51. Modina, S.C.; Andreis, M.E.; Moioli, M.; Giancamillo, M.D. Age assessment in puppies: Coming to terms with forensic requests. *Forensic Sci. Int.* **2019**, *297*, 8–15. [CrossRef]
52. Van den Broeck, M.; Cornillie, P. Legal framework and current techniques for age estimation in puppy trade. *Vlaams Diergeneeskd. Tijdschr.* **2020**, *89*, 135–144. [CrossRef]
53. Van den Broeck, M.; Stock, E.; Vermeiren, Y.; Verhaert, L.; Duchateau, L.; Cornillie, P. Age estimation in young dogs by radiographic assessment of the canine pulp cavity/tooth width ratio. *Anat. Histol. Embryol.* **2022**, *51*, 269–279. [CrossRef]
54. Bianco, C.; Forlani, A.; Ressel, L.; Verin, R.; Ricci, E. Cerebellar Histomorphometry for Age Determination of Puppies in Veterinary Forensic Pathology. *J. Comp. Pathol.* **2017**, *156*, 95. [CrossRef]
55. Tobias, G.; Tobias, T.A.; Abood, S.K. Estimating age in dogs and cats using ocular lens examination. *Compend. Contin. Educ. Vet.* **2000**, *12*, 1085–1091.
56. Gesierich, K.; Failing, K.; Neiger, R. Age determination in dogs using ocular light reflection, dental abrasion and tartar. *Tierärztl. Prax. Ausg. K Kleintiere Heimtiere* **2015**, *43*, 317–322.

57. Jagoe, A.; Serpell, J.A. Owner characteristics and interactions and the prevalence of canine behavior problems. *Appl. Anim. Behav. Sci.* **1996**, *47*, 31–42. [CrossRef]
58. Markwell, P.J.; Thorne, C.J. Early behavioral development of dogs. *J. Small Anim. Pract.* **2008**, *28*, 984–991. [CrossRef]
59. Lahunta, D.A.; Glass, E.; Kent, M. *Veterinary Neuroanatomy and Clinical Neurology*, 5th ed.; Elsevier Inc.: Philadelphia, PA, USA, 2020.
60. Veronesi, M.C. *Neonatologia del Cane e del Gatto*; EdiSES: Napoli, Italy, 2013; pp. 1–186.
61. Appleby, D.L.; Bradshaw, J.W.S.; Casey, R.A. Relationship between aggressive and avoidance behaviour by dogs and their experience in the first six months of life. *Vet. Rec.* **2002**, *150*, 434–438. [CrossRef] [PubMed]
62. Scott, J.P. Critical periods in the development of social behavior in puppies. *Psychosom. Med.* **1958**, *20*, 42–54. [CrossRef] [PubMed]
63. Lavely, J.A. Pediatric neurology of the dog and cat. *Vet. Clin. N. Am. Small Anim. Pract.* **2006**, *36*, 475–501. [CrossRef] [PubMed]
64. Marliani, G.; Di Marco, C.; Accorsi, P.A. The psychological and emotional care of the orphaned puppy: The management and the risk of behavioural disorders. *Dog Behav.* **2019**, *5*, 23–34.
65. Roccaro, M. New Advances in Estimating the Age of Dog Puppies for Medico-Legal Purposes. Ph.D. Thesis, Scienze Veterinarie, Università di Bologna, Bologna, Italy, 2020.
66. Roccaro, M.; Peli, A. Age determination in dog puppies by teeth examination: Legal, health and welfare implications, review of the literature and practical considerations. *Vet. Ital.* **2020**, *56*, 149–162.
67. U.S. Department of Agriculture, Animal and Plant Health Inspection Service: Dog's Health and Readiness for Travel—Dog's Age. Available online: https://www.aphis.usda.gov/aphis/pet-travel/pets-on-planes/quiz-series/quiz-dogs-age (accessed on 17 April 2021).
68. U.S. Department of Agriculture, Animal and Plant Health Inspection Service: How to Bring Dogs into the United States for Commercial Sale or Adoption. Available online: https://www.aphis.usda.gov/aphis/ourfocus/animalwelfare/ct_awa_import_live_dogs_regulation (accessed on 17 April 2021).
69. Houle, K.M. Perspective from the Field: Illegal Puppy Imports Uncovered at JFK Airport, Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), Division of Global Migration and Quarantine (DGMQ). Available online: https://www.cdc.gov/importation/bringing-an-animal-into-the-united-states/operation-dog-catcher.html (accessed on 10 December 2021).
70. Kremenak, C.R., Jr. Dental eruption chronology in dogs: Deciduous tooth gingival emergence. *J. Dent. Res.* **1969**, *48*, 1177–1184. [CrossRef]
71. Shabestari, L.; Taylor, G.N.; Angus, W. Dental eruption pattern of the beagle. *J. Dent. Res.* **1976**, *46*, 276–278. [CrossRef]
72. Jonasson, G.; Skoglund, I.; Rythén, M. The rise and fall of the alveolar process: Dependency of teeth and metabolic aspects. *Arch. Oral Biol.* **2018**, *96*, 195–200. [CrossRef]
73. Atkinson, S.R. Growth and development of teeth and jaws (A) Mandible (B) Maxilla. *Am. J. Orthod. Oral Surg.* **1940**, *26*, 829–842. [CrossRef]
74. Hyttel, P.; Sinowatz, F.; Vejlsted, M.; Betteridge, K. *Essentials of Domestic Animal Embryology*, 1st ed.; Saunders Ltd.: Nottingham, UK, 2010.
75. Törő, I.; Csaba, G.Y. *Az Ember Normális és Pathológiás Fejlődése II. Kötet*; Akadémiai Kiadó: Budapest, Magyarország, 1964; p. 248.
76. Keith, A. *Human Embryology and Morphology*; Arnold: London, UK, 1949.
77. Huja, S.S.; Fernandez, S.A.; Hill, K.J.; Li, Y. Remodeling dynamics in the alveolar process in skeletally mature dogs. *Anat. Rec.* **2006**, *288*, 1243–1249. [CrossRef]
78. Marx, R.E.; Cillo, J.E., Jr.; Ulloa, J.J. Oral bisphosphonate-induced osteo-necrosis: Risk factors, prediction of risk using serum CTX testing, prevention, and treatment. *J. Oral Maxillofac. Surg.* **2007**, *65*, 2397–2410. [CrossRef] [PubMed]
79. Huja, S.S.; Beck, F.M. Bone remodeling in maxilla, mandible, and femur of young dogs. *Anat. Rec.* **2008**, *291*, 1–5. [CrossRef] [PubMed]
80. American Veterinary Dental College AVDC Nomenclature. Available online: https://avdc.org/avdc-nomenclature/ (accessed on 28 February 2021).
81. WSAVA. WSAVA—Global Veterinary Community. Available online: https://wsava.org/ (accessed on 28 February 2021).
82. World Small Animal Veterinary Association. World Small Animal Veterinary Association Global Dental Guidelines. Available online: https://wsava.org/wp-content/uploads/2020/01/Dental-Guidleines-for-endorsement_0.pdf (accessed on 28 February 2021).
83. American Animal Hospital Association AAHA. Available online: https://www.aaha.org/ (accessed on 28 February 2021).
84. Bellows, J.; Berg, M.L.; Dennis, S.; Harvey, R.; Lobprise, H.B.; Snyder, C.J.; Stone, A.E.S.; Van de Wetering, A.G. AAHA Dental care guidelines for dogs and cats. *J. Am. Anim. Hosp. Assoc.* **2019**, *55*, 49–69. [CrossRef] [PubMed]
85. Bellows, J. Tooth Eruption and Exfoliation in Dogs and Cats. Available online: https://www.dvm360.com/view/tooth-eruption-and-exfoliation-dogs-and-cats (accessed on 27 February 2021).
86. Bartges, J.; Boynton, B.; Vogt, A.H.; Krauter, E.; Lambrecht, K.; Svec, R.; Thompson, S. AAHA canine life stage guidelines. *J. Am. Anim. Hosp. Assoc.* **2012**, *48*, 1–11. [CrossRef]
87. Teeth, Teething and Chewing in Puppies. Available online: https://vcahospitals.com/know-your-pet/teeth-teething-and-chewing-in-puppies (accessed on 17 July 2021).
88. How Do Vets Determine the Age of a Puppy or Kitten? Available online: http://www.vetstreet.com/our-pet-experts/how-vets-determine-a-puppy-or-kittens-age (accessed on 17 July 2021).

89. Veterinary Dental Center Delayed Eruption—Misaligned Teeth. Available online: https://www.veterinarydentalcenter.com/oral-conditions/misaligned-teeth/delayed-eruption/ (accessed on 17 July 2021).
90. General Dentistry Services and Procedures for Animals: Animal Dental Clinic, San Mateo County. Available online: https://animaldentalclinic.com/services/general-dentistry/ (accessed on 17 July 2021).
91. Pet Dental Center. Available online: https://petdental.center/ (accessed on 17 July 2021).
92. Texas Veterinary Dental Center—Pet Dentistry & Oral Surgery, Houston. Available online: https://www.veterinarydentalservices.com/ (accessed on 10 December 2021).
93. Purina Caring for Your Puppy's Teeth. Available online: https://www.purina.com.au:443/puppies/health/teeth (accessed on 10 December 2021).
94. Rao, N. *Textbook of Forensic Medicine and Toxicology*; Jaypee Brothers Medical Publishers (P) LTD: New Delhi, India, 2000; pp. 78–81.
95. Situmorang, B.; Nasution, L. Malnutrition. *Dentika Dent. J.* **2006**, *1*, 110.
96. Alhamda, S. Relationship between nutritional status and eruption of first permanent mandibular molar teeth among the school children in Indonesia. *South East Asia J. Public Health* **2012**, *2*, 85–86. [CrossRef]
97. Sheetal, A.; Hiremath, V.K.; Patil, A.G.; Sajjansetty, S.; Kumar, S.R. Malnutrition and its oral outcome—A review. *J. Clin. Diagn. Res.* **2013**, *7*, 178. [CrossRef]
98. Ueno, Y.; Saeki, K.; Yoshimura, S. The relationship between tooth eruption and ingestion of 15 food items among children aged 18–20 months. *Jpn. J. Public Health* **2017**, *64*, 143–149.
99. Bellei, E.; Ferro, S.; Zini, E.; Gracis, M. A clinical, radiographic and histological study of unerupted teeth in dogs and cats: 73 cases (2001–2018). *Front. Vet. Sci.* **2019**, *6*, 357. [CrossRef]
100. Marks, S.C., Jr.; Schroeder, H.E. Tooth eruption: Theories and facts. *Anat. Rec.* **1996**, *245*, 374–393. [CrossRef]