

# Condition of tiny dogs' homeostasis diagnosed having "spuria polyodontia"

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**Abstract.** Nowadays special attention must be paid to pathology associated with the violation of the change of milk teeth to permanent of dogs of dwarf breeds. This fact is confirmed by the results of a statistical analysis of appeals from dog owners to specialized dental care at the "Veterinary Hospital": 33 % of the animals were diagnosed with "false polyodontics" – a general increase in the number of teeth due to non-temporal loss. In the literature, it is noted that the hormones of the thyroid and parathyroid glands, sex hormones regulate the exchange of calcium and phosphorus in the blood, thereby affecting the speed of tooth changes and the degree of bone mineralization. As a result of the research, the authors determined the features of hormonal and mineral homeostasis of the body during the period of teeth change in dogs of dwarf breeds at the age of 6 months in the blood serum, characterized by the thyroid gland profile, sex hormones – at the lower reference values, increased phosphorus and calcium levels.

## 1. Introduction

The diseases of the oral cavity are a large group among pathologies of noncommunicable and infectious etiology. According to the literature, the damage to organs and tissues of oral cavity is associated with structural features and functioning, communication with the external environment, the presence of specific microflora, the effects of various environmental factors, etc. It is known, that pathologies of the dentofacial system lead to the development of chronic diseases of the gastrointestinal tract, musculoskeletal system, cardiovascular system and respiratory system, which affects their functional and morphological characteristics. Animals diagnosed with «spuria polyodontia» are common in the practice of a modern veterinarian dentist. «Spuria polyodontia» – is an abnormal increase in the number of teeth due to persistent teeth. Permanence of a temporary tooth together with a permanent one poses a serious threat to the health of the animal. Knowledge and understanding of the anatomical, morphological and functional characteristics of the dentition of dogs lies at the heart of the prevention and treatment of various oral pathologies.

At the moment, the interest has increased in the study of the effects of various factors affecting the eruption and change of teeth. In humanitarian medicine, there is a large number of studies devoted not only to the dates of tooth change, but also to their differences depending on the region, climatic conditions, diet, gender, anthropometric parameters, nationality. Similar studies in veterinary practice were not found by us. The

combinations of external and internal factors also affect the rate of change of teeth which may include: individual characteristics, concomitant pathological processes, heredity. With proper physiological development of the organism, the restoration of the roots of temporary teeth and the eruption of permanent ones simultaneously, which is caused by the growth processes in the body [1].

It is known that for the process of changing milk teeth with endocrine and parathyroid glands, growth hormone, which regulate the concentration of calcium and phosphorus in the blood, are responsible. Thyroid hormones determine not only the growth processes in the body as a whole, but also affect the local growth, the order of change teeth and the degree of bone mineralization. For example, in children with a diagnosis of "hypothyroidism," the process of teething and changing teeth slows down by 2–3 years. At the same time, bone restoration is enhanced by increasing the level of thyroid hormones. At the moment it has been proven, that the maxillofacial area tissues are sensitive to various hormone disruption. Differentiation, division and migration of tooth tissues cells occur under the influence of hormones.

The experimental data confirming the influence of sex hormones on the growth and development of teeth is not, however, in humanitarian medicine, gender differences are noted in the process of changing milk teeth [2]. At the same time, there are data in the literature indicating that in the process of change of teeth in dogs of small breeds, cases of the absence of restoration of the roots of temporary teeth are recorded.

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Based on the above mentioned aspects, the purpose of our work was to study the characteristics of the hormonal and mineral homeostasis of the body during the period of teeth change in dogs of dwarf breeds. In connection with the above purpose we set the following tasks:

1. To establish the nosological profile of dental diseases in dogs.
2. To determine the hormonal homeostasis in dogs of dwarf breeds at the age of 6 months.
3. To determine the mineral status in dogs of dwarf breeds at the age of 6 months.

## 2. Materials and methods

The research in this work was conducted on the basis of the Department of Animal Diseases and Veterinary-Sanitary Examination and the Veterinary Hospital's Scientific and Technical Center "Saratov State Agrarian University" from 2016 to 2018. At the first stage of the experiment, the data obtained from the examination of 310 sick animals at the clinical reception of a dentist served as material and biochemical studies were performed on an automated biochemical and enzyme immunoassay analyzer ChemWell2910 (Combi). As food, the animals received a prepared, balanced commercial diet with no additional mineral-vitamin complexes were present in the diet. Statistical analysis was performed using Microsoft Excel package. The results were presented as the arithmetic mean (M) and standard deviation (m).

## 3. Research results

According to the statistical analysis of appeals from owners of dogs to specialized dental care at the "Veterinary Hospital", we found that the special attention is required for the pathology associated with the impairment of the change of temporary teeth permanent (fig.1).



Fig. 1. Accessory temporary teeth

According to literary data it is known that untimely change leads to the development of pathologies of internal organs and various dental-maxillary system disorders. To date 33 % of animals in need of dental care

were diagnosed with "spuria polyodontia" – an overall increase in the number of teeth due to the non-loss of temporary teeth (Fig. 2) [3].

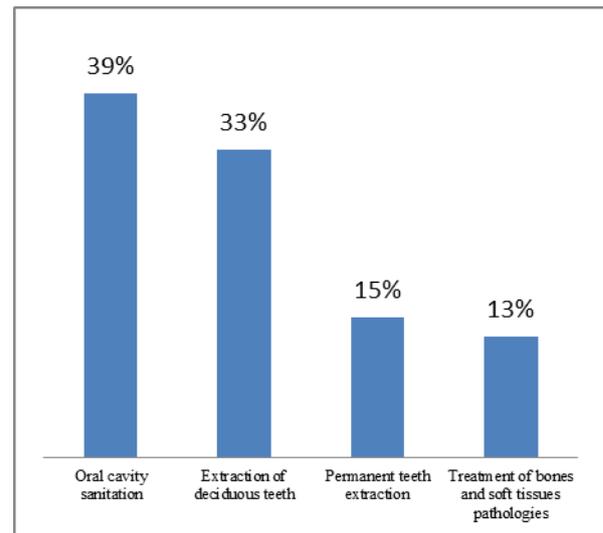


Fig. 2. Nosological profile of dental pathologies in dogs

According to the above mentioned aspects, we decided to conduct a statistical analysis of the identification of violations of the change of teeth. No clearly pronounced correlation between the genders of animals with a diagnosis of "false polyodontia" was found. However, the distribution by sex was as follows: 53 % – females, 47 % – males.

Among the dwarf dog breeds, the following breeds often needed surgical intervention to remove temporary teeth: Pomeranian Spitz, Yorkshire terrier, Chihuahua, and Russian Toy Terrier. In the modern cynology literature, it is noted that the normal replacement of temporary teeth with permanent barrels occurs from 3 to 7 months [4]. – From 4 months, in 18.3 % – from 5 months, and 8.4 % – from 6 months. Falling of temporary teeth out begins approximately 110 days after birth in beagle dogs. The change of teeth ends with the eruption of the third molar at the age of 175 days.

After analyzing the ration of animals studied, we found that 54.1 % of small breed dogs receive ready-made, commercial feeds as food, 31.4 % – exclusively natural products, the remaining 14.5 % – mixed ration (combination of ready-made rations with natural food). In 46 % of cases, the animals were supplemented with vitamin complexes with the obligatory content of calcium and phosphorus, the remaining group of animals did not receive vitamin-mineral supplements.

From the data of the anamnesis obtained from the owners of animals, it was revealed that there is reliably information about the violation of the process of changing milk teeth of the parents of dogs in 46 % of cases today, a widely applicable method for the treatment of applied polyodontia is the timely extraction of milk teeth. In the procedure for removing the canines of the upper and lower jaws, due to the absence of root restoration, 55 % of the animals needed, extraction of not only the canines, but also the incisor group of teeth by 24 %, and in 21 % of dogs, the group of premolars

was added to the previously specified complementary teeth.

The surrounding tissues absorb the resorption products of the roots of temporary teeth. Osteoclasts provide falling of temporary tooth out. They resorb the alveolar bone, making place for the permanent tooth growth. Since milk teeth functionate in the oral cavity for a rather short time, therefore, a misbalance of mineralization and synthesis of organic matter processes, due to the smaller thickness of the temporary tooth tissues, are characteristic for them. Untimely change of temporary teeth indicates insufficient mineralization of bone tissue, chronic infectious processes, and endocrine pathologies.

At the second stage of research, we identified some hormonal and biochemical parameters, the results of which are presented in Tables 1 and 2.

**Table 1.** Monitoring the hormone levels of experimental animals (n=15, M+m, p<0.05).

№	The indicator of hormonal status, units measuring	Results	Reference range
1	PTH, pmol/l	0.48±0.10	1.06–6.36*
2	TSH, μMU/ml	0.14±0.03	0.01–0.2****
3	Free T4, pmol/l	18.33±4.01	10–45**
4	TT4, nmol/l	38.2±0.51	20–60**
5	Free T3, pmol/l	3.95±0.53	1.41–5.34***
6	TT3, pmol/l	1.04±0.10	0.8–2.1***
7	E2, (females), nmol/l	0.23±0.04	0–118*
8	T (males), nmol/l	0.68±0.31	<1*

Note.\* E. Torrance, K. Mooney, 2006;

\*\* Karpetskaya, 2001; \*\*\* Massimo Giunti, 2017;

\*\*\*\* C.E. Reusch, 2017

**Table 2.** Monitoring the mineral metabolism of the blood serum of experimental animals (n=15, M+m, p<0.05).

№	Indicators, units measuring	Results	Reference range*
1	Na, mmol / l	140±1.20	138–164
2	K, mmol / l	4.27±0.09	4.2–5.6
3	Ca, mmol / l	1.41±0.12	2.3–3.3
4	P, mmol / l	1.92±0.22	0.8–2.0
5	Mg, mmol / l	1.11±0.21	0.6–1.0

Note. \* E. Torrance, K. Mooney, 2006

When analyzing the data obtained, it can be seen that the level of parathyroid hormone (PTH) in the serum at the time of the study is 2 times lower than the reference values, which, we assume, is related to bone remodelling processes as a result of the eruption of permanent teeth and an increase in calcium in the body. PTH plays an important role in the regulation of calcium-phosphorus metabolism and maintains a stable concentration of calcium and phosphorus in the extracellular fluid.

The level of PTH is closely related to the amount of calcium, vitamin D, phosphorus, calcium, magnesium in the body, the regulation of its secretion is carried out on the basis of feedback. Its deficiency affects the metabolism of phosphorus and calcium. Vitamin D supports calcium levels. It affects the intake of calcium from the intestine and stimulates its deposition in bone

tissue. Parathyroid hormone deficiency affects protein and mineral metabolism. This causes hypomineralization of dentin and enamel.

Parathyroid hormone, fibroblast growth factor and vitamin D have a direct effect on metabolic processes in bone tissue. This is confirmed by the presence of special receptors on the osteocyte surface that also provide phosphate metabolism.

Parathyroid hormone reduces phosphate reabsorption in the distal kidney tubules and increases calcium reabsorption of tubules [4]. Parathyroid hormone increases the level of calcium in the blood and simultaneously reduces the level of phosphorus. Increased calcium content is associated with the activation of phosphatase, osteoclast collagens, with the result that calcium is leached into the blood during bone renewal. The mechanism of action of parathyroid hormone on bone tissue is through cyclic adenosine monophosphate (cAMP), which occurs by activating cAMP-dependent protein kinesis, phospholipids C, diacylglycerol, inositol triphosphate and calcium ions [5].

In our results for dogs of small breeds at the age of 6 months, the concentration of thyroid-stimulating hormone (TSH) was within the physiological norm – 0.14 μMU/ml. This hormone provides the thyroid gland and adjusts the level of thyroxin (T4) and triiodothyronine (T3) according to the feedback principle [11]. In the animals studied by us, the concentration of T4-free was within the physiological norm, namely, 18.33 pmol / l. The level of triiodothyronine, both general and free, was recorded within the reference values, namely: TZ free – 3.95 ± 0.53 pmol/l, TZ-total – 1.04 ± 0.10 nmol/l. Triiodothyronine provides protein synthesis in the body, regulates the level of sex hormones and the amount of oxygen consumption by the tissues, thereby affecting the growth processes in the body.

In laboratory diagnostics, it is believed that the T3 level is uninformative when assessing thyroid function, because it is formed when deiodinating thyroxin in the liver and kidneys, but not in the thyroid gland. Untimely resorption of milk canines' roots are described in children with hypoparathyroidism. Changes in the shape of the teeth crown (canines and premolars take the form of incisors) are noted in the case of the thyroid gland hypofunction. This is accompanied by dystrophic changes in epithelial cells, impregnation of collagen fibers with edematous fluid and further them homogenization [6].

There are no experimental data confirming the influence of sex hormones on the growth and development of teeth. In humanitarian medicine, gender differences were noted in the process of changing temporary teeth. Slowdown in the processes of dentition and development of teeth was recorded in rats under the influence of orchietomy.

These processes are accelerated with the sex hormones preparations. According to experimental data, the concentration of testosterone in males was within the physiological norm – 0.68 nmol/l, the estradiol content in females was 0.23 nmol / l, which corresponds to the

lower limit of the physiological norm. According to literary data, it is known that the normal functioning of the sex glands is under the control of thyroid hormones (Lorenz C., Opitz R., Isoav., 2016).

However, in this case it is necessary to take into account that the full functioning of the sex glands begins after the completion of the formation of the organism. In literary sources it is indicated that at the age of 160-180 days' dogs reach sexual maturity.

The increase in the concentration of sex hormones in the blood serum in dogs was determined at the age of 3 years and persisted up to 7 years, which may be due to the completion of the maturation process of the organism.

Given this fact, we can conclude that the sex glands do not directly affect the process of changing teeth. From the data presented in Table 2, it can be seen that the level is slightly higher than the lower threshold of physiological values and is  $140 \pm 1.20$  mmol/l, this may be due to a decrease in the water content in the body and the lack of abundant drinking before taking blood for the study. Sodium provides the growth of bone tissue through the transport of amino acids due to its low concentration inside the cell.

According to the literature, it is known that the Akita breed in erythrocytes has higher potassium content than other breeds. Moreover, it has been proven that, during long-term storage, potassium from a clot of coagulated blood diffuses into the plasma, thus enriching it.

The level of potassium in dogs of dwarf breeds at the age of 6 months at the time of the change of temporary teeth was constant outside the reference values, determined to be slightly below the physiological limit —  $4.27 \pm 0.09$  mmol / l, which may result from electrolyte balance disturbances.

The change in the state of mineral homeostasis in dogs of small breeds during the period of temporary teeth changing to permanent ones, with a balanced diet, is explained by an excessive loss of potassium ions through the gastrointestinal tract, as well as a shift in the ion balance towards its intracellular concentration, and, as a result, a decrease in potassium circulating blood.

The calcium level in the blood serum of the studied animals was outside the reference values and was  $1.41 \pm 0.12$  mmol/l, this is 38 % below the physiological norm, which, in our opinion, is a consequence of the absence of restoration processes in the roots of temporary teeth, which leads to the possible intake of mineral substances from their depot during the period of temporary replacement of teeth permanent.

Besides, parathyroid hormone activates calcium absorption in the gastrointestinal tract with the participation of calcium binding protein, leading to a decrease in the concentration of calcium in the blood and its increased excretion in the urine [8, 9].

In the studied animals, the level of phosphorus in the serum was within the upper limit of the reference values, reaching  $1.92 \pm 0.22$  mmol/l, which is associated with the blocking of phosphate in the tubules of the kidneys by reducing the amount of 24-hydroxylase, which leads to the decrease in the phosphate content in the extracellular fluid [11].

The exchange of magnesium is regulated mainly by its excretion by the kidneys and there is no definite hormonal system regulating this process, although PTH slightly increases the reabsorption of magnesium in the renal tubules and absorbs about 30–50 % of the incoming magnesium in the intestine.

The analysis of the results showed a slight increase in the concentration of magnesium to the level of  $1.11 \pm 0.21$  mmol/l, which is due to the low content of calcium and parathyroid hormone in the blood [10].

## 4. Conclusion

Thus, the homeostasis of an organism is a dog, a Pomeranian spitz, a Yorkshire terrier, a toy terrier, a Chihuahua during the period of changing teeth at the age of 6 months, characterized by a number of features:

- the level of hormones of the thyroid gland profile is within the reference Val-
- the level of sex hormones is determined at the lower limit of the reference values, which is associated with the characteristics of the physiological development of dogs aged 6 months;
- increased phosphorus content (upper limit of the physiological norm) due to a decrease in 2 times lower than the normal level of parathyroid hormone;
- decrease in blood calcium levels due to the action of parathyroid hormone due to increased absorption of calcium in the gastrointestinal tract and its enhanced excretion in the urine.

## References

1. D. Gajdzik-Plutecka, J. Janicha, H. Boguszewska-Gutenbaum, A. Grzybowska, J. of Stomat. **1(67)**, 6–17 (2014)
2. J. Van Dyck, M. Cadenas de Llano-Pérula, G. Willems, A. Verdonck, Forensic Sci. Int. **300**, 63–74 (2019)
3. K. Megha, M. Narayana Swamy, L. Ranganath, M.P. Veena, P.T. Ramesh, Indian J. of Animal Res. **5(52)**, 674–677 (2016)
4. S.A.E. Van Meervenue, H.A. Volk, K. Matiassek, L.M.L. Van Ham, Veter. J. **1(201)**, 15–20 (2014)
5. A. Azarbar, Y. Zhang, S. Nadarajah, Quality and Quantity **2(52)**, 553–560 (2019)
6. V. Sebastián-Pérez, C. Roca, Awale J. of Chem. Informat. and Modeling **9(57)**, 2143–2151 (2017)
7. P. Poitras, Gastroenterology **4(87)**, 909–913 (1996)
8. D.Y. Kil, K.S. Swanson, Veterinary Clinics of North America, Small Animal Practice **2(40)**, 205–219 (2010)
9. I.F.C. Santos, S.C. Rahal, J. Shimono, Topics in Companion Animal Medic. **4(33)**, 86–90 (2017)
10. A.V. Krasnikov, V.V. Annikov, D.D. Morozova, Annals of Anatomy – Anatomischer Anzeiger **212**, 87 (2017)