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Comparative Morphology of Incisor Enamel and Dentin in Humans and Fat Dormice (*Glis glis)*

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A B S T R A C T

The structure of teeth in all living beings is genetically predetermined, although it can change under external physiological and pathological factors. The author's hypothesis was to indicate evolutional shifts resulting from genetic, functional and other differences. A comparative study about certain characteristics of incisors in humans and myomorpha, the fat dormouse (Glis glis) being their representative as well, comprised measurements of enamel and dentin thickness in individual incisor segments, evaluation of external enamel index, and also assessment of histological structure of enamel and dentin. The study results involving dormice showed the enamel to be thicker in lower than in the upper teeth, quite contrary to enamel thickness in humans. In the upper incisors in dormice the enamel is the thickest in the medial layer of the crown, and in the cervical portion of the crown in the lower incisors. The thickness of dentin in dormice is greater in the oral than in the vestibular side. These findings significantly differ from those reported in reference literature, but they are based on the function of teeth in dormice. Histological characteristics of hard dental tissues in dormice are similar to those in humans, with exception of uniserial structure of enamel and appearance of dentinoenamel junction.

Key words: *enamel, dentin, fat dormouse, humans*

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Introduction

The fat dormouse is referred to as our autochthonous game classified in the order of *Rodentia*, the family of *Muscaridinidae*, and the genus of *Gliridae*. Based on the shape of the cranium, morphology of masticatory muscles and structure of enamel and dentin, the rodents are classified into three sub-groups and the *Myomorpha* sub-group includes the dormice. With regard to diversity of functions, the upper and the lower incisors leave different prints, so that the teeth of rodents have prints characterized by grooves[1].

The function of gnawing is enabled by extremely hard enamel on incisors of dormice. The enamel is highly mineralized and hence the hardest tissue in living organisms. Its physical characteristics comprise thickness, hardness, density, permeability, color and elasticity. The thickness of enamel is not the same in each part of the dental crown and dental types, but there are individual differences as well. In humans, for example, the enamel layer is gradually thinned toward the cervical part of a tooth, while its density diminishes from the surface toward the dentinoenamel junction. Therefore in humans the surface of the enamel is more abundantly mineralized than its deeper layers, enabling better protection of teeth from undesirable external influences. The color of enamel is determined by its thickness, density and degree of mineralisation[1–5].

The fundamental units of enamel structure are referred to as enamel rods enclosed in a prism sheath and separated by interprismatic spaces. In the enamel of humans the lines of Retzius, or incremental lines, are visible and they reflect the rate of depositing. In the cervical part of the tooth along the dentinoenamel junction the dia or para-zones, the so-called Hunter-Schreger bands, are found and they are considered optical phenomenon, caused by different directions of winding and interlacing of enamel rods. Close to dentinoenamel junctions are enamel tufts and enamel spindles. The enamel tufts are filled with organic substance enamelin and they are formed within differently directed groups of enamel prisms in dentinoenamel junction.

The natural structure of dentin is made of odontoblastic processes located and protected within dentinal canaliculi that extend from periphery of the pulp to dentinoenamel junction and sometimes further into the enamel and enamel spindles. Within the tubules there is peritubular dentin and the tubules are connected by intertubular dentin. The Von Ebner's incremental lines show the dentin depositing rate, while the prenatal dentin is separated from the postnatal one by the so-called neonatal line[3–7].

The purpose of the comparative study is to define the evolutional shifts in humans and in animals indicating their similarities and differences that have resulted from genetic, functional and other distinguishing factors. Even though comparative studies are of great importance for establishing the evolutional shifts, we have found only few articles about comparative studies between human and rodent teeth in the recent literature[8–10].

Materials and Methods

The study sample comprised 30 fat dormice (20 females and 10 males) captured in the region of Gorski Kotar. Body length and body masses were taken for all animals, the parameters were then marked and specimens frozen. The preparation of study samples comprised separation of the lower jaw from the rest of the cranial skeleton by special scissors across the temporomandibular joint, separation of the left from the right half, and removal of the remaining soft tissue. The Sunshine diamond F6 199,014 turbo

Kavo Estetic 1,024 drill (Kaltenbach & Voigt D – 7950), at 1,500 turns per second was used to cut the upper jaw immediately before the premolars. All the specimens were stored into properly signed compartments and preserved in 5% formalin.

When making thin cuts one side of the lower jaw and parts of the upper jaw were dispensed in methacrylate in special molds using the Varidur 10 powder (dibenzyl peroxide) and Varidur fluid (tetrahydrofurfuryl 2 methacrilate). All the sections were made by Isomet 1000 cutter (Buehler), at 175–200 turns per second and 0.7 mm cut thickness. The obtained sections were photographed by Olympus BH-2 microscope at the magnification of 40, 100 and 200. The specimens were measured by special micrometer scale, using the 10 times magnifying eyepiece and 40 times magnifying lens.

The enamel thickness was measured in the cervical, medial and incisal parts of the tooth crown. From the thickness of exterior and interior enamel layers, external index was calculated[11]. The obtained measurements served to the calculation of enamel external index based on the following equation:

$$\text{External index} = (\text{outer layer thickness}/\text{total enamel thickness}) \times 100$$

The thickness of dentin was measured in the incisal and medial thirds of the tooth crown, while in the medial third of the crown the measurements were made on the vestibular and oral sides of teeth.

Many authors studied enamel and dentin characteristics of human incisors[2,3,12–14]. The results of these were compared with dormice incisors in our investigation.

The results were statistically analyzed by SPSS program for Windows Release 6.1.

Results

The measurement results of fat dormice physical features show that their body lengths ranged from 29.7 to 15.4 cm, the mean value being 18.5cm and standard deviation 2.61 cm. The maximal body mass (weight) was 154 g and the minimal was 84 g, while the mean value being 114.83 g and standard deviation 16.36 g.

The thickness of enamel in the cervical portion of the upper teeth ranged from 40.7 to 36.5 μm, the mean value being 38.18 μm and standard deviation 1.19 μm. The same measurement values for lower teeth ranged from 55.41 to 41.4 μm, the mean value being 43.95 μm and standard deviation 2.85 μm. The enamel thickness in the medial part of the tooth crown in the upper teeth ranged from 40.8 to 37.0 μm, the mean value being 38.59 μm and standard deviation 1.25 μm. The same measurement values for lower teeth ranged from 51.8 to 41.0 μm, the mean value being 44.48 μm and standard deviation 2.51 μm.

The thickness of enamel in the incisal edge of the upper teeth ranged from 40.7 to 35.0 μm, the mean value being 38.63 and standard deviation 2.86, while in the lower teeth the range was from 52.5 to 41.0 μm, the mean value being 45.0 μm and standard deviation 2.86 μm.

Figure 1 shows the correlation between the thickness of external enamel layer and the external index. The thickness of external enamel layer ranged from 15.2 to 11.3 μm, the mean value being 13.25 μm. This Figure shows that external index of 30.68% is conditioned by the smallest thickness of outer enamel layer (11.3 μm). The mean number of samples shows external index from 33 to 37%.

Figure 2 shows the correlation between the thickness if internal enamel layer and the external index. The thickness of internal enamel layer ranged

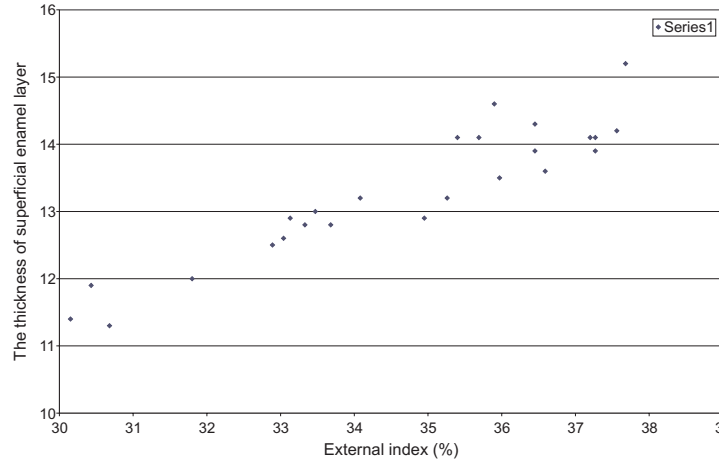

Fig. 1. Correlation between the thickness of superficial enamel layer (μm) and external index (%).

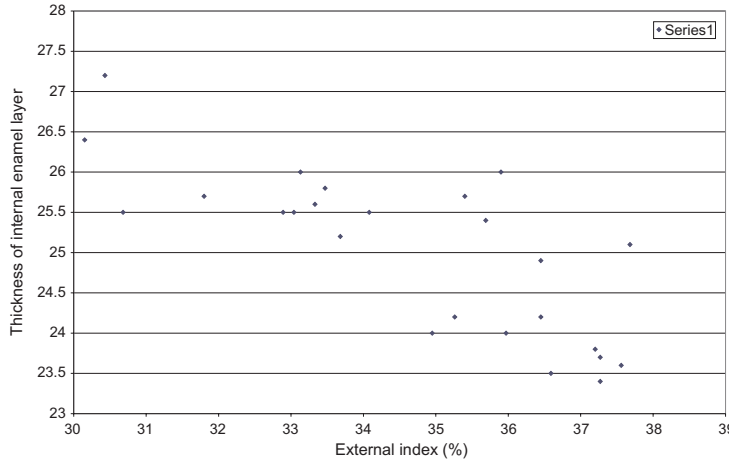

Fig. 2. Correlation between the internal enamel layer (μm) and external index (%).

from 27.4 to 23.4 μm, the mean value being 25.16 μm. This Figure shows that external index of 29.47% is conditioned by the thickness of inner enamel layer of 27.4 μm.

The results of dentin thickness measurements are as follows. The dentin thickness in the incisal third of the upper incisors ranged from 1.545 to 1.750 mm, the mean value being 1.665 mm. The dentin thickness in the lower incisors ranged from 1.540 to 1.700 mm, the mean value being 1.635. The dentin thickness is in the vestibular part of the tooth chamber in the upper teeth ranged from 0.490 to 0.723, the mean value being 0.620 mm and from 0.530 to 0.770 mm in the lower teeth, the mean value being 0.663 mm. In the oral part of the tooth chamber the dentin thickness ranged from 0.525 to 0.765 mm in the upper incisors, the mean

value being 0.654 mm, while it ranged from 0.560 to 0.790 mm in the lower incisors, the mean value being 0.666 mm.

Figure 3 shows the correlation between dentin thickness in the upper and lower teeth in the vestibular part. Figure 4 shows the same correlation for the oral part of the teeth. This Figure shows that for the mean number of samples thickness of dentin in the oral part of both upper and lower incisors is the same from the values of 0.650–0.700 mm. The bigger values in the upper incisors are in correlation with minor values in the lower incisors and the opposite.

Discussion

Our studies about physical characteristics of enamel and dentin comprised in the first place the measurements of enamel layer thickness in individual segments of incisors, calculation of external enamel index, and measurements of dentin thickness in different tooth segments.

The thickness of enamel in dormice and also in humans differs with regard to individual segments of the tooth crown, and it is also variable with regard to individual categories of the teeth. The thickness of enamel in human incisors varies from 2 to 2.5 mm[12,13]. In humans, the enamel is the thickest in molar tubercles, about 2.6 mm on the average, followed by the premolar tubercles, about 2.3 mm on the average, while in the incisal edges of the upper incisors the average thickness of the enamel is 2.0 mm[15–20].

Mishima and Kozawa[8] compared morphology of calcospherites between continuously growing teeth and uncontinously growing teeth. While Carlos et al.[21] used ground sections to perform comparative analysis of the structure of the dentinoenamel junction (DEJ) among diverse mammalian species.

The measurement results concerning the enamel thickness in dormice show that it is slightly thicker in the upper than in the lower incisors (40.8 μm vs. 55.5 μm), which is not quite in accordance with the data found in the available reference literature[1–7]. However, it is in conformity with their functional adjustment. The fact is that the animal gnaws by lower incisors so that their enamel layer is undergoing constant attrition and renewal, whereas the upper incisors serve

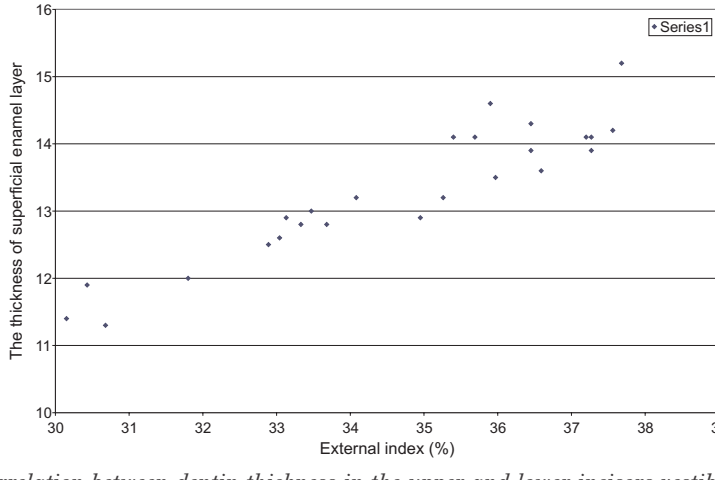

Fig. 3. Correlation between dentin thickness in the upper and lower incisors vestibulary (mm).

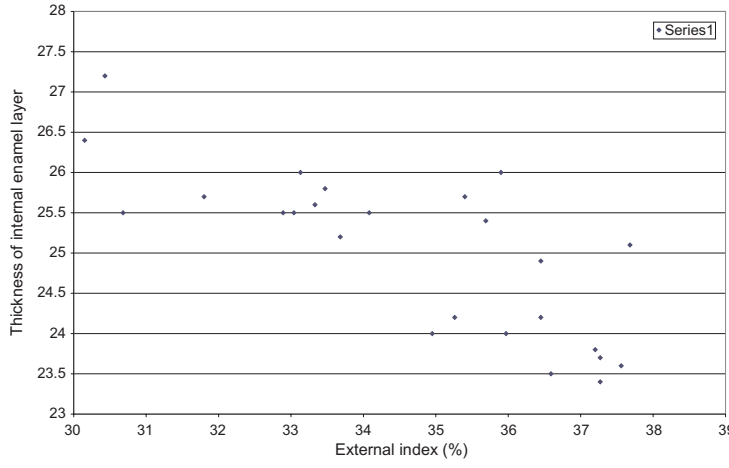

Fig. 4. Correlation between dentin thickness in the upper and lower incisors orally (mm).

only to hold the bite. The layer of enamel in the upper incisors is the thickest in the medial portion of dental crown and is more or less equally thick in the cervical part and the incisal edge (40.8–37.0 μm vs. 40.7–35.0 μm). In lower incisors the thickest layer of enamel is found in the cervical portion (55.5–41.4 μm), followed by incisal edge region (52.5–41.0 μm), and then in the medial part of the dental crown (51.8–41.0 μm). It is commonly considered to be the result of the gnawing function, since constant attrition leads to greater wearing out of the enamel in the incisal edge and medial third than in the cervical portion. The outer enamel layer is less thick than the internal one, which is caused by structural specifities of DEJ in dormice. In our study samples the thickness of dentin in vestibular side of the upper incisors was smaller than in the lower ones (0.490–0.723 mm vs. 0.530 –0.770 mm). Also, the thickness of dentin in the oral side was greater in lower than in the upper teeth (0.525– 0.765 mm vs. 0.560–0.790 mm). These findings are not in accordance with those found in relevant reference literature, but this may be attributed to special function of incisors in dormice[2,3,6,22].

All these characteristics have their effect on the structure of teeth. Based on the morphology of the jaw and its muscles, especially the masseter muscle, and the structure of enamel, rodents are usually divided into three sub-groups. The subgroup of *Myomorpha* includes the dormice, i.e. the *Gliridae*. The enamel in dormice surrounds the external anterior surface of the incisors. The remaining hard tissue is made of dentin. Abundant information about the characteristics of human teeth indicates the importance of the issue from the aspect of basic sciences, but also from the point of view of each individual dental medical specialty[17,23–31]. The data about structural properties of teeth in rodents, dormice in particular, are rather scarce and hence the incentive to undertake our study[11,15,16,18–20].

Our studies have also shown that histological structure of human teeth when compared with that in dormice is not significantly different, except in the following detail: unlike the *Lagomorpha*, which, similar to humans, have multiserial structure of the enamel, the *Sciuromorpha* and the *Myomorpha* (dormice), which are of specific interest to us, have uniserial

structure of enamel with parazones and diazones in the thickness of only one enamel prism. The prisms in these zones overlap and inter-cross with the prisms of the adjacent zones under the angle of nearly 90 degrees. In horizontal sections the prisms are obliquely intersected so that from the surface of the cross-section they turn toward the left and toward the right. For reasons of uniserial enamel structure in dormouse, the diazones and the parazones are less visible than in man. Another particularity of the enamel in dormouse is in smaller number of enamel tufts in dentino-enamel junction. The enamel tufts are regions in the enamel with a lesser degree of mineralization resulting from the disorders in protein removal in certain parts of the enamel during maturation. The removal of protein is usually inhibited by the action of forces during dimensional changes occurring in the course of detachment of single enamel segments, preventing thus resorption of organic matrix, which is therefore permanently retained in this part of the enamel. Hence the junction of enamel and dentin in dormice, for greater mineralization of DEJ, might be stronger and provide better protection of dentin during constant attrition of the enamel in the course of gnawing[15,18–20,23].

It should also be pointed out that the studies undertaken herewith should be supplemented by the studies of dental pulp, cementum and parodontal ligaments in the dormice in order to obtain complete insight into the relationship between their structure and function when compared with human teeth.

REFERENCES

1. FORENBACHER, S.: Kompendij Velebitske faune I. (Veterinarski fakultet, Zagreb, 2002). — 2. AVERY, J. K.: Essentials of oral histology and embryology. (Mosby, St. Louis-Baltimore, 2000). — 3. BASHAR, S. N.: Orban's oral histology and embryology. (Mosby, St. Louis, 1991). — 4. KODAKA, T., F. NATAJAMA, S. HIGASHI, Caries Res., 23 (1989) 290. — 5. KEROS-NAGLIĆ, J., D. IVANKOVIĆ, H. BRKIĆ, Z. AZINOVIĆ, B. LAZIĆ, I. VINTER, Coll. Antropol., 20 (1996) 387. — 6. BERKOVITZ, B. K. B., G. R. HOLLAND, B. J. MOXHAM: Oral anatomy, histology and embryology. (Mosby, Edinburgh-London, 2002). — 7. VUKOVIĆ, M.: Puhovi od biologije do kuhinje. (Hrvatski prirodoslovni muzej, Zagreb, 1997). — 8. MISHIMA, H., Y. KOZAWA, Scanning, 20 (1998) 235. — 9. LEE, S. K., P. H. KREBSBACH, Y. MATSUKI, A. NANCI, K. M. YAMADA, Y. YAMADA, Int. J. Dev. Biol., 40 (1996) 1141. — 10. BREYAN, D., H. SCHILDER, Oral. Surg. Oral. Med. Oral. Pathol., 44 (1977) 437. — 11. KORVEKONTIO, V. A., Annual Zool., 2 (1934) 274. — 12. OSBORN, J. W., Arch. Oral. Biol., 16 (1970) 1055. — 13. JOHANSEN, E., J. Dent. Res., 43 (1964) 1007. — 14. MJOR, I. A., Arch. Oral. Biol., 11 (1966) 1293. — 15. KAWAI, N., Okajimas Fol. Anat. Jap., 27 (1955) 115. — 16. OSBORN, J. W., Oral. Sci. Rew., 3 (1973) 3. — 17. RINSES, S., J. Human Evolut., 35 (1998) 331. — 18. WAHLERT, J. H., Breviora, 303 (1968) 1. — 19. VON KOENIGSWALD, W.: Abhandlungen der Senckenbergische Naturforschende Gesellschaft. (1980). — 20. PALMARA, J., P. P. PHAKEY, W. A. RACHINGER, H. J. ORAMS, Dent. Res., 38 (1989) 9249. — 21. CARLOS, A. O., L. P. BERGQUIST, S. R. P. LINE, J., Oral. Sci., 43 (2001) 277. — 22. HILLSON, S.: Teeth. (Cambridge University Press, Cambridge, 1986). — 23. KOENIGSWALD, W., P. M. SANDER: Tooth enamel microstructure. (A. A. Balkema, Rotterdam, 1997). — 24. ROBINSON, C., J. KIRKHAM, R. SHORE: Dental enamel. formation to destruction. (CRC Press, Boca Raton, 1995) — 25. BOSKEY, A., Rev. Oral. Biol., 2 (1991) 369. — 26. BUTLER, W. T., J. Oral. Sci., 106 Suppl. (1998) 204. — 27. GALE, M. S., B. W. DARVELL, J. Dent., 27 (1999) 1. — 28. MARSHALL, G. W., Quintessence Int., 24 (1993) 606. — 29. REES, J. S., P. H. JACOBSEN, J. HICKMAN, Clin. Materials, 178 (1994) 11. — 30. THOMAS, G. J., D. K. WHITTAKER, G. EMBERY, Arch. Oral. Biol., 39 (1994) 29. — 31. DEAN, M. C., Arch. Oral. Biol., 43 (1998) 1009.

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KOMPARATIVNA MORFOLOGIJA CAKLINE I DENTINA SJEKUTIĆA U LJUDI I SIVIH PUHOVA (*GLIS GLIS)*

S A Ž E T A K

Građa zuba je u svih živih bića genetski predodređena, premda se može mijenjati utjecajem vanjskih fizioloških i patoloških čimbenika. Ovaj rad je imao za cilj uputiti na razvojne promjene kao rezultat genskih, funkcionalnih i drugih razlika. Stoga su poredbene studije značajne jer upućuju na evolucijske pomake proistekle iz genskih, funkcijskih i inih raznolikosti. Poredbeno istraživanje nekih osobitosti sjekutića u ljudi i myomorpha, kojih je predstavnik i sivi puh (*Myoxus glis*), obuhvatilo je mjerenje debljine cakline i dentina u pojedinim dijelovima sjekutića te izračunavanje vanjskog caklinskog indeksa, ali i proučavanje histološke građe dentina i cakline. Rezultati istraživanja u puhova su pokazali da je caklina deblja u donjih nego gornjih zuba, dočim je u čovjeka obratno. U gornjih sjekutića puhova caklina je najdeblja u srednjem sloju krune, a u donjih u vratnom dijelu krune. Debljina dentina u puhova je veća na oralnoj nego na vestibularnoj strani. Svi se nalazi bitno razlikuju od onih iz literature, no imaju uporište u funkciji zuba u puhova. Histološke osobitosti tvrdih zubnih tkiva puhova slične su onima u čovjeka s izuzetkom uniserijalne građe cakline i izgleda dentinsko -caklinske granice.