HARD TISSUE DENSITY OF PERMANENT TEETH AS A RADIOMETRIC BIOMARKER OF THEIR QUALITY

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ABSTRACT

Background. The use of radiographic methods for examining patients with the ability to determine the density of examined tissues opens up wide opportunities for individually predicting damage to hard tissues of teeth, as well as determining risk groups for the development of their pathology at early stages, which requires a detailed study of the mineral density indicators of hard tissues of teeth of different groups within the norm, taking into account their age, sex, ethnic, and other characteristics.

The aim of the study was to determine the density indicators of hard tissues of permanent teeth of different groups in the cervical area and compare them.

Material and Methods. The density of hard tissues was determined by analyzing radiographs of 320 intact permanent teeth of 10 patients. Radiographs were made using a Siemens Sirona (XIOS XG Supreme, Germany) dental radiography unit with Trophy Radiologie software (version 7.0, Slovakia). The images were processed using Gendex VixWin Pro software (version 3.5, USA). The density was measured in Conditional Unit of Grayness (CUG). The results were presented as Me (25%; 75%), where Me represents the median, 25% denotes the 25th percentile (first quartile), and 75% denotes the 75th percentile (third quartile).

Results. Incisors, canines, and premolars exhibited the highest density in the dentin area; the lowest density was observed in incisors and premolars for cementum and in canines for enamel. In molars, enamel had the highest density, while cementum had the lowest. Significant differences in enamel density were observed among incisors and premolars, incisors and molars, canines and premolars, canines and molars, and premolars and molars. Significant differences in dentin density were found among incisors and canines, incisors and premolars, incisors and molars, canines and premolars, and canines and molars. Significant differences in cementum density were observed among incisors and canines, incisors and premolars, incisors and molars, canines and premolars, and premolars and molars.

Conclusion. The density indicators of enamel, dentin, and cementum established for groups of permanent incisors, canines, premolars, and molars are different for different tooth groups with characteristic density patterns.

Keywords: *enamel, dentin, cementum, incisors, canines, premolars, molars.*

Introduction

Due to the significant prevalence of lesions of hard tissues of teeth with carious and non-carious etiology, as well as the constant tendency to increase their number and rejuvenate this group of pathological processes, the search for ways of their early detection and prevention is particularly relevant [1]. Today, various methods of early diagnosis of caries and non-carious lesions of teeth are known. Boytsanyuk S.I., Kuznyak B.V. & Kuznyak L.V. (2014) propose a method for diagnosing tooth decay at an early stage using laser-induced fluorescence and the "DIAGNOdent" device [2]. This method also allows for the rapid and effective diagnosis of hidden caries. Studies by other authors are devoted to the development of methods for predicting and early diagnosis of lesions of hard tissues of teeth by determining their

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chemical composition, as well as the composition of oral fluid, since it has been proven today that the development of pathological processes in hard tissues of teeth are associated with mechanisms of ion exchange between oral fluid and enamel and dentin [1; 3; 4].

Today, one of the effective and widely used methods in clinical practice for detecting changes in the quality of mineralized tissues is determining their mineral density during patient radiographic examination [5–8]. In our opinion, the use of this method opens up wide possibilities for individual prediction of lesions of hard tissues of teeth, as well as determining groups of risk of developing their pathology based on the detected changes in the density of the investigated tissues and trends in its dynamics. A necessary condition for this is a detailed study of the normal indicators of mineral density of hard tissues of intact teeth of different groups, taking into account their age, sex, ethnic, and other features.

The aim of our study was to determine the indicators of density of hard tissues of formed permanent teeth of different groups in the cervical area and compare them.

Materials and Methods

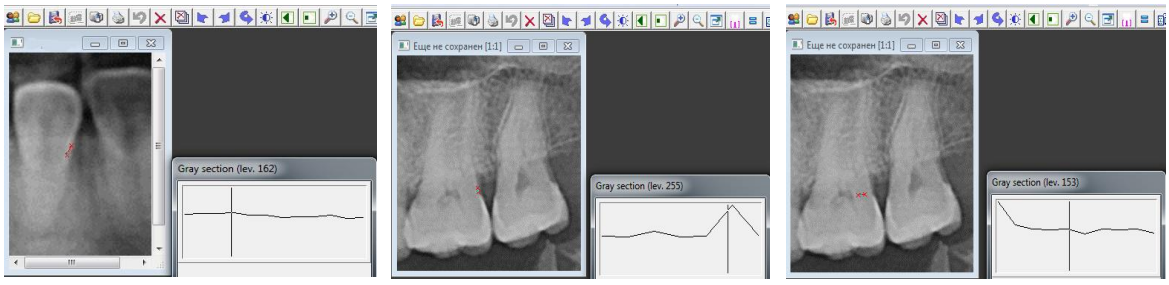
The density of hard tissues of the cervical region was determined by processing radiographs of 320 intact permanent teeth (n=10 for each tooth of the permanent bite) taken on a dental radiographic apparatus Siemens Sirona (XIOS XG Supreme, Germany) with Trophy Radiologie software (version 7.0, Slovakia). The images were processed using the using Gendex VixWin Pro software (version 3.5, USA). The Conditional Unit of Grayness (CUG) was taken as the unit of measurement of density. The indicators of density of hard tissues of teeth in the cervical region were determined separately for enamel and cement on the proximal and distal surfaces of the crowns and roots, respectively, for dentin – in the projection of the tooth neck in the interval between the tooth cavity and the lateral edge, so in this area the indicator was determined for dentin itself and the tissues that were layered on it (*Figure 1*).

To ascertain the conformity of the obtained data to the normal distribution law were used: an analysis of the distribution histogram, coefficients of skewness and kurtosis, the Shapiro-Wilk test. Since the established indicators of density of hard tissues of permanent teeth of different groups differ from the normal distribution characteristics, they are presented in the form of Me (25%; 75%), where Me is the median, 25% is the 25th percentile (first quartile), and 75% is the 75th percentile (third quartile). The reliability assessment of the difference between the means of samples was carried out using non-parametric methods: the Wilcoxon U-test (Mann-Whitney) and the Kruskal-Wallis method for comparing multiple samples.

The research was carried out as part of the planned scientific work of the Department of Normal Anatomy and the Department of Operative Surgery with Topographic Anatomy of Danylo Halytsky Lviv National Medical University, "Morphofunctional features of organs in pre- and postnatal periods of ontogenesis, under the influence of opioids, dietary supplements, reconstructive surgeries, and obesity" (state registration number 0120U002129). The patients signed an informed consent to participate in the scientific research. The Bioethics Committee of Danylo Halytsky Lviv National Medical University (protocol No.5 dated June 22, 2020) has determined that the research was conducted in accordance with the World Medical Association's Code of Ethics (Helsinki Declaration).

Results and Discussion

The indicators of enamel, dentin, and cement density established for groups of permanent incisors, canines, premolars, and molars indicated their difference for different groups of teeth, as well as characteristic features of the ratio (*Table*).



A B C

Fig. 1. Determination of density of hard tissues of permanent teeth: A – enamel, B – cement, C – dentin.

Table. Indicators of density of hard tissues of permanent teeth of different groups (CUG)

	Incisors	Canines	Premolars	Molars
Enamel	112.33 [99.00; 124.75]	118.50 [105.00; 137.75]	146.00 [131.00; 162.00]	168.00 [154.00; 182.75]
Dentin	125.00 [110.25; 139.00]	139.00 [125.00; 153.75]	159.50 [145.00; 173.00]	165.50 [152.00; 179.00]
Cement	105.00 [94.00; 119.00]	126.00 [110.00; 141.00]	122.00 [110.00; 137.00]	133.50 [121.00; 148.75]

It has been determined that in incisors, canines, and premolars the dentin area has the highest density. Meanwhile, in incisors and premolars the lowest density is observed in cement, while in canines, it's in the enamel. A different correlation of the investigated indicators is characteristic for molars, where the enamel has the highest density and cement has the lowest (*Table*).

The comparison of density indicators of the investigated hard tissues of incisors, canines, premolars and molars allowed establishing the significance of the difference between the teeth of different groups.

Upon pairwise comparison of enamel density indicators, a significant difference was found between incisors and premolars ($p<0.001$), incisors and molars ($p<0.001$), canines and premolars ($p<0.001$), canines and molars ($p<0.001$), premolars and molars ($p<0.001$). The difference between enamel density indicators of incisors and canines is less significant ($p<0.1$) *(Figure 2*).

Pairwise comparison of dentin density indicators of teeth from various groups revealed significant differences between incisors and canines, incisors and premolars, incisors and molars, canines and premolars, canines and molars ($p<0.001$). The difference in dentin density indicators between premolars and molars is less significant ($p<0.05$) (*Figure 3*).

The results of comparing cement density indicators of teeth from various groups showed a significant difference between incisors and canines ($p<0.001$), incisors and premolars ($p<0.001$), incisors and molars ($p<0.001$), premolars and molars ($p<0.001$). The difference between cement density indicators of canines and molars was less significant ($p<0.005$), and no significant difference was found between canines and premolars (*Figure 4*).

The analysis results of the investigated indicators showed a similar correlation between enamel density and dentin density of teeth from different groups – the lowest density indicators are in inci-

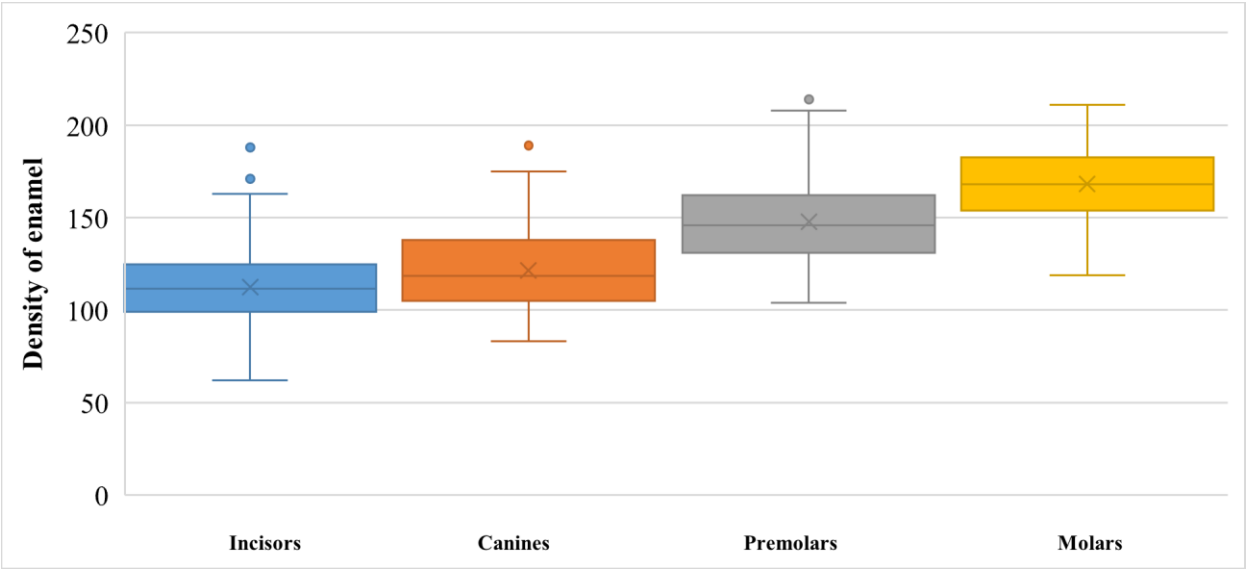


Fig. 2. Comparison of enamel density indicators of teeth from different groups.

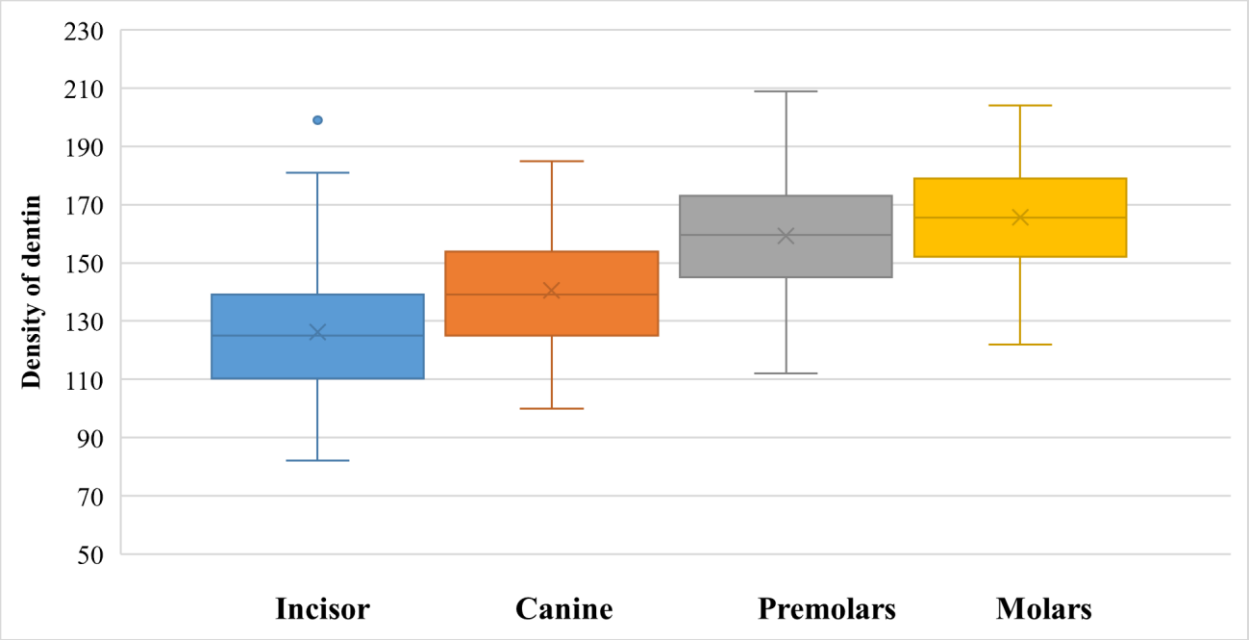


Fig. 3. Comparison of dentin density indicators of teeth from different groups.

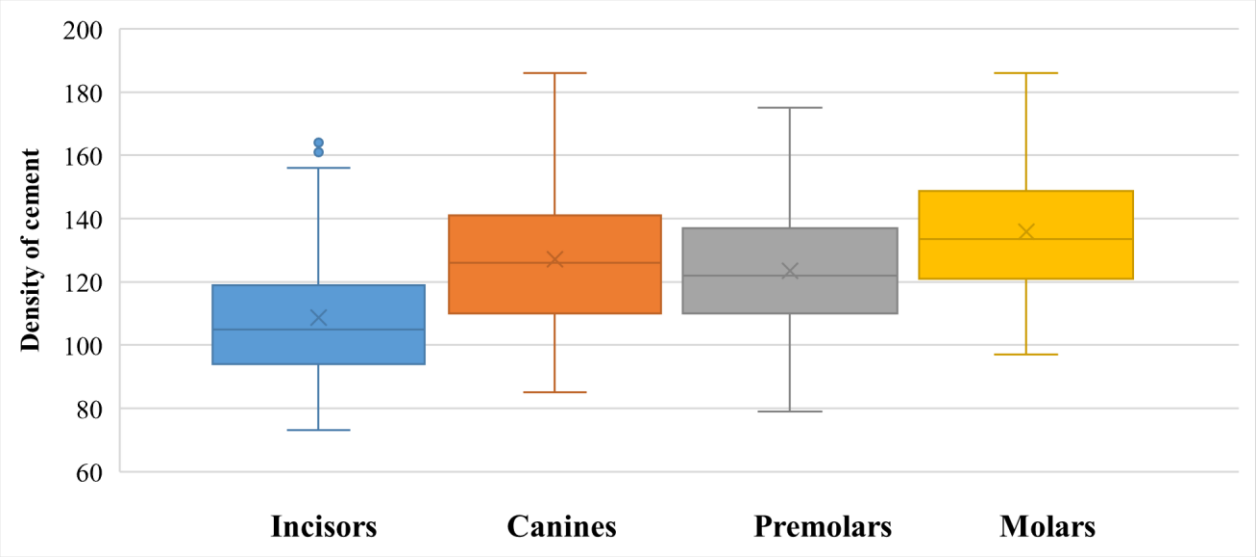


Fig. 4. Comparison of cement density indicators of teeth from different groups.

sors in both cases, increasing in canines, then in premolars, and highest in molars. The relationship of cement density indicators is somewhat different – similar to enamel and dentin, the lowest investigated indicator is in incisors, highest in molars, and the density indicators of canines and premolars occupy an intermediate position, but with a reverse correlation – the cement density in canines is higher than in premolars (*Table, Figures 2–4*).

The data obtained from this study could serve as a basis for developing a scale of normative quality indicators for the hard tissues formed by permanent teeth of different groups during their radiological examination. However, when conducting examinations and measuring density indicators of the investigated tissues, it is necessary to take into account that absolute indicators determined during patient examinations on different devices and using different image processing pro-

grams may significantly differ from each other. Therefore, the analysis of the relationship between the investigated indicators, the change of which can be interpreted as the first manifestation of pathology, is of primary importance, in our opinion.

Conclusions

1. The density indicators of enamel, dentin, and cement established for groups of permanent incisors, canines, premolars, and molars differ among the various tooth groups with characteristic correlation features.

2. In incisors, canines, and premolars, the dentin area exhibits the highest density; the lowest density in incisors and premolars is observed in cement, while in canines, it is enamel. In molars, enamel demonstrates the highest density, while cement exhibits the lowest.

3. The density indicators of enamel show a significant difference between incisors and premolars, incisors and molars, canines and premolars, canines and molars, and premolars and molars.

4. The density indicators of dentin show a significant difference between incisors and canines, incisors and premolars, incisors and molars, canines and premolars, canines and molars, and premolars and molars.

5. The density indicators of cement exhibit a significant difference between incisors and canines, incisors and premolars, incisors and molars, premolars and molars, and canines and molars.

6. The density of enamel and dentin is lowest in incisors, gradually increasing in canines and molars and highest in molars. Cement density is lowest in incisors, slightly higher in premolars and canines, and highest in molars.

Prospects for Further Research

Further investigation into the qualitative and quantitative characteristics of the hard tissue of intact teeth from different groups, as well as studying the dynamics of their changes during the development of pathological processes using modern non-invasive and accessible radiological methods, will contribute to the development and improvement of new methods for their early diagnosis, effective treatment, and prevention, with subsequent practical implementation.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included. The authors confirm that artificial intelligence technologies were not used in the creation of this work.

Data Transparency

The manuscript contains no associated data.

Statement of Ethics

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All authors give their consent to publication.

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