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# Secondary caries prevention by considering the features of enamel prisms location during filling of carious cavity

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## Abstract

Enamel is the hardest substance in the human body and contains the highest percentage of minerals (96%), with water and organic material composing the rest. **The objective**: to improve the quality of carious dental cavities filling in patients by determining the regularities of enamel prisms direction and quality of “enamel-filling”connection in topographically different parts of permanent human canines crown. **Materials and methods**. 40 permamnnet canines with intact enamel, removed because of trauma or orthodontic indications; 89 caries patients. **Results.** Angulation and direction of enamel prisms in different parts, surfaces and layers of a human permanent canines has been revealed. **Conclusions.** Features of different parts of enamel prisms inclination in toporgathically different parts of a human permanent canines has been shown. It has been revealed that the efficiency of a filling and enamel coalescence depends on the prevailing direction of enamel prisms in different parts of canine crown. Taking into account the peculiarities of enamel

prisms location in the tooth crown at carious cavity preparation, increases the effectiveness of secondary caries prevention.

**Key words: enamel prism, human permanent canine, angulation.**

The strength of enamel as a tissue, which can be considered as a biocomposite with a multilevel and multicomponent structure, is provided, in particular, by the complex architectonics of enamel prisms (EP) [1, 2]. Differences in enamel biomechanical properties in different parts of the tooth's crown, which are due to the peculiarities of EP formation, enamel mineralization, create the preconditions for its damage in certain areas at excessive loads [3, 4]. The researches of relationship between the strength characteristics of tooth enamel and peculiarities of its microstructure will make it possible to understand the mechanisms of enamel deformation [1, 2]. The study of tribological properties of enamel and factors they provide are highlighted in numerous researches, but still there is not enough data to form an exhaustive view of enamel properties [5].

At present, there is evidence of a decrease in the enamel microhardness from its surface to dentin-enamel border [6]. The dependence between the direction of EP in different parts of molars enamel and its microhardness [7] was determined. Features of enamel microhardness are essential in the formation of defects of a tooth solid tissues of carious and non-carious origin [8]. Taking into account the peculiarities of the prisms angulation in different parts of enamel, it is possible to scientifically substantiate the optimal methods for the preparation of dental enamel in practical dentistry [9]. However, the architectonics of EP in different parts of different functional groups of teeth crowns requires further updating [10].

The objective: to improve the quality of carious dental cavities filling in patients by determining the regularities of enamel prisms direction and quality of "enamel-filling"connection in topographically different parts of a permanent human canines crown.

Materials and methods. Clinical researches were conducted on the basis of the Institute of Dentistry and Maxillofacial Surgery of the National Academy of Medical Sciences of Ukraine (Odessa), under the conditions of PIC. 40 permanent canines with intact enamel removed due to injury or orthodontic indications were selected for clinical studies. After removal, the teeth were fixed in 10% of the formalin solution, further they were sprayed onto fragments in the thickness of 0.5-1 mm of which were prepared slices 50-90 microns thick according to the developed method [11]. The slices were prepared by cutting the fragments of the teeth in two directions: in the mesio-distal to study the oral and vestibular surfaces of the crowns and in the vestibula-oral to study the lateral surfaces. Using the polarization

microscopy method, the angles of inclination of enamel prisms to the enamel - dentine surface were measured in each topographic areas of enamel under study: on each surface in the lower, middle and upper third of the crown in deep (50-100 microns from the enamel-dentine boundary), middle and superficial (50-100 μm from the surface of enamel) layers of enamel [9]. Also there were caries 89 patients under observation. Assessment of carious cavities filling quality was performed in a year after its treatment. The method of vital staining with 2% methylene blue solution was used. Either absence or presence of the stain's penetration at the border of the filling and enamel was determined.

The reliability of the differences between the comparison groups was estimated using dispersion analysis, and if the null hypothesis was rejected, Newman-Keuls test was used.

The reliability of the differences in the quality of the filling and enamel coalescence in the different parts of the crown was evaluated by nonparametric methods using $\chi 2$ compliance criterion.

Results and their discussion

As a result of the studies conducted, the patterns of the location of EP in different parts of the crown of permanent human canines (Table) were revealed. It is established that in all investigated parts and crown surfaces in deep enamel layers, the initial parts of EPs have a slope directed towards the occlusive surface of a tooth crown. In the lower and middle parts of the crown, the angle of inclination of EPs to the enamel-dentine border in the middle layer of the enamel is greater, compared with the deep layer, respectively, at 5.1 - 12.1 and 2.2-3.4 °. In the surface layer of the enamel, the angle is smaller than in the middle of the lower part of the crown at 8.2-15.4 °; in the middle part of the crown - at 5.2 - 6.8 °. This provides an arc - like direction of EPs with an apex of the arc directed towards the root of a tooth. The arc - like direction of EP is observed on the vestibular, tongue, and lateral surfaces of the crown of the human canine.

In the upper part of the crown on its lateral surfaces in the middle layer of the enamel, the angle of inclining of EP to the enamel - dentine border is lower by an average of 5.3 ° compared to the deep. In the surface layer, the angle is larger in comparison to the middle one at 8.3 ° on average, and provides the arc - like direction of EP with an arc top directed toward the occlusal surface of the crown.

On the vestibular and tongue surfaces of the crown in its upper part, no statistically significant differences were found between the angles of inclination of the EP to the enamel-dentine surface between the middle and the surface layer of enamel. The absence of

significant differences in these topographic sections of the crown indicates a relatively straightforward direction of EPs.

It has been established that in the parts of the crown with predominating rectilinear direction of EPs the staining of the joints “filling – enamel” took place at 12.9% of cases. Instead, in areas with arcual direction of EPs it was found in 29.0% of cases ($\chi 2 = 6.848$, $p = 0.009$).

It should be noted that during the preparation of carious cavities, enamel beveling was formed at an angle of 45˚ to the outer enamel’s surface, i.e. at an angel of 45º to EPs in the case of their rectilinear direction.

In the case of an arcual direction of enamel prisms, the bevel will be virtually at right angles to their direction. This factor may be the cause of the lower efficiency of a filling and enamel coalescence and should be taken into account in treating caries.

The data obtained specify the existing information on the direction of EPs in the enamel of crowns of permanent human teeth [9, 10]. Differences in EPs direction in the enamel of the teeth of various functional groups are noteworthy. In previous studies it was found that in molars there is also a relatively straight and arc-like direction of EPs, and the direction of the arc to the root or the occlusive surface coincides with that in the premolars [11]. However, in molars, the relatively straightforward direction of EPs is observed besides the middle part of the crown on the tongue surface of the lower and upper parts of the crown, and in the premolars - on the tongue surface of the crown in its upper part and the lateral surface of the lower part.

In canines, unlike molars and premolars, in the middle part of the crown, there is no straight guidance of EPs, but arc-like with an arc apex directed toward the root of the tooth. A similar arrangement of EPs is observed in premolars and canines in the lower part of the crown on its vestibular and tongue surfaces, as well as in the lower part of the crown of the molar on its vestibular surface [11, 12]. In the upper part of the canines’ crown on its tongue surface, the rectilinear guidance of EP coincides with those in premolars, but there are differences from molars. Finally, in the upper part of the canines crown on the vestibular surface there is a straight direction of EPs in contrast to both the molars and premolars. Thus, the arrangement of EPs in the enamel of crowns of teeth of different functional groups is significantly different. Earlier it was established that the microhardness of enamel in molars depends on the angle of inclination of EPs to the enamel-dentinal boundary [13], therefore, microhardness of enamel in topographically different parts of the other functional groups of

teeth requires further researches taking into account the differences in the direction of EPs in different parts of the crown.

Conclusions. The differences of enamel prisms different parts location in topographically dissimilar parts of a crown of permanent human canines are revealed. On all surfaces of the canine crowns in the middle and lower parts, the enamel prisms are of arcual direction with an apex directed towards the tooth's root. The upper part of the canines crown, on the vestibular and tongue surfaces, is characterized by a rectilinear direction of enamel prisms. On the lateral surface of the upper part of the canines crown there is an arcual direction of enamel prisms with an apex of the arch directed toward the occlusive surface of the crown of the tooth.

The efficiency of a filling and enamel coalescence depends on the prevailing direction of enamel prisms in different parts of canine crown. Taking into account the peculiarities of enamel prisms location in the tooth crown at carious cavity preparation, increases the effectiveness of secondary caries prevention.

Table

Middle angles of inclination of enamel prisms to the enamel-dentine border in topographically different parts of the enamel of crowns of permanent human canines (M ± m, n = 40, °)

| Surfaces of crown | Part of crown | Layers of enamel | | |
|---|---|---|---|---|
| | | Superficial | Median | Deep |
| Vestibular | Upper | 58.2 ± 1.3 | 55.7 ± 1.2*[2] | 67.8 ± 1.2 |
| | Middle | 70.6 ± 1.8*[1] | 77.4 ± 1.7 | 80.8 ± 1.7 |
| | Lower | 78.4 ± 2.0*[1] | 93.8 ± 2 | 81.7 ± 3.0 |
| Lateral | Upper | 62.1 ± 2.3*[1] | 53.8 ± 2.0 | 59.1 ± 2.1 |
| | Middle | 64.2 ± 2.0*[1] | 71.9 ± 2.5 | 74.5 ± 2.1 |

*Notes:* 1. * [1] - $p < 0.05$ in comparison with middle layer of enamel;

2. * [2] - $p < 0.05$ in comparison with deep layer of enamel.

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