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AN ELECTRONIC EXCEL–CALCULATOR FOR CALCULATING DENTAL CROWN VOLUMES

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Abstract

Summary. Previous research has shown that due to the increase in volume of tooth cavities, the sensitivity of the restored structure to physical and mechanical characteristics of the restoration also increases. Since the existing volume measurement techniques cannot be used in a clinical setting, it raises the questionhow important is it to determinethe dimension of tooth cavity volume.
Aim of research. The aim of this research is to develop and evaluate the possibility of using methods to determine dental crown volumes and volumes of tooth cavities.
Materials and methods of research. To determine dental crown volumes and volumes of tooth cavities, appropriate geometric models have been used for each group of teeth. According to the models, mathematical calculations have been performed to calculate their linear dimensions.
Results of the research. We have developed and substantiated the appropriateness of an electronic Excel calculator usage to calculate dental crown volumes in clinical settings.
Conclusions. With the help of our electronic Excel calculator for calculating dental crown volumes and methods to determine the volumes of tooth cavities in clinical settings, we can evaluatethe diagnostic process in the presence of dental hard tissue defects. The mathematical approach doesn't accurately measure the volume of various tooth cavities. So, it is not appropriate to use.

Key words: tooth cavity, volume, diagnosis.

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Introduction

In current clinical practice, to replacetooth cavities dentists are offer methods of direct, indirect and semi–direct restoration. [1, 2]

The choice between direct and indirect restoration methods is complicated by the fact that it does notdepend onspecificfactors, butonother factors that have nothing to do with evidence–based medicine.

To help in determining a method of restoring a damaged tooth crown and diagnosis the index of destruction of the occlusal surface of the tooth (IDOST) proposed by V. Milikevich can be used. [3] IDOST in no way takes into account the depth of destruction of dental hard tissues; therefore, a slightly improved method was proposed later, which besides IDOST takes into account an additional index of the depth of tooth crown destruction (IDTCD) and gives recommendations for the usage of two–dimensional diagnosis scale. [4]

Mechanical–mathematical research that was carried out by modelling the contact interaction of restoration with tooth tissues and clarify strength assessment of this composition, confirmed that in previous work analytical mechanical and mathematical models of the «tooth–dental filler» system are somewhat simplified and do not take into account a number of important factors.

The constructed mechanical–mathematical model of contact interaction of the dental filler (inset) with solid tooth tissues, confirmed the hypothesis that as the volume of the defect increases, the sensitivity of the restored structure to the physical and mechanical characteristics of the restoration also increases. [5]

Anthropometric studies and calculations of VIC (volume index of cavity) for the defects of different groups of teeth allow the amount of tooth cavities' loss to be estimated while treating the patients with defects of dental hard tissues. The coronal tooth cavity volume and the total volume of the crown have been determined by applying a

creamy substance using an insulin syringe into the cavity of the tested teeth and into the imprints of these teeth. [6–8]

Since the existing volume measurement techniques cannot be used in a clinical setting, it raises the question of how important is it to determine the dimension of tooth cavity volume.

Materials and methods of research

To determine dental crown volumes and volumes of tooth cavities, appropriate geometric models have been used for each group of teeth. We have modelled the tooth crowns for such groups as molars and premolars in the form of truncated cones with averaged linear dimensions, and groups of incisors and canines in the form of a triangular prism with averaged individual linear dimensions or without averaging respectively.

Using the constructed models, mathematical calculations have been performed to calculate the volumes of dental crowns based on their linear dimensions *lo, lv, lL, lI; wo, wM, wD; dl, dr; hv, hL, hM, hD* (Figure 1–4) and determined formulas.

For molars:

$$V_{molar} = \frac{\pi}{192}(h_V + h_L + h_M + h_D)\left(2(l_O w_O + d_l d_r) + \sqrt{2(l_O w_O + d_l d_r)(l_V + l_L)(w_M + w_D)} + (l_V + l_L)(w_M + w_D)\right) \quad (1)$$

For premolars:

$$V_{premolar} = \frac{\pi}{192}(h_V + h_L + h_M + h_D)\left(4l_O w_O + 2\sqrt{l_O w_O (l_V + l_L)(w_M + w_D)} + (l_V + l_L)(w_M + w_D)\right) \quad (2)$$

For incisors:

$$V_{incisor} = \frac{1}{8}(w_M + w_D)h_V(l_V + l_I) \quad (3)$$

For canines:

$$V_{canine} = \frac{1}{2}w_I h_V l_V \quad (4)$$

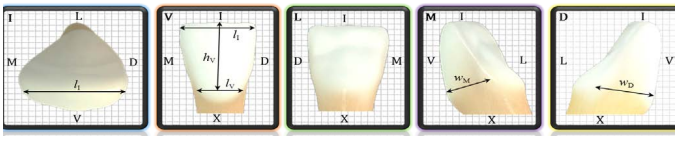

Fig. 1: Schematic illustration of the incisors crown with input dimensions

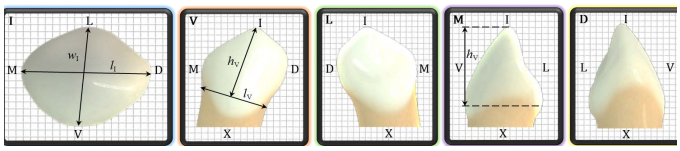

Fig. 2: Schematic illustration of the canines crown with input dimensions

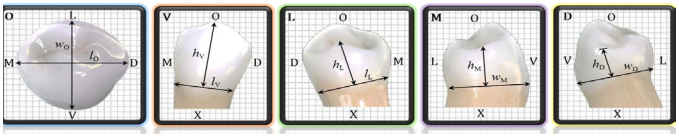

Fig. 3: Schematic illustration of the premolars crown with input dimensions

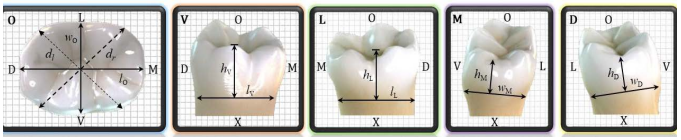

Fig. 4: Schematic illustration of the molars crown with input dimensions

Appropriate geometric modelswere used to determinethe crown volumes and the volumes of tooth cavities for each group of teeth Using prepared models mathematical calculationswere carried out to evaluate the volume of teeth crowns based on their linear dimensions $l, l_1, l_2, w, w_1, w_2, h, h_1, h_2$ and determined formulas. We built these geometric models for the typical cavities described in our research. [9]

Results of the research and their discussion

In order to optimize the diagnostic process and to avoid spending a lot of time on calculations in clinical settings, we conducted a series of mathematical calculations.

To determine volumes of crowns, for each group of teeth appropriate geometric models are used. We modelled the tooth crowns of molars and premolars groups in the form of truncated cones with averaged linear dimensions, and groups of incisors and canines in the form of a triangular prism with averaged linear dimensions or without averaging respectively. With the use of constructed models mathematical calculationswere carried outto calculate tooth crown volumes based on their linear dimensions $l_o, l_v, l_L, l_I; w_o, w_M, w_D, d_l, d_r, h_v, h_L, h_M, h_D$ (Figure 1–4) and the obtained calculation formulas (1-4).

To save time on calculations in a clinical setting and for easy calculation of tooth crown volumes we have developed an electronic Excel calculator (Figure 5). Using a micrometer and periodontal probe, we conducted measurements of input linear dimensions of the tooth. Consequently, the data was enteredinto an electronic Excel calculator, and thus we have received a calculated volume. Linear dimensions should be measured in accordance with the recommendations displayed on geometric models (particularly where this is shown in mutually perpendicular directions) (Figure 1–4). Otherwise, one should expect an increase in the relative error of computation.

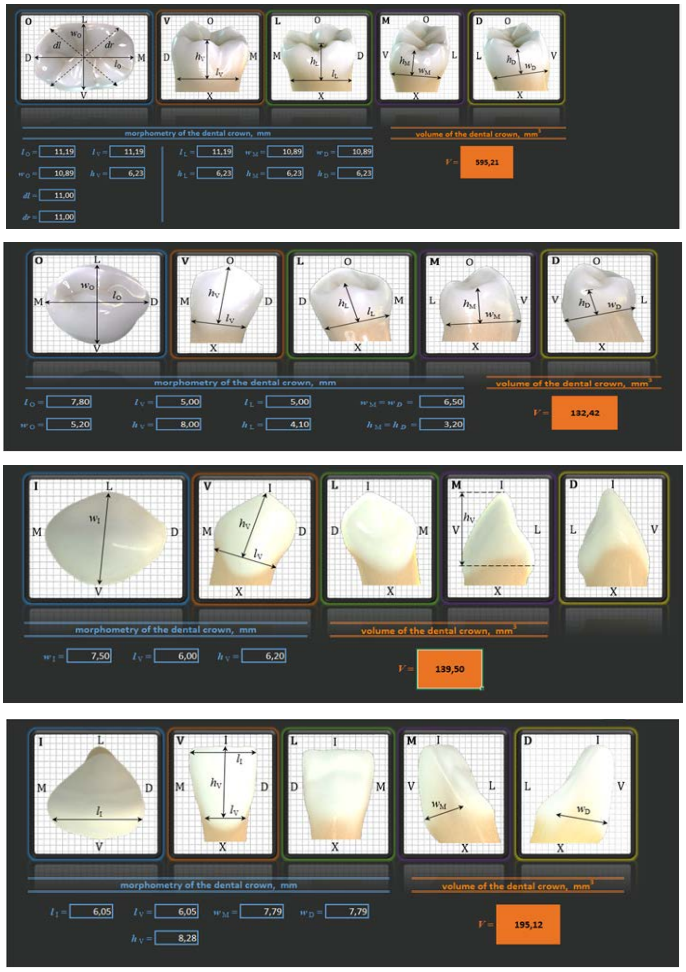

Fig. 5: An electronic Excel calculator for calculating dental crown volumes

To determine the reliability of the results we conducted a comparative analysis of tooth crown volumes Vc, found by our proposed approach (based on geometric model) and volumes of the same tooth crowns V, defined by a known physical formula (5) (based on a real gypsum model).

$$V = \frac{m}{\rho} \tag{5}$$

Where V – volume, ρ – density (gypsum density is 2.3 g/cm^3), m – mass (weight) of the tooth gypsum model.

On a gypsum model we useda micrometer and a periodontal probe.First, we conducted measurements of input linear dimensions of the tooth. Then we entered this data into an electronic Excel calculator and obtained a calculated volume *Vc*. In the next step, we weighed gypsum model of clinical crowns of teeth and calculate the volume V by the formula (5). Weighing crowns was done using analytical scales Radwag AS 220/c, which are intended for accurate weighing in the laboratory.

For each group of teeth, we calculated the relative error of calculation ΔV, by the formula 6:

$$\Delta V = \frac{|Vc - V|}{V} \cdot 100\% \tag{6}$$

The relative error of calculations ΔV showed that the results of calculations of the volumes crowns obtained by mathematical and physical simulations are quite close. At the same time, the advantage of the mathematical approach over the physical is obvious (here we mean the inability to measure tooth weight in clinical settings). This, to some extent, proves the feasibility of using electronic Excel–calculator for calculating crown volumes in clinical settings. We have published a program on the scientific portal Research Gate with free access at the following link: https://www.researchgate.net/publication/325301320_Electronic_Excel_calculator_for_calculating_the_volume_of_crowns_of_teeth_Rozrobka_elektronnogo_Excel-kalkulatora_dla_rozrahunku_ob'emiv_koronok_zubiv

To determine the volume of defects in hard tissue, for each group of teeth appropriate geometric modelswere used. We built these geometric models for the typical cavities described in our study. [9] With the use of constructed models mathematical computationswere performed to calculate the volume defect hard tissue based on their linear dimensions. To determine the accuracy of the results on a gypsum model micrometer and periodontal probe initially measured the input linear dimensions of defects in hard tissues. We have noted the difficulty of accurate measurements. Therefore, we should expect an increase in the relative calculation errors. The process of measurement in the clinical setting was even more difficult. Using our method[6] and by using creamy substance, on the same gypsum models we defined the volumes of tooth cavities. We found significant errors in the mathematical computation of dental cavity volumes. Therefore, using a mathematical approach it is difficult to accurately measure the volume of various tooth cavities in clinical settings, and it is not appropriate to use.

To calculate the volume of defects in the hard tissue of the tooth, we proposeusing a physical approach. We restored the anatomical shape of the destroyed tooth by using wax (by known methods of modelling insert [10]). The obtained wax composition was weighed. Then using the formula (5) we calculated the volume of tooth cavities (Vcav), where ρ – density of wax, m – mass (weight) of the wax composition. Counting the ratio Vcav to Vc, we can get a percentage of the volume that takes the cavity to the volume of its crown. We call this value VIC (volume index of cavity), calculated by the formula:

$$\text{VIC} = \text{Vcav} / \text{Vc} \times 100\% \tag{7}$$

Consequently, the analysis of the obtained results will help in the development of methodologies for the optimi-

zation of the diagnostic process in the treatment of tooth cavities.

Conclusions

1. It is advisable to use an electronic Excel calculator to calculate dental crown volumes in clinical settings.
2. The mathematical approach doesn't accurately measure the volume of various tooth cavities. So, it is not appropriate to use.
3. To calculate the volume of tooth cavities it isadvisable to use a physical approach: by weighing the wax that reconstructed the anatomical shape of the destroyed tooth and calculating the volume.
4. Using our electronic Excel calculator to compute crown volumes and methods for counting the volume of tooth cavities and calculating the value VIC in clinical settings will improve the assessmentof the diagnostic process in the presence of tooth cavities.

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