Pediatric Dental Medicine

Anatomical and morphological characteristics of the pulp chamber of second primary molars, observed by a dental microscope

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Анатомо-морфологични характеристики на пулпната камера на втори временни молари, изследвани с помощта на дентален микроскоп

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Introduction: *Micro-assisted dental medicine has proven clinical success and it is already considered a new standard in dental treatment. This significant technology is a prerequisite for changing current and future trends in dental practice, including pediatric dentistry.*

Aim: *To study the morphology of the pulp chamber in second primary molars in relation to their anatomical characteristics.*

Materials: *Twenty primary second mandibular and 20 primary second maxillary molars from 36 children aged 5-8 years were examined. The teeth had history of irreversible pulpitis or chronic apical periodontitis. The roof was removed so that the contour of the pulp chamber was preserved. Color photographs were taken with a 23.3x magnification with the help of dental operating microscope. All images were analyzed with the software product Photoshop CC 2017. The validity of the laws about the anatomy of the pulp chamber floor in the permanent teeth was verified in primary teeth.*

Results: *Using high quality digital images of the pulp floor of primary molars allows better visualization and analysis of pulp chamber morphology.*

Conclusion: *The use of a microscope in dental practice facilitates the identification of important anatomical features in the pulp chamber of the primary teeth, such as the size and location of the orifices, the presence of additional canals or anatomic variations. The application of a dental operating microscope would increase the precision of manipulations with minimal removal of dental structures.*

Key words: *dental operating microscope, primary molars, pulp chamber*

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Въведение: *Микро-асистираната дентална медицина има доказан клиничен успех и се смята за нов стандарт в денталното лечение. Тази технология е предпоставка за промяна на настоящите течения в денталната практика, включително детската дентална медицина.*

Цел: *с помощта на дентален микроскоп да се изследва в клинични условия морфологията на пода на пулпната камера при втори временни молари във връзка с техните анатомични характеристики*

Материали и методи: *Изследвани са 20 втори мандибуларни и 20 втори максиларни временни молара на 36 деца на възраст между 5-8 години с диагноза необратим отворен/затворен пулпит или хроничен грануломатозен/екзацербирал периодонтит, което изисква провеждане на ендодонтско лечение. Отстранява се покрива на пулпната камера със стремеж да се запази контурът й. Правят се правят цветни снимки с увеличение 23.3x с помощта на дентален микроскоп. Получените изображения се анализират с помощта на софтуерен продукт Photoshop CC 2017. Проверява се валидността на описаните при постоянни зъби закономерности, касаещи анатомията на пода на пулпната камера при временните втори молари.*

Резултати: *Използването на висококачествени дигитални изображения на пода на пулпната камера позволява по-добра визуализация на нейната морфология.*

Заключение: Използването на микроскоп в денталната практика улеснява идентифицирането на важни анатомични белези в пулпната камера на временните зъби като големина и разположение на орифициумите, наличие на допълнителни канали или анатомични вариации.

Ключови думи: *дентален микроскоп, временни молари, пулпна камера*

Introduction

The knowledge about the anatomy of primary teeth clearly explains why carious lesions progress rapidly and the pulp complications are so common [1]. Specialized literature describes the differences between primary and permanent teeth. They can be summarized as follows: the enamel in the primary teeth is thinner and the dentin thickness between the pulp chamber and the enamel is smaller than that in the permanent teeth. The dental structures in the first dentition have a lower degree of mineralization, wide proximal contact area and there is a tapering of the vestibular and lingual walls in occlusal direction [1, 2]. These features cause the carious lesion to progress more rapidly in the dentin, creating the risk of an early onset of an inflammatory process in the pulp [3].

The uniqueness of children as patients makes the precise cavity preparation in primary teeth difficult. This is a prerequisite for unjustified hard dental structure loss, in contrast to one of the modern concepts of dental medicine - the microinvasive approach [4]. It requires extreme precision of the manipulations during the minimal removal of dental structures. Emphasis is placed on good visibility and excellent illumination of the operative field. The magnifying digital technologies are an important tool in modern dental medicine [5, 6].

Micro-assisted dental medicine has proven clinical success and it is already considered a new standard in dental treatment. This significant technology is a prerequisite for changing current and future trends in dental practice, including pediatric dentistry [7-9]. Dental operating microscope (DOM) is used both in endodontic treatment of immature permanent teeth and primary teeth. DOM enables:

- Better visualization of the pulp chamber and orifices [10];
- Detection of hidden canals / canal systems [11];
- Identification and elimination of obliteration, calcifications and denticles [12].

The use of DOM in the treatment of primary dentition has not yet been sufficiently studied, especially in the context of the minimally invasive approach and its potential for magnification and photo documentation of pulp chamber morphology and the presence of accessory canals in the furcation zone.

Aim: To study the morphology of the pulp chamber in second primary molars in relation to their anatomical characteristics.

To fulfil this aim, the following tasks were set:

1. Photo documentation of the pulp chamber floor of second mandibular and maxillary molars with DOM at 23.3x magnification.

2. Analysis of the obtained images through the software product Photoshop CC2017.

Materials: 20 primary second mandibular and 20 primary second maxillary molars from 36 children aged 5-8 years were examined. The teeth had history of irreversible pulpitis (clausa/ aperta) or chronic periodontitis (periontitis chronica granulomatosa / periodontitis chronica exacerbata) and endodontic treatment was necessary. Informed consent was signed by the patients' parents. The study was approved by the Ethics Committee of the Medical University – Sofia, KENIMUS №24 / 07.12.2018.

Criteria for inclusion of teeth in the study

Diagnosis is performed according to the accepted clinical criteria for irreversible pulpitis or periodontitis in primary teeth.

- Second primary molars:

• with a large carious lesion with or without pulp exposure;

• large filling with or without defects;

• with or without discoloration;

• with or without sinus track;

• pain on percussion might be present;

• spontaneous pain, night pain, pain on chewing, pain from sweet and cold stimuli, which lingers after removal of the irritant.

Diagnostic X-rays were made and they verified the presence of partially or completely demineralized dentin in the area of the pulp horn and that 2/3 of the length of the roots was preserved.

Methods: If needed local anesthesia was administered and carious dentin was removed from the periphery of the cavity. The pulp chamber was then opened with carbide endo access bur with non- cutting tip (Endo Z bur, Dentsply Sirona, Ballaigues, Switzerland). The roof was removed so that the contour of the pulp chamber is preserved. Coronal pulp was removed with round bur and irrigation with 3% H_20_2 was performed. If there was bleeding, hemostasis was achieved and the pulp chamber was dried. The teeth were then isolated and all necrotic tissue is removed from the pulp chamber with 5,25% sodium hypochlorite. In order to calibrate the digital images of examined teeth, the distance between the two mesial or distal cusps was measured with orthodontic caliper. After the initial inspection of the pulp chamber, color photographs are taken with a 23.3x magnification. These images are then used to localize and register the orifices, presence or absence of isthmuses, accessory canals or other anatomical landmarks. After that the floor of the pulp chamber is treated with methylene blue (Canal detector, Cerkamed) for 5-10 sec. The excess dye is removed and the pulp chamber was rinsed with water and dried. The aim was to identify the orifices easier. Then a new picture was taken with 23.3x optical zoom. The resulting images were used for the same purpose.

All images were analyzed with the software product Photoshop CC 2017. The location of the canal orifices, their position relative to each other and the distances between them, the presence of isthmus, additional canals or other anatomical features were recorded. The location of the orifices and the outline of the pulp chamber are marked with lines. Lines were also drawn through the center of the orifices in the vestibulo-lingual direction and the middle of the crown in mesio-distal direction. The validity of the laws about the anatomy of the pulp chamber floor in the permanent teeth was verified and confirmed in primary teeth. Statistical processing was performed with IBM SPSS Statistics v.19 (IBM Corporation).

The study used a Semorr DOM 3000E dental

Table 1. *Distances between the orifices of primary second mandibular molars and surface area of the pulp chamber floor. (Mesial – mesiolingual and mesiovestibular, Distal – distolingual and distovestibular, MLDL – mesiolingual and distolingual, MVDV – mesiovestibular and distovestibular).*

	Count (n)	Min	Max	Mean	Standard Deviation
Mesial (mm)	20	2,40	3,60	3,0095	,35224
Distal (mm)	20	2,06	3,15	2,6125	,30741
MLDL (mm)	20	2,63	3,88	3,2298	,37427
MVDV (mm)	20	2,73	3,98	3,3147	,38025
Surface area (mm^2)	20	9,21	11,34	9,9794	,62114

Table 2. *Distances between the orifices of primary second maxillary molar (MBDB – mesio-buccal and disto-buccal, MBP – mesio-buccal and palatal, PDB –palatal and disto-buccal and surface area of the floor of the pulp chamber.*

	Count (n)	Min	Max	Mean	Standart Deviation
MBDB (mm)	20	3.3523	4.4164	4.0411	0.4045
MBP (mm)	20	5.3845	6.2683	5.96042	0.5184
PDB (mm)	20	1.088	2.6312	2.0959	0.5620
Surface area (mm^2)	20	21.1255	26.8815	23.5411	2.1524

operating microscope with a monitor (23-inch IPS LED matrix display, 1920-1080 resolution) for real-time imaging and a digital camera with a ring flash.

Results: Using high-quality digital images of the pulp floor of primary second mandibular molars allowed better visualization and analysis of pulp chamber morphology of primary second mandibular (Table 1) and maxillary molars (Table 2).

Table 1 lists the mean distances between mesiolingual and mesiovestibular orifices (Mesial), distolingual and distovestibular (Distal), mesiolingual and distolingual (MLDL), and mesiovestibular and distovestibular (MVDV).

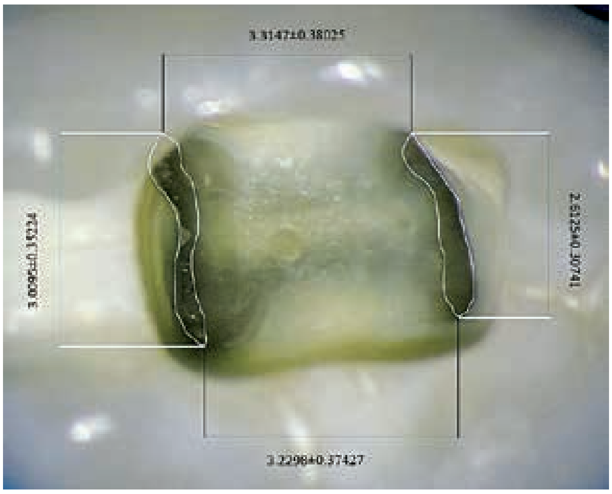

Figure 1*. Image of pulp chamber floor of primary second mandibular molar with mean values*

The analysis of the images shows, that the mesio-distal dimensions of the pulp chamber are larger than the vestibulo-lingual dimensions (3.3147 and 3.0095). The mean surface area of the pulp chamber floor is approximately 10 mm^2.

Figure 1 shows an image of pulp chamber floor of primary second mandibular molar with mean values from the morphological analysis.

The analysis shows that the pulp chamber of primary second mandibular molars has an approximately trapezoidal shape with a broad base toward the mesial orifices. The ribbon-like shape of the orifices is clearly visible.

The analysis of the results show clearly that the vestibulo-palatal dimension of the pulp chamber is larger than the mesio-distal one (5.9604 mm and 3.3323 mm, respectively). The mean surface area of the pulp chamber floor of maxillary second primary molars was 20 mm^2 (Table 2). It is almost twice the size of the mandibular second primary molars (Table 1).

Figure 2 shows a representative digital image of the pulp chamber floor of a maxillary second primary molar.

The shape of the pulp chamber in maxillary second primary molars is also trapezoidal with a

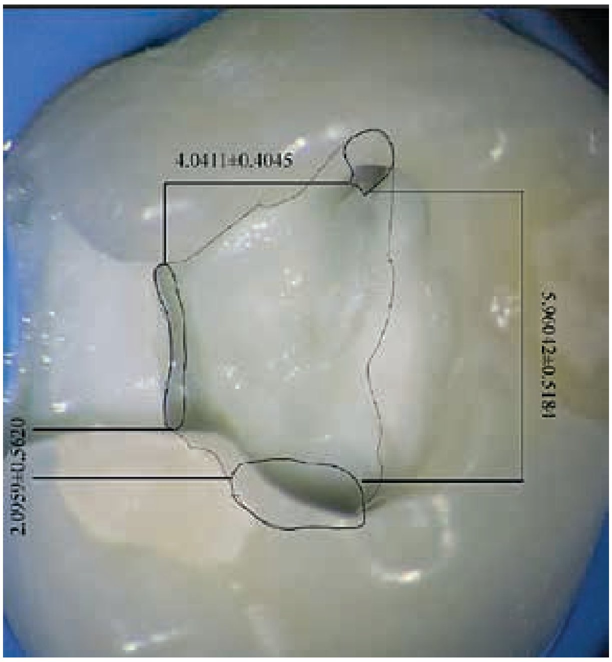

Figure 2. *Representative image of the pulp chamber floor of a maxillary second primary molar with the mean distance between the canal orifices, created with DOM (Semorr DOM 3000E), magnification of 23.3x.*

broad base to the line connecting the mesial and palatal orifices.

Figures 1 and 2 show the ribbon-like shape of the orifices. This finding was observed in all of the examined teeth. All of the second mandibular molars had two roots with three or four channels. The maxillary second primary molars have three roots with three or four root canals.

With the help of the software product (Photoshop CC2017) we found that, like permanent molars, the dentin on the floor of the pulp chamber has a darker color in the primary molars. The orifices are always located at the boundary between the floor and the walls of the pulp chamber. In the mandibular second molars, they are equidistant from the line that bisects the floor of the pulp chamber in the mesio-distal direction (Figure 1). Such dependence on the location of the orifices is not observed in the maxillary second primary molars.

Discussion

The second primary molars have three or four canals – two mesial and one or two distal. The mesial canals begin as a common ribbon like canal, which is then divided into two. The distal root contains an oval or ribbon-like canal with large bucco-lingual size and small mesio-distal, similar to the first primary lower molars [13-15]. With the advancing age and calcification, two separate canals can be distinguished in the distal root.

Abnormalities of the pulp floor and root canals have also been documented. Taurodontism - the inability of the epithelial diaphragm of Hertwig's root sheath to infiltrate horizontally, has been observed in primary molars uni- or bilaterally in healthy children or in association with syndromes [16]. In some populations, the incidence of this condition may reach 9% and affect both permanent and primary molars [17]. In extremely rare cases, it is possible to have single rooted maxillary primary molars, second primary molars with C-shaped canals, fusion and dens invaginatus [17-19].

Accessory roots in primary mandibular second molars have been found in the Danish, Japanese, Chinese, Taiwanese and Korean populations [20]. Their presence is often associated with persistence of infection and failure of treatment. In our study, we did not find any accessory roots, as well as anatomical anomalies in the studied tooth groups, which can be explained by the smaller sample size.

Most studies identify two canals in the mesial root, and one or two canals in the distal root [21-23]. In our study, all teeth have two roots with three or four canals. The mesial roots have two canals and the distal – one or two, which coincides with published data [21-23].

There are known cases of three-rooted teeth with five canals - two mesial and three distal. Additional root canals can be identified radiographically, but in most cases this is done by clinical examination of the pulp floor and the pulp chamber [24]. All mandibular molars in the present study have two roots with three or four canals. The maxillary second primary molars have three roots with three or four root canals. The most common are the lower second molars with three canals, two in the medial root and one in the distal, and upper second primary molars with three or four canals. These results coincide with the published data in the specialized literature [22, 23, 25].

When comparing with the published information in the specialized literature, we found that the mesio-distal dimensions of the pulp chamber of the mandibular second primary molars takes around 33.1% of the crown size and the buccal - lingual 33.2% respectively. For the maxillary second primary molars, these ratios are 45.15% and 59.6%, respectively [26]. This indicates that the pulp chamber of the maxillary molars is relatively wider than that of the mandibular molars, which may be related to the incidence of pulpal inflammation in these teeth.

The pulp floor morphology of primary molars can be assessed in the clinical practice with the help of DOM, thus preventing unnecessary removal of dental structures during endodontic access preparation. The magnification allows better identification of the anatomical landmarks in the pulp chamber, as well as remnants of the pulp roof, it facilitates the initial penetration of the pulp chamber, the reading of the dentin map, the identification of orifices and the differentiation of the pulp horns from the pulp body into the chamber [10]. Anatomical variations are frequent and of great variety. In many cases, they cannot be treated with traditional endodontic methods [11]. The introduction of the dental microscope and the ability to inspect the root canals have fundamentally changed our perception of dental morphology and its complexity [12, 27]. Although rare, obliterations, calcifications and denticles are also found in primary teeth. These situations make microinvasive access cavity preparation and root canal negotiation difficult [12].

There are several known laws about the location of the orifices on the pulp floor based on observation of the anatomy of permanent teeth. They help the clinician to locate accurately the pulp chamber, orifices and root canals [28]. Using DOM and the images made with it, in the present study we found that some of the laws for the location of the root canal orifices in permanent teeth were only valid in the mandibular second primary molars:

First law of symmetry: for all mandibular molars, the orifices of the canals are equally distant from a line drawn in a mesial distal direction through the pulp chamber floor;

Second law of symmetry: for all mandibular molars the orifices of the canals lie on a line perpendicular to a line drawn in a mesial-distal direction across the center of the floor of the pulp chamber;

The validity of other laws established in permanent teeth was confirmed for maxillary and mandibular second primary molars.

Law of Color Change: the color of the pulp chamber floor is always darker than the surrounding walls;

First law of orifice location: the orifices are always located at the junction of the walls and the floor;

Second law of orifice location: the orifices are located at the angles in the floor-wall junction;

Third law of orifice location: the orifices are located at the terminus of the root developmental fusion lines;

Knowing these laws would make locating the orifices easier and thus would improve the quality of endodontic treatment of primary second mandibular molars.

Conclusion:

The use of a microscope in dental practice facilitates the identification of important anatomical features in the pulp chamber of the primary teeth, such as the size and location of the orifices, the presence of additional canals or anatomic variations. The application of a DOM would increase the precision of manipulations with minimal removal of dental structures.

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