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SEM Characteristic of Peritubular and Intertubular Coronal Dentin of Young, Adult and Senescent Teeth

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Abstract: ***Dentinis considered as an amizing tissue regarding new insights about its composition. Dentine is composed of tubules surrounded by a hypermineralized layer called peritubular dentin, and a softer intertubular matrix. Its organic components concentrates in form of collagen fibrils and non-collagenous proteins and complex macro-molecules. The aim of this study is to analyze the morphology of peritubular and intertubular dentin of young, adult and senescent teeth in the middle coronal area. Permanent human third molars (n=30) were examined by SEM. Our study is in parallel to the recently proposed model of peritubular dentin that provides novel evidence about structure and chemistry of peritubular dentin. It lacks collagen fibrils, contains an organic scaffold embedded with mineral and the peritubular dentin organic matrix is manly composed of glycosaminoglycans, whereas the lamina limitans is primarily made of proteoglycans protein cores. Age-related characteristics of coronal dentin are evident in peritubular meshwork thickening, reduction of inter-fibrillar connections and mineral deposition within the tubules.***

Keywords: peritubular dentin, age-related characteristics of dentin, SEM, lamina limitans

1. Introduction

Dentinis considered as an amazing tissue regarding new insights about its composition, especially non-collagenous proteins and additional macromolecules with complex chemistry and origin. From a biological point of view, dentin can be described as a nanostructured vital semi-permeable barrier between enamel and pulp [1], whereas biomechanically it functions as a tougher foundation helping to prevent propagation of cracks from the brittle enamel [2].

2. Literature Survey

The steps involved in the formation of the peritubular dentin are not well understood. It is known that it develops from the inner wall of the tubules towards the lumen, narrowing the tubule space with advancing maturation until it reaches a stage of hypermineralization [3].Recent studies have also suggested that it may form from an extracellular matrix rich in glutamic acid [4, 5], or by continuous mineral deposition from the pulpal fluid, which results in the accumulation of mineral around the tubules [6].

3. Problem Definition

The aim of this study is to analyze the morphology of peritubular and intertubular dentin of young, adult and senescent teeth in the middle coronal area.

4. Materials/ Approach

Material – sample selection and preparation

Permanent human third molars (n=30) were obtained according to protocols approved by the Ethical Committee of Medical University – Plovdiv, Bulgaria. All teeth were fixed in neutral formalin solution (10%) for 24-72 hours and assembled in three groups: young coronal dentin (in 18-35 years old patients), adult coronal dentin (in 36-50 years old patients) and senescent coronal dentin (above 51 years old patients). The specimens were dehydrated in ascending grades of ethanol and acetone (from 25% to 100%). Fresh fractured fragments were subsequently coated with gold for 10 min in vacuum.

Method

The images were gained using a SEM (JSM-IT500HR, USA).

5. Results and Discussion

Our results show expected ring-like structure of the peritubular dentin surrounding the tubules in all specimens.In young coronal dentin a fibrillar meshwork is evident (Fig.1 and Fig.2)

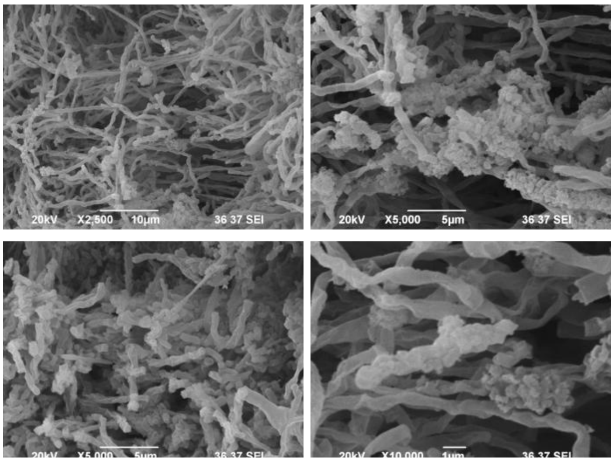

Figure 1: Coronal young dentin. Structural fibrils are coated by crystals (spheroids)

It is noteworthy that, although the filaments appearedto be organic in nature, the 67 nm periodicity relative to the staggeredpattern of collagen fibrils was not present in any of thestructures we found within the peritubular dentin region, thussuggesting the presence of another super-molecular structure atthe peritubular organic matrix [7].

It is interesting to note that in ultrahigh magnification (x10 000) the fibrils are coated by prismatic and spherical in shape crystals (Fig.1 and Fig.2).

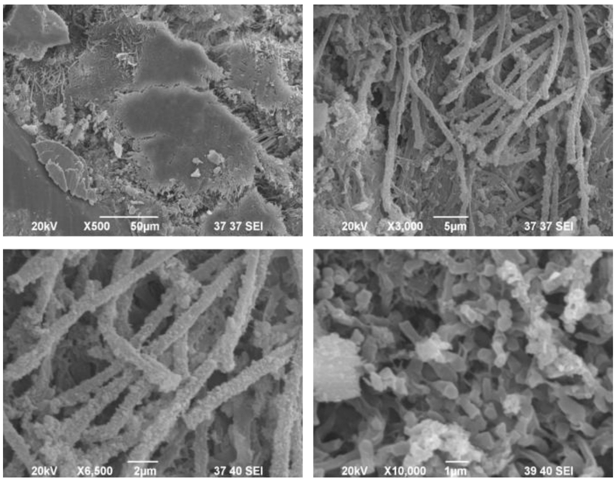

Figure 2: Coronal young dentin. A fibrillar meshwork is evident coated by crystals

Early microscopy studies on the microstructural organization of the organic features contained within the peritubular matrix date back to 1960s. Studies on partially demineralized dentin also revealed fine organic fibrils [8, 9], a flatwork of delicate fibrils [10], and a low density of amorphous substance [3]by TEM and SEM.

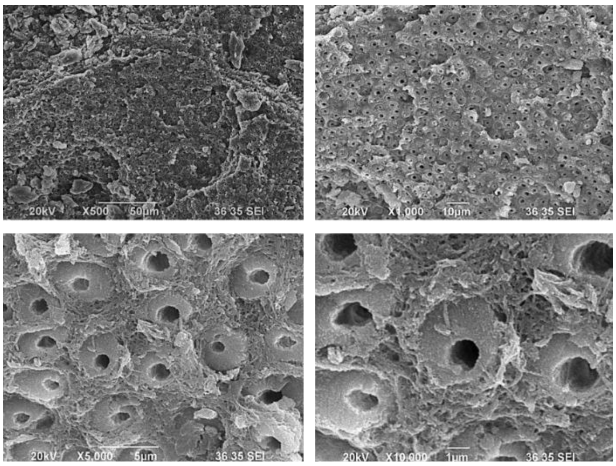

Figure 3: Coronal adult dentine. Ring-like hypermineralized peritubular dentin

The peritubular dentin organic matrix may be a complex of phosphorylated proteins, proteoglycans and glycosaminoglycans, lacking collagen fibrils [11].The carbohydrate component is called glycosaminoglycan and combined with the proteoglycan protein core it forms the primary element responsible for the structural stability of the extracellular matrix of nearly all vertebrates [12, 13]. Thesecomplexes, also known as shape modules [13], are thought to function as a scaffold giving support and facilitating mineralization during development, also organizing and stabilizing the matrix of connective tissues. In dentin, the most prominently expressed proteoglycan protein cores are decorin and biglycan[14], whereas the mostly frequently found glycosaminoglycans are chondroitin 4-sulfate and a relatively lower content of chondroitin 6-sulfate, although dermatan sulfate, hyluronan andkeratan sulfate have also been reported [14].

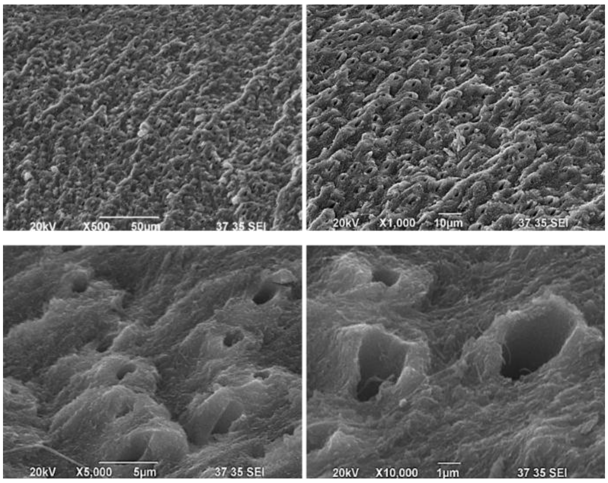

Figure 4: Coronal adult dentin. Ring-like hypermineralized peritubular dentin

Our results are consistent with the findings of recent studies [7] that peritubular dentin is hypermineralized and non-collagenous in nature, well-defined from the intertubular dentin preferably composed of super-molecules belong to SIBLINGs and SLRPs.

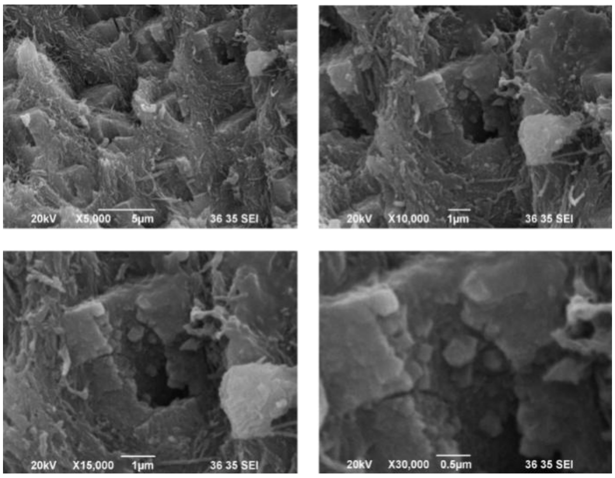

Figure 5: Coronal senescent dentine. Mineral deposits within the dentinal tubules are clearly visible

The senescent coronal peritubular dentin is slightly thicker, the intertubular regions are narrower than the young and adult specimens. Mineral deposits within the dentinal tubules are clearlyvisible (Fig.3, 4, 5, 6).

On ultrahigh magnification (x30 000), it is evident that the minerals within the dentinal tubuls are attached to the walls, irregular in shape, single-positioned or forming conglomerates of larger crystals (Fig. 5). However, some of the tubules are free of mineral deposites (Fig.6).

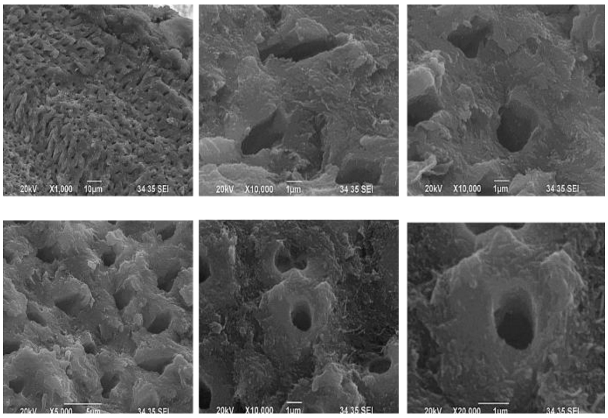

Figure 6: Coronal senescent dentine. Peritubular dentin is slightly thicker and the intertubular regions are narrower.

6. Conclusions

Our study is in parallel to the recently proposed model of peritubular dentin structure by Luiz et al. [7] who provide novel evidence about structure and chemistry of peritubular dentin. It lacks collagen fibrils, contains an organic scaffold embedded with mineral and the peritubular dentin organic matrix is manly composed of glycosaminoglycans, whereas the lamina limitans is primarily made of proteoglycans protein cores. Age-related characteristics of coronal dentin are evident in thickening of peritubular ring-like dentin, intertubular space reduction and mineral deposition within the tubules.

7. Future Scope

We acknowledge the limitations of our study regarding the lack of selective enzymatic disintegration or digestion of non-collagenous proteins “building” the peritubular dentin as well as the evaluation of intratubular mineral deposits in senescent coronal dentin.A more recent investigation provided thorough description of the structural organization of the organic components in the peritubular matrix [15]. Although these studies offered excellent qualitative and microstructural description of the peritubular matrix, only recently the specific composition ofsuch structures started to be determined.

References

[1] Bertassoni, L.E., Habelitz, S., Kinney, J.H., Marshall, S.J., Marshall Jr., G.W., 2009. Biomechanical perspective on the remineralization of dentin. Caries Res. 43, 70–77.

[2] Imbeni, V., Kruzic, J.J., Marshall, G.W., Marshall, S.J., Ritchie, R.O., 2005. The dentin–enamel junction and the fracture of human teeth. Nat. Mater. 4, 229–232.

[3] Takuma, S., Eda, S., 1966. Structure and development of peritubular matrix in dentin. J. Dent. Res. 45, 683–692.

[4] Gotliv, B.A., Veis, A., 2007. Peritubular dentin, a vertebrate apatitic mineralized tissue without collagen: role of a phospholipid–proteolipid complex. Calcif. Tissue Int. 81, 191–205.

[5] Gotliv, B.A., Robach, J.S., Veis, A., 2006. The composition and structure of bovine peritubular dentin: mapping by time of flight secondary ion mass spectroscopy. J. Struct. Biol. 156, 320–333.

[6] Dai, X.F., Tencate, A.R., Limeback, H., 1991. The extent and distribution of intratubular collagen fibrils in human dentin. Arch. Oral Biol. 36, 775–778.

[7] Bertassoni, L.E., Stankoska, K. and Swain, M.V., 2012. Insights into the structure and composition of the peritubular dentin organic matrix and the lamina limitans. *Micron*, *43*(2-3), pp.229-236.

[8] Shroff, F.R., Williamson, K.I., Bertaud, W.S., 1954. Electron microscope studies of dentine. Oral Surgery 7, 662–670.

[9] Shroff, F.R., Williamson, K.I., Bertaud, W.S., Hall, D.M., 1956. Further electron microscope studies of dentine. Oral Surgery 9, 432–443.

[10] Johansen, E., Parks, H.F., 1962. Electron-microscopic observations on sound human dentine. Arch. Oral Biol. 7, 973–981.

[11] Gotliv, B.A., Veis, A., 2009. The composition of bovine peritubular dentin: matching TOF-SIMS. Scanning electron microscopy and biochemical component distributions. Cells Tissues Organs 189, 12–19.

[12] Scott, J.E., 2001. Structure and function in extracellular matrices depend on interactions between anionic glycosaminoglycans. Pathol. Biol. (Paris) 49, 284–289.

[13] Scott, J.E., Thomlinson, A.M., 1998. The structure of interfibrillar proteoglycan bridges (shape modules’) in extracellular matrix of fibrous connective tissues and their stability in various chemical environments. J. Anat. 192 (Pt 3), 391–405.

[14] Goldberg, M., Takagi, M., 1993. Dentine proteoglycans: composition, ultrastructure and functions. Histochem. J. 25, 781–806.

[15] Kodaka, T., Hirayama, A., Abe, M., Miake, K., 1992. Organic structures of the hypercalcified peritubular matrix in horse dentine. Tissues, Cells, Organs (former ActaAnatomica) 145, 181–188.

Author Profile

Neshka Manchorova, Graduated from the Medical University – Plovdiv, Bulgaria in 2000. Started working as an assistant professor in 2002, associate professor in 2012 and professor in 2016 in the Department of Operative Dentistry and Endodontics in the same university. Successfully defended her PhD thesis in May 2009 on the topic of “Postoperative sensitivity in posterior composite restorations”. Areas of interest include the restoration of endodontically treated teeth, biomechanical properties of dentin, adhesive strategies, and molecular biology.