MICRO-MORPHOLOGICAL STRUCTURE OF TEETH AND AGE-RELATED CHARACTERISTICS

Fergana medical Institute of Public Health
Faculty of Pediatrics, Dentistry Department
Student: ***Tolkhinjonova Durdona***
Mamasoliyeva N.X. *teacher of Human Anatomy*

Abstract

This article analyzes the micro-morphological structure of the main dental tissues—enamel, dentin, cementum, and pulp—their functional importance, and morphological changes occurring with aging. From a microscopic perspective, the cellular and fibrous structure of each tissue, their interrelations, as well as physiological and pathological changes are examined. Additionally, the diagnostic and therapeutic significance of age-related changes is discussed in the context of dental practice. The article holds scientific and practical value for students and professionals in gerontostomatology, therapeutic, and prosthetic dentistry.

Keywords:

Tooth micromorphology, enamel, dentin, cementum, pulp, gerontostomatology, age characteristics

1. Introduction

Within the complex and sophisticated systems of the human body, teeth occupy a distinct place. They are not only responsible for mastication, but are also closely linked with speech, facial aesthetics, craniofacial structure formation, and psychological well-being. Therefore, comprehensive study of the structure of teeth is one of the fundamental research directions in dentistry.

Micromorphological structure refers to the microscopic internal architecture of dental tissues, their cellular and non-cellular components, and their functional features. Teeth are composed of multilayered tissues such as enamel, dentin, pulp, cementum, and periodontium, each with a unique micromorphological structure.

These microscopic structures determine the tooth's durability, sensitivity, regenerative capacity, and age-related changes.

Modern microscopic research techniques allow for in-depth examination of the developmental stages of dental tissues, the morphological changes that occur with age, and their susceptibility to pathological processes. Identifying and evaluating regressive (degenerative) changes associated with aging plays an important role in developing clinical strategies for diagnosis, treatment, and prevention in dentistry.

Additionally, understanding changes in dental tissues is useful in forensic age estimation, as well as in planning orthodontic and orthopedic procedures. In this context, this article thoroughly explores the micromorphological structure of teeth, cellular characteristics of the main tissue components, age-related changes, regressive processes, and their clinical significance.

Pulp (Pulpa dentis)

The pulp is a living structure located inside the tooth, composed of soft connective tissue that includes nerves, blood vessels, lymphatic vessels, and fibroblasts. It provides vitality, sensitivity, and regenerative capacity to the tooth. The pulp lies within the inner part of the dentin, occupying the pulp chamber in the crown and the root canal in the root portion.

Main functions of the pulp:

- **Trophic (nutritional):** Nourishes the dental tissues through blood supply.
- **Sensory:** Detects stimuli such as heat, cold, and pain.
- **Formative:** Produces dentin via odontoblasts.
- **Reparative:** Enables the replacement of damaged dentin with tertiary dentin.
- **Protective (immunologic):** Fights microorganisms with immune cells.

Microscopic structure:

The pulp mainly consists of the following cells and structures:

1. **Odontoblast layer** – Located at the dentin border, these cells produce dentin.
2. **Fibroblasts** – Produce collagen and other matrix components.
3. **Undifferentiated mesenchymal cells** – Can transform into odontoblasts or fibroblasts when needed.
4. **Blood and lymphatic vessels** – Support high metabolic activity.
5. **Nerve fibers** – A-delta and C fibers are responsible for pain perception.

The pulp is divided into three main zones:

- **Odontoblastic zone** – The outermost layer directly adjacent to dentin.
- **Cell-rich zone (Höchstetter zone)** – Contains fibroblasts, collagen, and other cells.
- **Central zone (neurovascular zone)** – The innermost area rich in blood vessels and nerves.

Age-related changes:

In childhood, the pulp is relatively large, more cellular, and highly active, with intense odontoblastic function. In adolescence and adulthood, the pulp maintains normal function, with resilient tissues and high regenerative capacity. In old age, the pulp volume decreases, collagen tissue increases, and the number and activity of cells decline. Blood vessels become sclerotic, and pulp stones (denticles) may form due to calcium salt deposition. These changes reduce tooth sensitivity and complicate clinical procedures: in elderly patients, endodontic treatments become more difficult due to narrowing or complete closure of access pathways to the pulp.

Cementum

Cementum is a mineralized tissue that covers the external surface of the tooth root and anchors it to the alveolar bone. Located on top of the dentin, cementum plays a functional role in connecting the tooth to the periodontal apparatus. It is primarily found in the root region, though in some pathological cases, it can extend to the crown.

Composition:

Cementum consists of approximately 45–50% inorganic materials (mainly hydroxyapatite) and 50–55% organic matter and water. Its organic portion is primarily made up of type I and III collagen fibers.

Types of cementum:

1. **Acellular cementum** – Found mostly in the cervical (upper) part of the tooth root and does not contain cells. It plays a role in mechanical stability.
2. **Cellular cementum** – Located mainly in the apical (lower) part of the root and in the furcation areas. Contains cells called cementocytes, which contribute to the renewal and repair of cementum.

Microscopic structure:

Cementum is directly attached to dentin. Collagen fibers known as **Sharpey's fibers** extend from the periodontal ligament into the cementum, anchoring the tooth to the bone. On its surface, **cementoblasts** are found, which secrete new cementum. In cellular cementum, **cementocytes** are embedded within **lacunae** (small cavities) and interconnected via canaliculi, playing a role in metabolic activity.

Physiological and clinical significance:

- Cementum anchors the tooth to the alveolar bone.
- It coordinates tooth movement (e.g., in orthodontic treatment, cementum remodeling is crucial).
- Insufficient or excessive cementum on the root surface may be associated with periodontal diseases.

Age-related changes:

In children, cementum is thin, and acellular cementum predominates. Tooth movement (e.g., during orthodontic treatment) is relatively easier. In adolescence and adulthood, cementum thickens, and cellular cementum appears. In old age, overall cementum thickness increases, especially near the root apex. The number of cementocytes rises, and **hypercementosis** may occur in some cases. These age-related changes in cementum can influence periodontal health and orthodontic outcomes. In elderly patients, cementum thickness is an important consideration when locating endodontic access points.

Periodontium

The periodontium is a complex of tissues that connect the tooth to the alveolar bone and support its functional activity. It consists of four main components:

1. **Alveolar bone**
2. **Periodontal ligaments**
3. **Cementum**
4. **Gingiva** – sometimes included as part of the periodontium

The periodontium acts as a non-movable connective tissue that protects the tooth from various mechanical forces, distributes pressure, and provides cushioning (shock-absorbing) effects.

1. Periodontal Ligaments:

These fibers attach the root cementum to the alveolar bone. They are composed of elastic collagen fibers arranged in various directions:

- Horizontal and oblique
- Apical (oriented toward the root tip)
- Interradicular (in multi-rooted teeth)

These fibers allow the tooth to withstand forces from different directions. The ligaments also contain blood vessels, lymphatics, nerve fibers, and fibroblasts.

2. Alveolar Bone:

The alveolar bone surrounds and supports the tooth roots. It includes the **lamina dura** (visible radiographically) and a spongy bone layer. After tooth loss, the alveolar bone undergoes resorption.

3. Gingiva (Gums):

Gingiva forms the outer portion of the periodontium. It surrounds the teeth and serves as the first line of defense against infections. Healthy gums are firm, pink, and tightly attached to the teeth.

Functions of the Periodontium:

- **Supportive** – firmly anchors the tooth in the bone
- **Protective** – defends against microbial and mechanical insults
- **Trophic** – nourishes tissues via blood and lymph circulation
- **Sensory** – provides sensation via nerve fibers
- **Shock-absorbing** – reduces pressure during mastication

Age-related changes:

In childhood, the periodontium is soft, with wide and elastic fibers, making orthodontic tooth movement easier.
In adulthood, periodontal tissues are at their peak functional capacity, with dense alveolar bone and good blood supply.
In old age, the following changes are observed:

- Collagen fibers become more rigid and lose elasticity
- Periodontal space narrows
- Alveolar bone density decreases, with increased susceptibility to resorption
- Gingiva becomes thinner and more prone to inflammation
- Risk of periodontal diseases such as **periodontosis** and **gingivitis** increases

These changes must be considered during dental treatments, especially in prosthodontics and orthodontics. For instance, in elderly patients, tooth movement occurs more slowly, and treatment duration may increase.

4. General Age-Related Characteristics of Tooth Micromorphology

Tooth micromorphology refers to the microscopic structure of the main dental tissues—enamel, dentin, pulp, cementum, and periodontium. Throughout a person's life, these tissues undergo morpho-physiological, biochemical, and functional changes. These alterations are influenced by age, genetics, environmental factors, dietary habits, and oral hygiene levels.

Types of age-related changes:

Tissue	Key age-related changes
Enamel	Increased mineralization, but more microcracks; erosion and abrasion become more pronounced with aging.
Dentin	Formation of secondary and tertiary dentin; narrowing of dentinal tubules.
Pulp	Decreased volume, reduced cell number and activity; formation of pulp stones (denticles).
Cementum	Thickening of cellular cementum; increased cases of hypercementosis.
Periodontium	Collagen fibers become stiffer, increased bone resorption, gingival involution (thinning and degeneration).

Clinical significance of micromorphological changes:

1. **Diagnosis** – Recognizing age-specific changes helps differentiate between conditions (e.g., pulpitis vs. periodontitis).
2. **Treatment strategies** – In children, soft and active tissues respond quickly to treatment; in elderly patients, a more cautious approach is required.

3. **Prosthodontics** – Internal structural changes in aging teeth affect denture fitting and compatibility.
4. **Endodontic procedures** – Narrowed pulps and calcified canals complicate root canal treatment.
5. **Orthodontics** – High periodontal plasticity in children allows easier tooth movement.

Regenerative potential:

- **In youth** – Odontoblasts, fibroblasts, and other regenerative cells are active.
- **In old age** – These cells decrease in number and activity, leading to slower tissue renewal and reduced repair capacity.

Biochemical changes:

- **In enamel** – Fluoride and calcium levels decline with age.
- **In pulp and dentin** – Slower metabolism and weakened immune response.

Micromorphological changes in dental tissues occur systematically and progressively with age. These transformations are not only part of the biological aging process but also crucial for clinical decision-making in dentistry. Each age group has distinct structural and functional traits that serve as key criteria in diagnosing and treating dental diseases.

Conclusion

Tooth micromorphology undergoes significant changes depending on age. The tissues of the tooth—enamel, dentin, pulp, cementum, and periodontium—not only differ in structure but also adapt functionally as a person ages. In children, these tissues are more cellular and active, with a high regenerative capacity, which makes dental treatments more effective. In old age, however, the density of dental tissues increases, collagen fibers become more rigid, pulp volume decreases, and mineral deposits begin to form. These processes require special attention in endodontic, periodontal, and orthodontic treatment.

Therefore, a deep understanding of age-related changes in tooth micromorphology is of great importance in all branches of dentistry. These changes reflect in the microscopic structure, biochemical composition, and functional activity of all main tooth tissues—enamel, dentin, pulp, cementum, and periodontium. In children, these tissues are rich in cellular activity and high in metabolic and regenerative potential. Although enamel is less dense in early life, its mechanical resistance increases with age. Dentin actively produces secondary and tertiary layers, protecting the tooth from external stimuli. The pulp is larger, containing numerous cells and blood vessels, which ensures high tissue metabolism.

In adulthood, the dental tissues operate at their peak, with increased density and improved mechanical and biochemical properties due to continued growth and development. The periodontium retains elasticity and strength, ensuring tooth stability.

In old age, significant micromorphological changes occur. Microcracks appear in the enamel, mineral content declines, and mechanical resistance is reduced. Dentin tubules narrow, and additional layers of dentin reduce pulp volume. The pulp becomes smoother, with decreased cell number and activity, while calcified structures (denticles) increase, affecting the function of nerves and blood vessels. Cementum thickens, with more cellular cementum and sometimes hypercementosis. In the periodontium, collagen fibers become rigid, alveolar bone density decreases, and the gingiva becomes thinner. These changes increase tooth mobility and susceptibility to inflammation in older adults.

Micromorphological changes play a crucial role in diagnosis, treatment, and rehabilitation in dental practice. By taking into account the structural and functional features of each age group, dentists can implement individualized treatment plans and ensure effective dental care at any stage of life. Moreover, age-related changes are decisive in determining therapeutic approaches in orthodontics, endodontics, and prosthodontics. For instance, the high regenerative capacity of young tissues accelerates orthodontic movement, whereas in elderly individuals, tissue rigidity and slower metabolism complicate treatment procedures.

As a result, a thorough understanding of age-related micromorphological changes is essential for providing modern and high-quality dental care. This knowledge supports the preservation and improvement of dental health across all ages.

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