CEMENTUM-STRUCTURE & FUNCTIONS

OUTLINE

Cementum covers the roots of the teeth and is interlocked firmly with the dentin of the root. Cementum is a mineralized connective tissue similar to bone except that it is avascular; the mineral is also apatite, and the organic matrix is largely collagen. The cells that form cementum are called cementoblasts. The two main types of cementum are cellular and acellular. The cementum attached to the root dentin and covering the upper (cervical) portion of the root is acellular and thus is called acellular, or primary, cementum. The lower (apical) portion of the root is covered by cellular, or secondary, cementum.

INTRODUCTION

Cementum is a specialized hard layer of calcified mesenchymal tissues which forms the outer covering of the anatomical root. First demonstrated microscopically in 1835 by Purkinjee. It is also called as Substantia Ossea. Human Cementum is avascular & has no innervation. It consists of a calcified interfibrillar matrix and collagen fibrils

PHYSICAL PROPERTIES

1. **Hardness:** Hardness is less than dentin and least calcified.
2. **Color:** Light yellow in color, Darker hue than enamel, Dull surface (Lack of Lusture)
3. **Permeability:** More permeable than dentin. In some areas canaliculi of cementum may be contiguous with dentinal tubule (Blayney et al ,1941)
4. **Thickness:** Coronal ½ of root: **16-60 micron.**
    - Apical third of root & furcation area: **150-200 micron.**
    - Thinnest at CEJ.: Surrounds the apical foramen and lines the root canal
5. **Surface Texture:** Mosaic (mogul like) pattern (Vrahopoulos et al)

TYPES OF CEMENTUM

1. **RADICULAR CEMENTUM:** Derivative of dental follicle, properly covers the entire dentin of the root from CEJ to the apex. It extends partially into apical foramen to line the apical walls of the root canal

2. **CORONAL CEMENTUM:** In herbivores like guinea pig, cattle, horse etc. Cementum is found on anatomic crown where it covers the enamel. In humans it is restricted to areas of reduced enamel epithelium

CLASSIFICATION:

I. Based on time of formation (Gottlieb, 1942)

* Primary cementum-before tooth eruption
* Secondary cementum-after tooth eruption

II. Based on Fibers (Selvig, 1965)

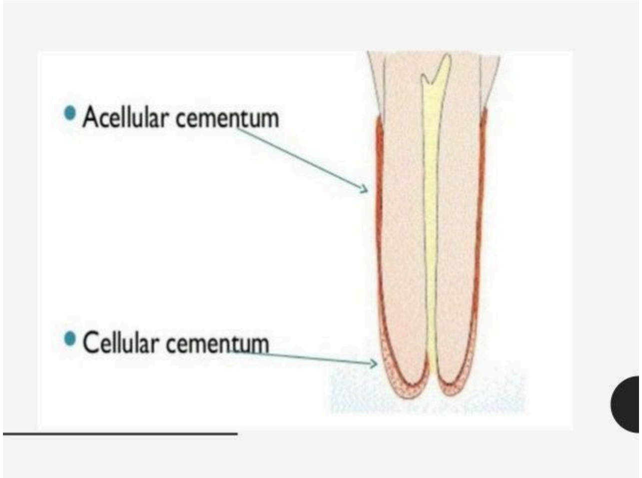
* Extrinsic fibers
* Intrinsic fibers

Intrinsic fibers: Produced by cementoblasts or cementocytes, oriented parallel to root surface, 1-2 microns in diameter, uniformly mineralized

Extrinsic fibres (Sharpey's fiber) -Terminal portions of the principal fibers that insert into cementum & bone are termed as "Sharpey's Fibers". Oriented perpendicular to root surface Produced by cells of the dental follicle during development and later by periodontal ligament fibroblasts. These have a principal role of supporting the tooth within jaw. 5-7microns in diameter. Mineralized partially with unmineralized core

III. Based on Presence or Absence of Cells

* Cellular cementum
* Acellular cementum



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IV) On the basis of location, structure, function, rate of formation, biochemical composition and degree of mineralization cementum can be classified as (Schroeder,1992):

1. Acellular Afibrillar Cementum
2. Acellular Extrinsic Fiber Cementum.
3. Cellular Mixed Stratified Cementum.
4. Cellular Intrinsic Fiber Cementum
5. Intermediate cementum

ACELLULAR AFIBRILLAR CEMENTUM

Enamel organ may produce mesenchymal proteins found in cementum and form AAC. Produced by cementoblasts and are found as coronal cementum at dentino-enamel junction (most common in molars) with a thickness of 1-15microns. It occurs as Spurs extending from AEFC or isolated patches on enamel surface close to CEJ. Produced as an aberration of development process. Little functional importance as not involved in fiber insertion or anchorage

ACELLULAR EXTRINSIC FIBER CEMENTUM (AEFC)

Extrinsic fibers but no cementocytes. Product of fibroblasts and cementoblasts. Sharpey's fibers are continuous with the fibers of PDL. Extrinsic fibers are mineralized (45-60%) except for their inner cores in a zone 10-50micron wide near CDJ. Cementoid layer is absent. The outer layers are characterized by alternating bands of more and less mineral content that run parallel to the root surface. AEFC fibers increase in thickness with age and the rate and extent of thickening vary in different teeth (Sequeira et al 1992). From cervical margin of the tooth & covers 2/3 of the root. In single rooted teeth, extends till apical foramen. Its function is tooth anchorage through sharpey's fibers

CELLULAR INTRINSIC FIBER CEMENTUM (CIFC)

Cementocytes enclosed in lacunae embedded in collagenous intrinsic fibers. Formed by cementoblasts. Less mineralized than AEFC. It is because of - Heterogeneous collagen organization**,** rapid speed of formation**,** presence of cells and lacunae**,** Layer of unmineralixed matrix - cementoid is present. Similar to bone and found in resorption lacunae fracture sites and may cover apical third and interradicular regions of premolars and molars. Rate of formation of CIFC is 0.5-3.0microns/day**.** Function is Repair and Adaptation**,** as it can be formed very rapidly and focally, it helps to Reshape root surfaces to accommodate for physiologic shift and non-physiologic shifting of teeth in the tooth socket for the repair of resorption sites (Schroeder, 1986)

INTERMEDIATE CEMENTUM (Mostehy, 1968)

Poorly defined zone near CDJ separating cementum from dentin, Rich in glycoproteins but has sparsely produced collagen fibers (Yamamoto, 1969)**.** HERS cells may synthesize amelogenins that accumulate on the forming root surface to form this layer (Slavkin, 1989). HERS cells become trapped in a rapidly deposited dentin or cementum matrix giving rise to intermediate layer**.** Dentinal in origin with no tubules, but wide spaces which are enlarged terminals of dentinal tubules. May be continuous or present in isolated areas. No characteristic features of either dentin or cementum**.** Also called as Hyaline Layer of Hopewell Smith as it appears hyaline or structureless and is involved in "cementing" cementum to radicular dentin**.** Seen in apical 2/3 of molars and premolars

CELLULAR MIXED STRATIFIED CEMENTUM

It is present in the apical third and interradicular regions of premolars and molars. Its thickness-100-1000microns. Its major function is root anchorage and adaptation

DISTRIBUTION OF CEMENTUM ON THE ROOT

* Acellular afibrillar: cervical enamel
* Acellular extrinsic: Cervix to the whole root (incisors, canines) increasing in thickness towards the apical portion 50□200μm
* Cellular: Apical third, furcations

CEMENTUM FORMING CELL

Cementum is deposited on the root surface during tooth development, subsequent to eruption of the tooth during normal function. The cells responsible for cementum formation may be Cementoblasts, Cementocytes, or Fibroblasts

CEMENTOBLASTS:

They are Large, cuboidal cells**,** with round, euchromatin-rich nucleus. Full cytoplasmic armamentarium required for protein synthesis and export. (Furseth, 1969). Its functions are to **s**ynthesize collagen**,** Non collagenous proteins**.** Cementoblasts of AEFC type produce sharpey's fibers and that of CIFC type produce intrinsic collagen fibers**.** They originate and develop from the mesenchymal cells of the dental follicle and secrete cementum.

CEMENTOCYTES:

Rapid formation and a multipolar mode of matrix deposition are held responsible for the entrapment of cementoblasts in the cementum matrix (Bosshardt and Schroeder, 1992). These entrapped cells with reduced secretory activity are called as cementocytes residing in lacunae. Cementocytes have processes that lodge in canaliculi that communicate and extend all the way to the surface. Nourishment is by diffusion from periodontal ligament into canaliculi of cementocytes. Cementocytes in deeper layers are not vital as cementum lacks a vascular system that can keep cementocytes alive in deeper portions of the matrix. Loss of intracellular organelles and ultimate cell death is progressive in the deeper layers of cellular cementum

FRINGE FIBERS

They are formed by fibroblasts that are alkaline phosphatase positive, parallel to each other and perpendicular to the root surface. It intermingles with the fibers of the dentinal matrix. When first fiber fringe reaches maximum density. Base of fiber mineralizes. Fringe elongates with advancement of the mineralization front and connects to the principal fibers of the periodontal ligament.

INCREMENTAL LINES

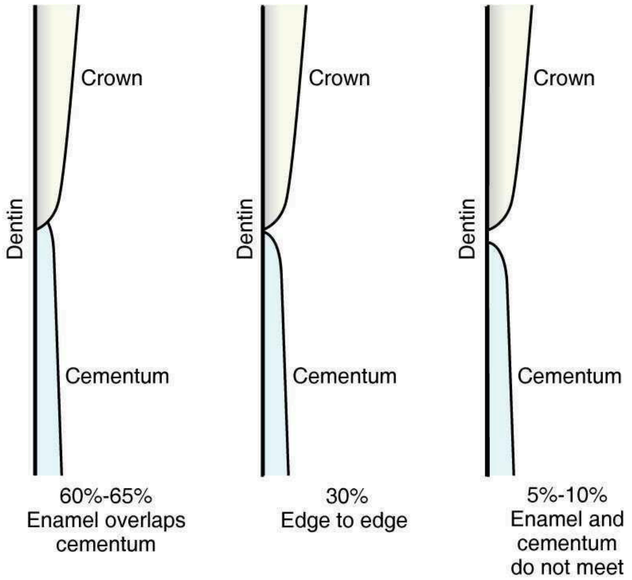
Acellular and cellular cementum are arranged in lamellae separated by incremental lines parallel to the long axis of the root and represent rest periods in cementum formation. More mineralized than adjacent cementum (Romanos et al, 1992). Incremental lines are farther apart in cellular cementum than in AEFC. Incremental lines in cementum can be used as most ***reliable age marker*** than any other morphological or histological traits in skeleton. Evaluation of annual incremental lines of dental cementum is one of potentially valuable methods for biological age estimation in forensic anthropology and digitalized visual analysis system enhances the count and provides better results. (Bojarun et al, 2003)

DECIDUOUS TEETH

The root resorption is not continuous, and has resting periods. In the resting period, cementum deposits in resorbed root surface. The present study examined apices of roots of human deciduous incisors with apical periodontitis and roots of sound deciduous incisors by light and transmission electron microscopy. Root dentin and original cementum had a severe irregular caved surface. Cementum was partially deposited on the caved root surfaces. The deposited cementum had made the caved root surface relatively flat. The cementum was lax and had some defects. The deposited cementum was belt-like in shape and had a stratified structure. (NORIYUKI et al, 2004**)** Each layer had various structures consisting of abundant microfibrils and fine granular materials, and collagen fibrils, and a relatively homogeneous structure. The original cementum had many collagen fibrils, such as intrinsic and extrinsic fibers, and no granular materials or homogeneous structure. Therefore, structure of the deposited cementum was very different from that of original cementum in deciduous teeth and from that of deposited cementum in permanent teeth. (Yawaka et al, 2003)

CEMENTOENAMEL JUNCTION

The interface between the Cementum & Enamel at the cervical region of tooth is known as cementoenamel junction. It is of 3 types (Cloquet, 1899 and Thoreson, 1917)



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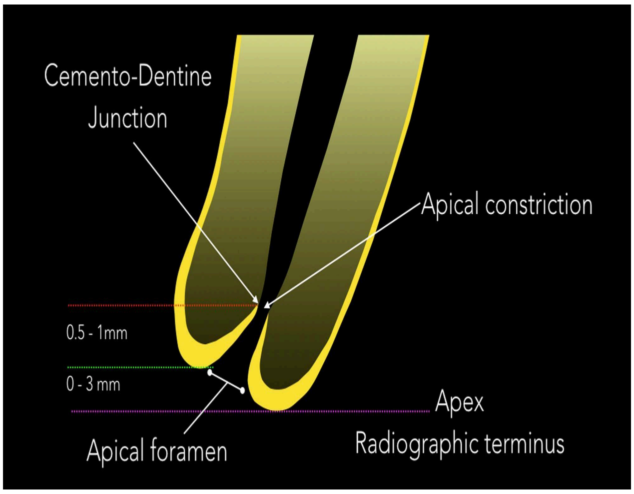
CEMENTODENTINAL JUNCTION

It is interface between the dentin & cementum, scalloped in deciduous teeth, smooth in the permanent teeth. Large quantities of collagen associated with GAGs like Chondroitin Sulphate and Dermatan Sulphate increase in water content, stiffness, redistribution of occlusal loads to the alveolar bone. It is 2-3microns wide Cemental fibers intermingle with the dentinal fibers at the CD junction more in cellular cementum than in acellular cementum**.** Fibers and Proteoglycans help in attachment of cementum to dentin



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CEMENTICLES

Calcified ovoid or round nodule found in the PDL. Single or multiple near the cemental surface. Free in PDL; attached or embedded in cementum. In Aging and at sites of trauma. It originates at Nidus of epithelial cell that are composed of calcium phosphate and collagen to the same amount as cementum (45% to 50% inorganic and 50% to 55% organic)

BIOCHEMICAL COMPOSITION OF CEMENTUM

- **Organic – 50-55%**
- **Inorganic – 45- 50%**

ORGANIC:

Type I Collagen, Type III – high concentration during development and regeneration

Type XII – bind Type I with noncollagenous matrix proteins

Trace amounts of Type V, VI, XIV

INORGANIC: Calcium and Phosphate mainly in hydroxyapatite crystals form

The extracellular matrix contains water, Minerals, Collagen, Non-collagenous proteins, GAGs, Proteoglycans and Growth factors

ROLE OF CEMENTUM

It covers and protects the root dentin (covers the opening of dentinal tubules). It provides attachment of the periodontal fibers. It reverses tooth resorption

FUNCTIONS

1. ANCHORAGE: Cementum serves as a medium for the attachment of collagen fibers that bind the tooth to alveolar bone

2. ADAPTATION: Continuous Deposition of cementum in apical area compensates for loss of tooth substance from occlusal wear. This process also serves to maintain the width of the periodontal ligament space at the apex of the root.

3. REPAIR: Major reparative tissue for root surfaces in case of fractures and resorptions. Cellular cementum is formed. Repair of root fractures. Sealing off necrotic pulps (apical occlusion) protection of the subjacent dentinal tubules. Cementogenic activity contributes to periodontal ligament fiber reattachment and relocation that occurs as a consequence of mesial drifting of teeth. Cementum repair requires viable connective tissue. Repair can occur in devitalised or vital tooth

- *Anatomic repair-Outline of the root is restored*
- *Functional repair-Shape of the root is not restored.*

ANKYLOSIS (Abnormal Repair)

Fusion of cementum with alveolar bone with obliteration of the periodontal ligament. It occurs as a result of repair (deposition of bone) after cemental resorption. Develops after chronic periapical inflammation, tooth replantation, occlusal trauma and around embedded teeth. Common in primary teeth (Mcnamara et al 2000)

CEMENTUM SIMULATES BONE

Organic fibrous framework, ground substance, crystal type, development, Lacunae, Canaliculi,Cellular component. Incremental lines (also known as “resting” lines; they are produced by continuous but phasic, deposition of cementum)

RESORPTION

Cementum resorption may be caused by:

Local Factors -Trauma from occlusion, orthodontic movement, pressure from malaligned erupting teeth, cysts and tumors, teeth without functional antagonist, embedded teeth, replanted and transplanted teeth.

Systemic Factors -Calcium deficiency, hypothyroidism, hereditary fibrous osteodystrophy and Paget’s disease

Idiopathic Resorption- *Bay like* concavities in root surface, m*ultinucleated giant cells* and large mononuclear macrophages are found. Several sites may coalesce to form large areas of destruction. Resorption may alternate with deposition of new cementum. *REVERSAL LINE-Newly* formed cementum is demarcated from root by a deeply staining irregular line. Few collagen fibers and high amounts of proteoglycans with GAGs

ALTERATIONS IN CEMENTUM

1. PHYSIOLOGIC-Age changes
2. ORTHODONTIC TOOTH MOVEMENT
3. TRAUMA FROM OCCLUSION
4. CEMENTAL APLASIA
5. HYPERCEMENTOSIS
6. PATHOLOGIC- Effect of gingival inflammation, Subsurface alterations, Cervical root resorption, Exposure to oral environment, Bacterial contamination, Hypermineralisation, Aggressive Periodontitis
7. SYSTEMIC DISEASES

AGING AND CEMENTUM

CONTINUOUS DEPOSITION- Increase in cemental width from 5-10 times (Berglundh et al)**.** Continuous deposition of cementum after tooth eruption more apically and lingually (Vander welden, 1984)**.** Accumulation of resorption bays explains increase surface irregularities (Grant Det al, 1972)**,** Permeability decreases with age**.** Between 11 and 70 years of age, the average thickness of cementum increases three fold with the greatest increase in the apical region. Average thickness of 95um at age 20, 215um at age 60 have been reported. (Zander et al, 1958)

CEMENTUM REACTION TO PHYSIOLOGIC TOOTH MOVEMENT

Cementum is thicker in areas exposed to tensional forces on labial and lingual surface of incisors (Geppert, 1974). Thicker in distal surfaces than in mesial surfaces because of functional stimulation from mesial drift over time. (Polson et al, 1990)

ORTHODONTIC TOOTH MOVEMENT

The deposition of considerably more new cementum has been noted on the tension side compared with the pressure side of the root surface of teeth undergoing orthodontic tooth movement (Dastmalchi R et 1990). Root resorption, number of teeth resorbed and severity of resorption markedly increased by orthodontic treatment (Massler, 1954). Spike like excrescences (cemental spikes)-This occurs due to excessive orthodontic force (Lester, 1969). Cementum is more resistant to resorption: Important in permitting orthodontic tooth movement

TRAUMA FROM OCCLUSION

Hypercementosis- Localized Hypercementosis is evident in case of trauma from occlusion

Root resorption- in severe trauma, resorption may continue into dentin. Repair is done by deposition of CMFC.

Cementopathia (Gottlieb): Loss of Cemental Vitality. This causes apical migration of epithelial attachment, Deep Pocket formation**,** diffuse alveolar atrophy

SUB-SURFACE ALTERATIONS

PHYSICAL CHANGES IN CEMENTUM

Microhardness of the cemental surface is reduced because of demineralization (Emslie and Stack, 1958). Microradiography shows zone of cementum with a radio dense line 10-50 um wide at the tissue’s surface. Decrease in Hardness and modulus of elasticity signifies demineralisation thus increased susceptibility to root resorption (Reitan, 1969).

CHEMICAL CHANGES IN CEMENTUM

Absorption or depletion of major mineral components leading to areas of hypermineralization-minerals increased are calcium, Magnesium,Phosphorus and fluoride, areas of demineralization, root caries and root resorption

ORGANIC CHANGES IN CEMENTUM

Loss of or reduction in cross banding of collagen near cementum surface and subsurface condensation of organic material of exogenous origin

AGGRESSIVE PERIODONTITIS

In localized aggressive periodontitis the permanent incisors and first molars show advanced pocket formation, loss of attachment and advanced alveolar bone resorption, tissue destruction develops rapidly without associated inflammatory response. Root surfaces of affected teeth have hypoplastic cementum (Lindskog, Blomlof, 1983). Sometimes serum alkaline phosphatase is low

SYSTEMIC DISEASES

HYPOPHOSPHATASIA-(Whyte, 1994)- Heriditary disease, autosomal recessive trait, Cementum formation on primary anterior teeth is defective, Premature loss of teeth without root resorption is first sign of the disease, other skeletal abnormalities are present, Alkaline phosphatase levels are low.

DOWN SYNDROME (Bimstein, 2008) - Narrow cementum areas

**PAPILLON-LEFE`VRE SYNDROME**- Aso et al reported an abnormal keratin molecule in Papillon-Lefe`vre syndrome as well as other structural defects as in the cementum and a functional imbalance of collagenolytic activity in the periodontal ligament.

EHELER'S DANLOS SYNDROME- A striking radiographic appearance with a bulbous enlargement of the roots together with pulp stones is seen in teeth. 'Giant channels' and vascular inclusions resembling 'intermediate cementum' are prominent within this area. (Pope, 1992)

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