
# Relevant Physiology

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## Objectives

- Understand the different systems and processes involved in growth and tooth movement
- Explain the impact of pathology on facial growth

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## What do you need to know?

Orthodontic therapists need a working knowledge of human physiology—particularly systems and processes that are directly involved in growth, tooth movement, and oral health. Here's a concise breakdown of the key physiological knowledge areas relevant to orthodontic practice:

- Bone, tooth and periodontal physiology
- Respiratory, muscular and neuromuscular physiology
- Growth and development physiology

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## Bone remodelling

**Orthodontic forces cause:**

- Bone resorption on the pressure side (by osteoclasts)
- Bone deposition on the tension side (by osteoblasts)

- Knowledge of osteoclast and osteoblast activity, and how force affects bone over time
- Influence of hormones (e.g., growth hormone, estrogen) on bone growth and healing


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## Bone Physiology

**Increased Mechanical Force**

**(e.g, exercise, orthodontic appliances):**

- Osteoblast activity ↑
  - Bone formation is stimulated at stressed areas.
  - Bone becomes thicker, denser, and stronger where needed.

Used in orthodontics: Controlled forces move teeth by:

- Compression side: Osteoclasts resorb bone.
- Tension side: Osteoblasts lay new bone.

- This allows the tooth to move through bone over time

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## Bone Biology

**Decreased Force or Disuse**

**(e.g., immobilization, space travel):**

- Osteoclast activity ↑, osteoblast activity ↓
  - Leads to bone loss (osteopenia or osteoporosis).
  - Bone becomes weaker and more prone to fractures.

- Bone is dynamic and adapts to mechanical stimuli.
- Osteoblasts build, osteoclasts break down.
- Proper mechanical forces = healthy bone adaptation.
- Too little or too much force = bone weakening or damage.

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## Growth Hormone

- Stimulates longitudinal bone growth at the growth plates, especially during childhood and puberty.
- Increases production of Insulin-like Growth Factor 1 (IGF-1), which directly promotes:
  - Chondrocyte proliferation (cartilage cell growth)
  - Osteoblast activity (bone formation)

**In Bone Healing:**

- Enhances osteoblast function, speeding up fracture repair.
- Promotes collagen synthesis and matrix deposition.

Deficiency -Short stature in children

Excessive: Gigantism in children

Acromegaly in adults

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## Oestrogen

**Functions in Bone Growth:**

- Promotes closure of the growth plates, ending linear growth at puberty.
- Modulates the balance of osteoblasts and osteoclasts:
  - Inhibits osteoclast activity → reduces bone resorption.
  - Supports osteoblast survival and function.

**Bone Healing:**

- Encourages bone matrix formation.
- Regulates inflammation and remodeling during healing.

Deficiency: bone loss, osteoporosis

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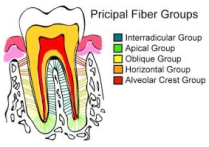
## Tooth and Periodontal Physiology

- Structure and function of the periodontium (gingiva, periodontal ligament, cementum, alveolar bone)
- Role of the periodontal ligament (PDL) in tooth movement:
  - Acts as a cushion
  - Responds to mechanical stress from braces
- Tooth eruption process and age-related changes
- Pulp physiology: how excessive forces can cause inflammation or necrosis

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## Periodontal Fibres

| Fiber Type | Location & Function |
|---|---|
| Transseptal fibers | Run from the cementum of one tooth to the next across the interproximal area. Maintain tooth alignment. |
| Alveolar crest fibers | Extend from just below the cementoenamel junction (CEJ) to the alveolar crest. Resist lateral movement. |
| Horizontal fibers | Run perpendicular to the long axis of the tooth. Resist horizontal forces. |
| Oblique fibers | Most numerous. Run diagonally from cementum to bone. Resist vertical forces (major shock absorbers). |
| Apical fibers | Radiate from the apex of the root to the bone. Resist tipping and extrusion. |
| Interradicular fibers | Found only in multirooted teeth, in the furcation area. Stabilize the tooth. |

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## Pulp Structure and Vulnerability

- Excessive force → compresses blood vessels at the apex
- This reduces blood flow (ischemia) to the pulp
- Leads to accumulation of inflammatory mediators (prostaglandins, cytokines)
- Causes increased pressure inside the pulp chamber
- Triggers pain and inflammation = pulpitis

**Outcomes:**

- Reversible pulpitis: Mild inflammation; pain on stimulus (e.g., cold), but pulp can heal
- Irreversible pulpitis: Severe, lingering pain; may progress to necrosis if untreated

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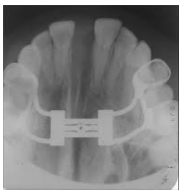
## Respiratory System

- Understand airway function and how it relates to facial development
- Impact of mouth breathing on:
  - Palatal growth
  - Anterior open bites and long-face syndrome
- Role of nasal breathing in proper jaw posture and tongue position



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## Normal airway function promotes:

- Balanced facial growth (vertical and horizontal)
- Correct jaw positioning
- Proper tongue posture
- Harmonious dental arch development

When the airway is compromised (due to enlarged adenoids/tonsils, allergies, or nasal obstruction), children may switch to mouth breathing, which significantly alters facial and dental development.

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## Impact of Mouth Breathing on Growth

Vertical facial growth pattern:
- Long, narrow face (also called "adenoid face" or "long-face syndrome")

- Backward and downward rotation of the mandible:
  - Leads to retrognathia (receding chin)

- High-arched palate (due to lack of tongue pressure)
- Narrowed maxillary arch → crowded teeth
- Malocclusion (especially Class II or open bite)

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## Functional Issues

- Poor sleep quality (linked with obstructive sleep apnea)
- Speech difficulties
- Delayed or abnormal swallowing patterns

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## Muscular and Neuromuscular Physiology

Role of muscles of mastication and facial expression in:
- Jaw movement
- Bite development

- Influence of tongue position, swallowing, and oral habits (e.g., thumb sucking) on occlusion
- Muscle adaptation during and after orthodontic treatment

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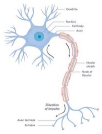
## Nervous & Immune Systems



**Immune and Inflammatory Response**
- Inflammatory response in periodontal tissues during tooth movement
- Importance of good oral hygiene in preventing gingivitis or periodontitis
- Recognition of signs of excessive force, infection, or abnormal tissue response

**Nervous System**
- Basic understanding of:
  - Pain pathways (especially in tooth movement or adjustments)
  - Trigeminal nerve (CN V) – innervates teeth and facial structures
- Patient comfort and management of orthodontic pain or discomfort

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## Signs of Excessive Force

**Dental:**
- Prolonged or severe pain
- Tooth mobility
- Root resorption
- Pulpal necrosis
- Tooth extrusion or intrusion
- Delayed tooth movement

**Soft Tissue**
- Swelling/pus
- Bleeding on probing
- Halitosis
- Radiographic bone loss

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## Pain Pathways

**Stimulus Initiation**

- Pain begins when nociceptors (pain receptors) in tissues are activated by:
  - Pressure
  - Inflammation
  - Chemical signals (e.g., prostaglandins, bradykinin)
- Peripheral nerve- trigeminal
- Signals travel via the maxillary or mandibular branch of the trigeminal nerve to the brain.
- Perceived as toothache-type pain even though the tooth is healthy.

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## Pain of Tooth Movement

**Periodontal Ligament (PDL) Compression**

- Force compresses the PDL on one side and stretches it on the other.
- This causes:
  - Local inflammation
  - Release of chemical mediators (prostaglandins, cytokines)

**Activation of Nociceptors**

- These chemicals stimulate free nerve endings in the PDL and surrounding bone.
- Pain is usually dull, aching, or pressure-like, peaking within 24–48 hours after force application.

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## Growth and Development Physiology

- Stages of craniofacial growth (especially in adolescents)
- Pubertal growth spurt and timing of orthodontic interventions
- Influence of hormones (growth hormone, thyroid hormones, sex hormones)

**Nutritional Physiology (Basic)**

- Nutrient needs for bone health (calcium, vitamin D)
- Impact of poor diet or systemic disease on healing and tissue response


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## Nutrition

- Vitamin A & C- periodontal tissues
- Vitamins D – normal bone physiology
- Protein – sulphur containing amino acids – collagen formation
- Fats = omega fatty acids – supportive role in calcium metabolism

Calcium

- Bone formation
- Maintain skeletal structure
- Blood coagulation
- Maintain membrane permeability – cardiac rhythm
- Enzyme activation

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## MCQs

What is the primary tissue involved in tooth movement during orthodontic treatment?

- A. Gingiva
- B. Dentin
- C. Periodontal ligament
- D. Pulp

Which type of bone cell is responsible for breaking down bone during orthodontic tooth movement?

- A. Osteoblast
- B. Osteoclast
- C. Cementoblast
- D. Fibroblast

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## MCQs

Which hormone is most associated with growth during puberty and can influence orthodontic treatment timing?

- A. Insulin
- B. Cortisol
- C. Growth hormone
- D. Estrogen

Mouth breathing in a growing child is most likely to result in:

- A. Deep bite
- B. Broad dental arches
- C. Anterior open bite and long face
- D. Crossbite of lower molars

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## SAQs

- Describe how the periodontal ligament contributes to orthodontic tooth movement.
- Name two systemic conditions or factors that may affect bone remodeling during orthodontic treatment.
- Explain why orthodontic treatment is often timed to coincide with the pubertal growth spurt.
- Discuss the physiological processes involved in orthodontic tooth movement and the potential consequences of applying excessive force.

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## Describe how the periodontal ligament contributes to orthodontic tooth movement.

- The periodontal ligament (PDL) transmits forces applied by orthodontic appliances to the alveolar bone. On the pressure side, it stimulates osteoclasts to resorb bone, and on the tension side, osteoblasts are activated to deposit new bone, allowing controlled tooth movement.

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## SAQs

Name two systemic conditions or factors that may affect bone remodeling during orthodontic treatment.

- Osteoporosis
- Hormonal imbalances (e.g., thyroid dysfunction or low estrogen levels)

Explain why orthodontic treatment is often timed to coincide with the pubertal growth spurt.

- During the pubertal growth spurt, there is increased growth hormone activity, especially in the craniofacial bones. Timing treatment during this period can enhance outcomes by using natural growth to assist in correcting skeletal discrepancies.

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## Discuss the physiological processes involved in orthodontic tooth movement and the potential consequences of applying excessive force.

- Role of PDL and alveolar bone
- Bone resorption and deposition (osteoclasts and osteoblasts)
- Inflammatory response and cytokines
- Effects of excessive force: root resorption, hyalinization of PDL, pain, tissue necrosis

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