Development & Growth

Orthodontics is the branch of dentistry that focuses on the prevention, diagnosis and treatment of irregularities of the teeth and jaws. This section is combined with the paediatric section on the INBDE so overall, there are less questions on orthodontics compared to other sections.

In dentistry, **growth** is most relevant to the increased size of anatomy or increase in number of anatomic parts. Thus, it is more about quantity than it would be in development.

Meanwhile, **development** refers more to the greater complexity or specialization of functions. There is more of a qualitative focus on the physiological or behavioural effects on the body.

Both growth and development depend on **pattern**, **timing**, and **variability** of the individual.

1 Growth Curves

Cephalocaudal Growth

The **cephalocaudal growth gradient** refers to a pattern where early on in life, growth tends to occurs faster in parts that are closer to the cranium. Consequently, parts further way from the cranium experience more growth later in life.

- Observed in utero until adulthood (the head takes up less of the body as we grow into adulthood)
- Upper limbs grow earlier on in life, followed by the lower limbs
- Maxilla matures earlier than the mandible*

Human Growth Curve

The human growth curve uses terms of distance and velocity

- **Distance** - person's height
- **Velocity** - person's rate of change in height
  - Generally the earlier the peak growth, the shorter the duration of the growth spurt
  - Males and females exhibit different velocity
    - Male - peaks at 14 years
    - Female - peaks at 12 years

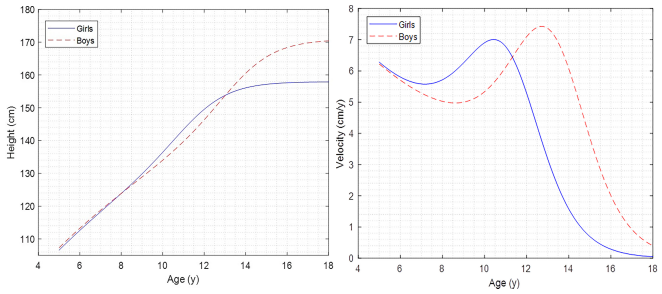

Figure 1.01 Human Growth Curve

Scammon's Growth Curve

Scammon's growth curve describes the growth of variable body regions in terms of years and percentage of total adult body size.

- Notice that different regions have different growth patterns
- Brain and neural tissues grow rapidly after birth and reach near adult size by 6-7 years
- Lymphoid tissues grows rapidly to twice its adult size by 10 years, and then decreases until adulthood
- Maxilla more similar to neural growth curve
- Mandible more similar to general growth curve

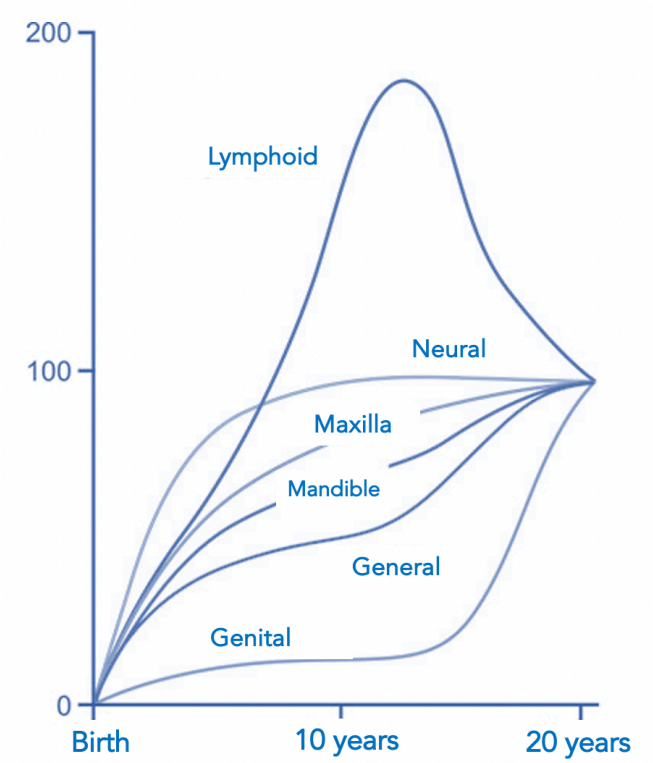

Figure 1.02 Scammon's Growth Curve

Timing

Timing of growth can be judged based on several different factors.

- **Chronological age** - not a good indicator of maturity due to variability
- **Biologic age** - based on markers of maturation, best indicators of growth and maturity
  - Menstruation
  - Secondary sex characteristics
- **Skeletal age** - based on maturity of cervical vertebrae or maturity of hand and wrist bones, better indicator of maturity
- **Dental age** - based on teeth that have exfoliated/erupted, generally not a good indicator of maturity

2 Growth Sites

The location of growth can be described in sites or centres. **Sites** refer to the parts of the body where the growth is actually occurring. **Centers** are the sites of the body that are able to control its own growth.

- **Synchondroses** are the main growth centers for craniofacial structures

Intramembranous Growth

- Growth from the outside of bone from fibrous connective tissue = increased diameter of bone
- Controlled more by environmental factors
- Found in the following sites
  - Sutures
  - Cranial vault surface

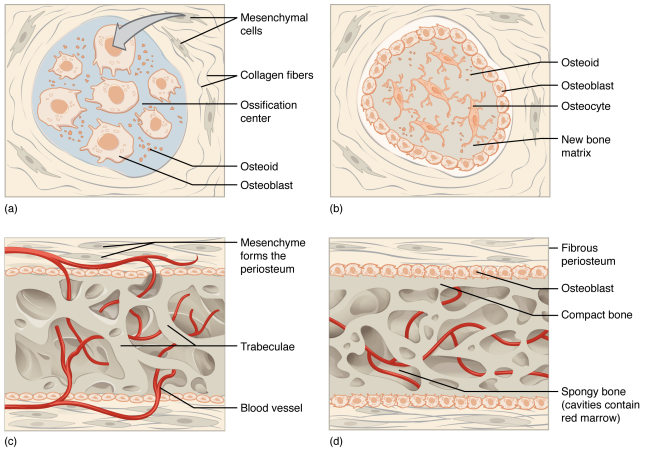

Figure 1.03 Intramembranous Ossification

Endochondral Ossification

- Growth that occurs within cartilage that is eventually replaced by bone, 5 zones
  - Zone of **Resting Cartilage**
  - Zone of **Proliferation**
  - Zone of **Hypertrophy**
  - Zone of **Calcification**
  - Zone of **Ossification**
- Results in increased bone length
- Controlled more by genetics
- Found in the following sites
  - Epiphyseal plates (long bones)
  - Synchondrosis of cranial base
  - Condylar cartilage of the mandible

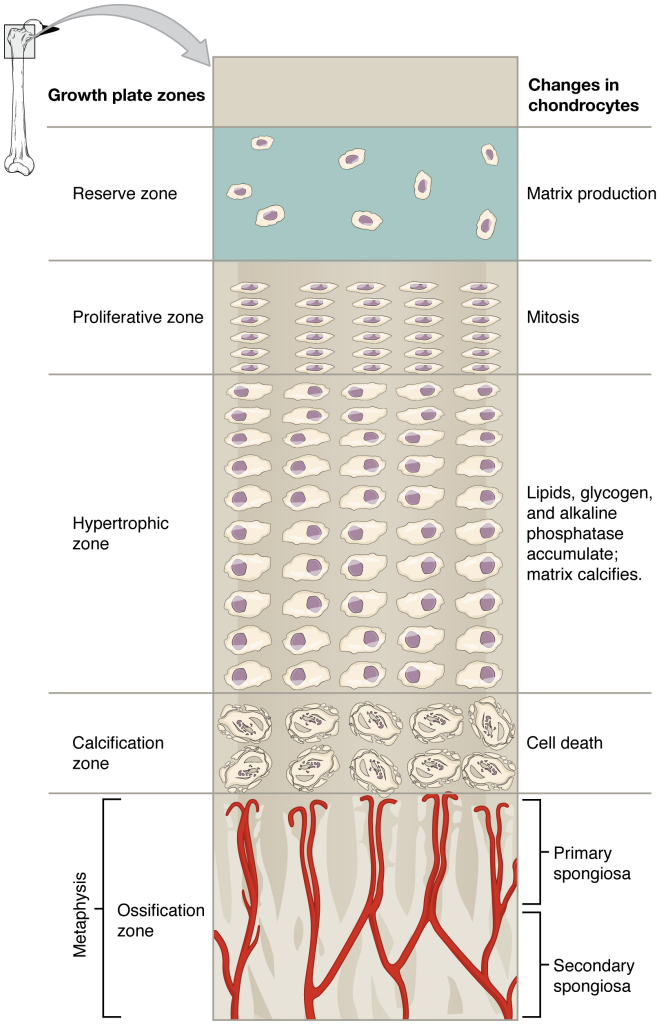

Figure 1.04 Endochondral Ossification

Growth Theories

No one theory can explain craniofacial growth and its control. Thus all three of the following theories should be considered.

1. **Cartilage Theory**
   - 1.1. Created by James Scott
   - 1.2. Epigenetic control of growth where cartilage is the growth center
   - 1.3. Holds some validity
2. **Suture Theory**
   - 2.1. Created by Harry Sicher
   - 2.2. Now known to be *mostly* false
   - 2.3. Genetics determine bone growth
   - 2.4. Sutures act as growth centres (but now we know they are growth sites)
3. **Functional Matrix Theory**
   - 3.1. Created by Melvin Moss
   - 3.2. Environment (speaking, chweing, function) controls growth
     - 3.2.1. Causes nasal and oral cavities to grow bigger
     - 3.2.2. Primary determinant of growth in maxilla and mandible

Planes of Growth

1. **Transverse** - width, 10-12 years
2. **Anteroposterior/sagittal** - length, 14-16 years
3. **Vertical** - height, 18-20+ years

3 Craniofacial Growth

Cranial Base

- **Cranial base** - ethmoid, sphenoid and occipital bones
  - Are cartilage at birth and go through **endochondral ossification** later on at snchondroses
    - 3 years, **intersphenoid** synchondrosis
    - 7 years, **spheno-ethmoid** synchondrosis inactive
    - Later on, **spheno-occipital** synchondrosis inactive

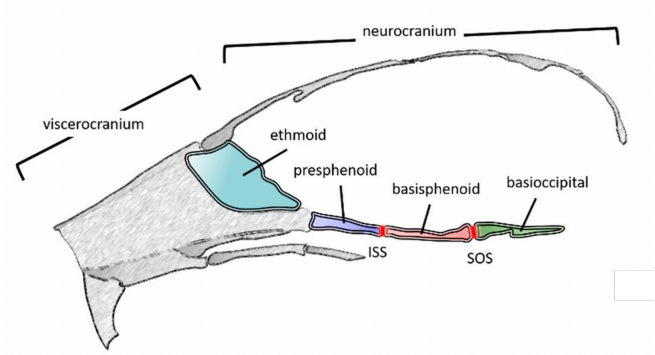

Figure 1.05 Cranial Base

Cranial Vault

- **Cranial vault** - part of the skull that holds the brain
- **Intramembranous ossification** occurs
  - At fontanelles and sutures, as the brain goes and pushes cranial bones apart
  - Direct apposition of bone on external bone surface and resorption on internal bone surface

Maxilla

- **Intramembranous ossification** posterior and superior to the nasomaxillary complex at the sutures and for remodelling
  - Apposition - palate, tuberosity, alveolar ridge
  - Resorption - anterior maxilla
  - Results in net forward and downward movement of maxilla from cranial base

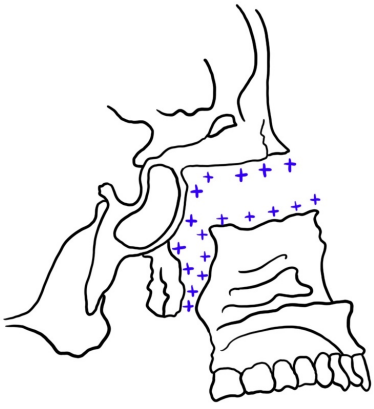

Figure 1.06 Maxillary Growth

Mandible

- Embryonic growth
  - Condylar cartilage from **endochondral ossification**
  - Embryonic corpus/ramus from **intramembranous ossification**
  - 4 months (in utero) → Condylar cartilage and ramus fuse
- Adulthood
  - Intramembranous ossification → surface remodelling
    - Apposition - ramus, coronoid, alveolar ridges, chin
    - Resorption - anterior ramus
  - Endochondral ossification → proliferation and bone formation at condylar cartilage
  - Results in net towards and downwards movement from cranial base

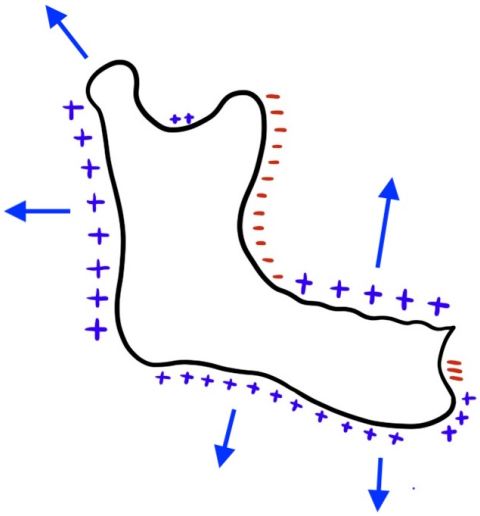

Figure 1.07 Mandible Growth

- **Growth Rotation** - mandible rotates during growth at the axis of the condyle
  - **Average growth rotation** - condylar growth roughly equal to the amount of molar eruption
    - Mandible does not rotate, just downward and forward translation

- **Forward rotation** - counter-clockwise growth
  - Condylar growth exceeds the amount of molar eruption
  - Tends to lead to shorter lower face height and deep bite
- **Opening rotation** - clockwise growth
  - Condylar growth less than the amount of molar eruption
  - Tends to lead to a longer lower face height and anterior open bite

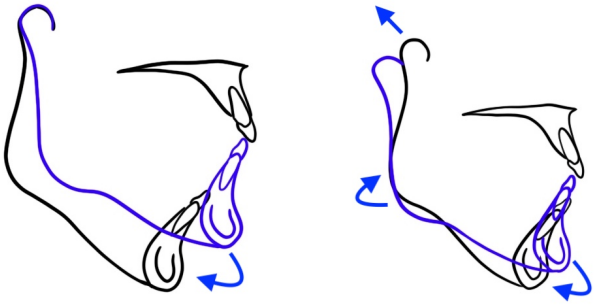

Figure 1.08 Growth Rotation

Craniofacial Anomalies

Generally birth defects, including craniofacial anomalies, can be described as syndromes or sequences.

- **Syndrome** - single etiology that results in predictable pattern of anomalies occurring together with recognizable presentation
- **Sequence -** usually a single major anomaly effecting development of surrounding structures, resulting in more anomalies

1 Craniofacial Development

There are five stages of embryonic craniofacial development. Problems can arise during these stages to result in craniofacial abnormalities.

Problems with Neural Crest Cell Formation

1. **Stage 1 - Germ Layer Formation**
   i. Time In Utero = Day 17
   ii. Abnormal development
      a. Fetal Alcohol Syndrome
2. **Stage 2 - Neural Tube Formation**
   i. Time in Utero = Day 18-23
   ii. Abnormal development
      a. Anencephaly - absence of parts of the brain and skull
3. **Stage 3 - Neural Crest Cell Migration**
   i. Time in Utero - Day 19-28
   ii. Abnormal development
      a. Teacher Collins Syndrome (mandibulofacial dystosis)
      b. Hemifacial microsomia

Lack of Fusion of Cells

4. **Stage 4 - Formation of Organ Systems**
   i. Time in Utero = Week 4-5 (Day 28-38)
   ii. Abnormal development → Cleft lip

4a. **Primary Palate formation**
   i. Time in Utero = Week 6
   ii. Abnormal development → Cleft palate

4b. **Secondary Palate formation**
   i. Time in Utero = Week 8
   ii. Abnormal development → Cleft palate

Problems with Suture Development

2. **Stage 5 - Final Differentiation of Facial Tissues**
   i. Time in Utero = Day 50 - birth
   ii. Abnormal development
      a. Achondroplasia
      b. Crouzon's syndrome (Craniostynosis)

Figure 1.09 Ancephaly

2 Craniofacial Anomalies

Down's Syndrome (Trisomy 21)

- Extra chromosome 21 due to nondisjunction
- Upslanted palpebral fissures
- Increased risk of periodontal disease
  - But no increased caries risk
- Midface deficiency*

Figure 1.10 Down's Syndrome

Treacher Collins Syndrome

- Aka **mandibulafacial dysostosis**
- Caused by genetic mutation
  - Affects neural crest cell development → abnormal development of facial bones and tissues
- Downslanted palpebral fissures
- Microtia (small ear)
- Cleft palate - 35% incidence
- Underdeveloped mandible*
  - Hence the name of the syndrome

Figure 1.11 Treacher Collins Syndrome

Hemifacial Microsomia

- Due to neural crest cell loss during the migration stage
- Affected side exhibits deficient ear and mandibular ramus

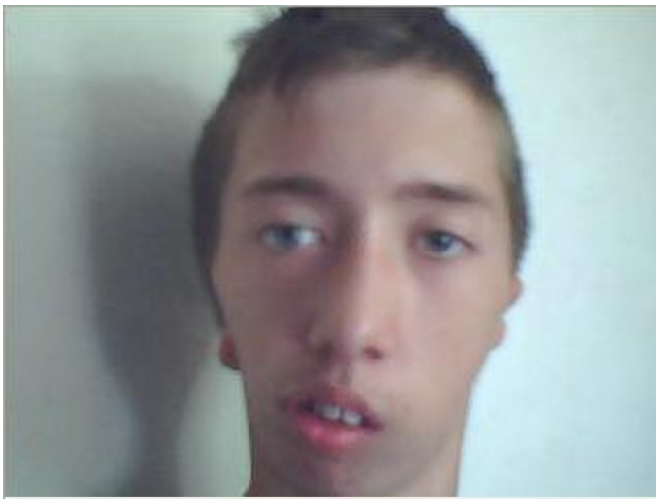

Figure 1.12 Hemifacial Microsomia

Fetal Alcohol Syndrome

- Early developing fetus exposed to high levels of ethanol (alcohol is a teratogen)
- Alcohol exposure to fetus can cause neural plate tissue deficiency
  - Leads to abnormal brain development and microcephaly
  - CNS problems
    - Communication difficulty
    - Learning problems
    - Hearing and vision problems
- Deficient midface* (important on exam)
- Smooth philtrum, small palpebral fissures, thin upper lip
- Cleft lip

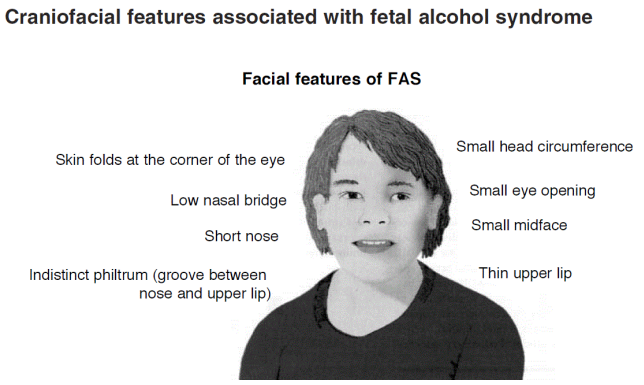

Figure 1.13 Fetal Alcohol Syndrome

Crouzon Syndrome

- Autosomal dominant genetic disease
- Type of **craniosynostosis**
  - Early closure of sutures of the skull
- Proptosis - bulging eyes
- Brachycephalic - short skull
- Frontal bossing - forehead prominent
- Hypertolerism* - wide set eyes
- Midface deficiency*
  - Associated with Class III skeletal relationship

Figure 1.14 Crouzon Syndrome

Apert Syndrome

- Aka **Acrocephalosyndactyly**
- Exhibits **craniosynostosis**
  - Similar to crouzon with exception of
    - **Byzantine arch** - narrow palate and high palatal vault
    - Acrocephalic - tall skull
- **Syndactyly** - fusion of fingers and toes → symmetric webbing of hands and feet

Figure 1.15 Syndactylyl in Apert Syndrome

Hurler & Hunter Syndrome

- Aka **mucopolysaccharidosis**
- Two separate syndromes but usually grouped together
- Deficient in enzyme that breaks down glycosaminoglycans, resulting in their build up

Pierre Robins Sequence

- Sequence: Micrognathia → Glossoptosis → Cleft palate
- **Micrognathia** - smaller mandible
- **Glossoptosis** - tongue displaced backwards
- Clossoptosis and cleft palate make breathing and feeding difficult

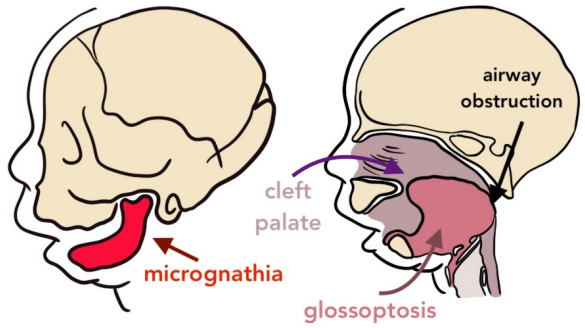

Figure 1.16 Pierre Robins Sequence

Cleft Lip & Palate

- Both due to failure of fusion of tissues during development
- Associated with Class III skeletal relationship + deficient maxilla
- **Cleft Lip**
  - Occurs in utero at 4-6 weeks
  - When medial nasal prominence and maxillary prominence fail to fused anteriorly
  - Usually occurs off centre and is unilateral
    - Bilateral less common

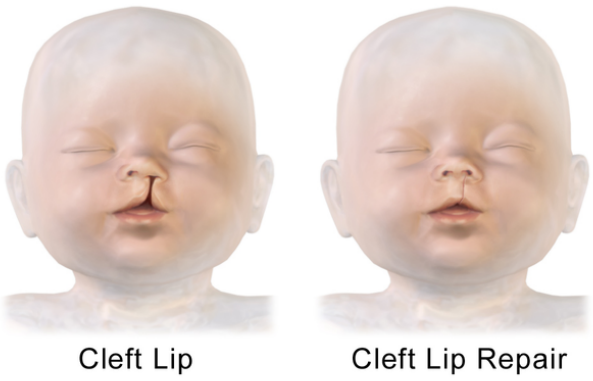

Figure 1.17 Cleft Lip

- **Cleft Palate**
  - Occurs in utero at 6-8 weeks
  - When medial nasal prominence and maxillary prominence fail to fused posteriorly

Figure 1.18 Cleft Palate

Development of Occlusion

1 Birth and Primary Dentition

Gum Pads

- Infants only have gum tissue pads with no teeth present
  - Birth - 6 months
- Ends with eruption of first primary tooth
- Positions of unerupted teeth can be predicted by elevation and grooves on alveolar ridges
  - Areas with adjacent transverse grooves represent a developing tooth bud
  - **Lateral sulcus** - more prominent groove on the gum pads dividing the primary canine and primary first molar

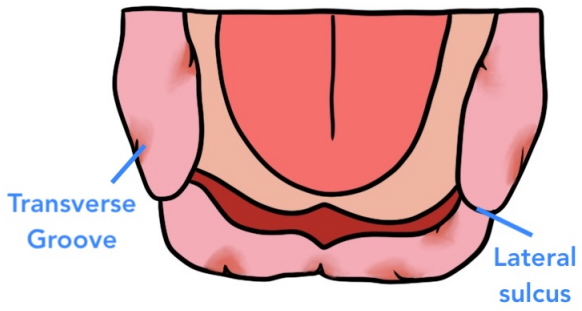

Figure 1.19 Gum Pads (Mandible)

Primary Dentition

- Begins with first primary tooth eruption and ends with first permanent tooth eruption
  - Runs from 6 months to 6-years
- Minimal overbite and overjet found in young children
  - Can be an edge to edge relationship

Terminal Plane Relationship

- **Terminal Plane** - relationship of the distal surface of primary second molars, will guide the eruption of the following:
  - **Flush Terminal Planes** - mandibular and maxillary terminal planes are flush with each other
    - 37% of patients
  - **Distal Step** - mandibular terminal plane is distal to maxillary terminal plane
    - 14% of patients
  - **Mesial Step** - mandibular terminal plane is mesial to maxillary terminal plane
    - 49% of patients

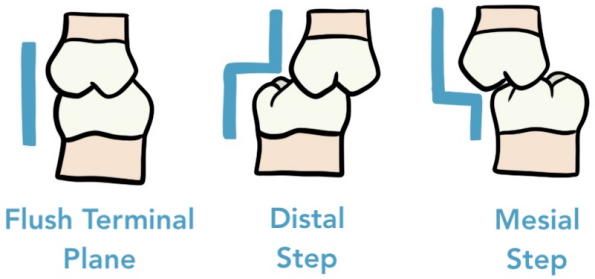

Figure 1.20 Terminal Plane Relationships

Primary Dental Spacing

- **Primate Space**
  - For maxilla, space between primary lateral incisor and primary canine
  - For mandible, space between primary canine and primary first molar

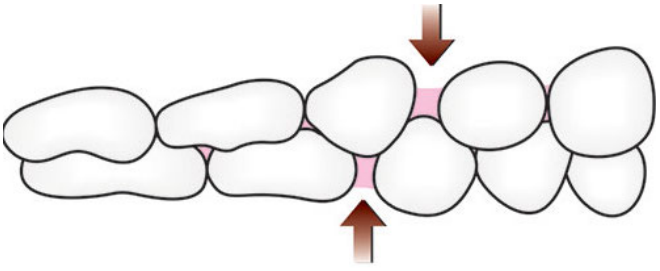

Figure 1.21 Primate Space

- **Leeway Space** - difference in combined mesiodistal width of primary canine, primary first molar and primary second molar and their subsequent underlying teeth (canine, first and second premolar)
  - Premolars are smaller than primary molars = results in gain of space
    - 1.5mm gain of space per side in maxilla (3.0mm total)
    - 2.5 mm gain of space per side in mandible (5.0mm total)

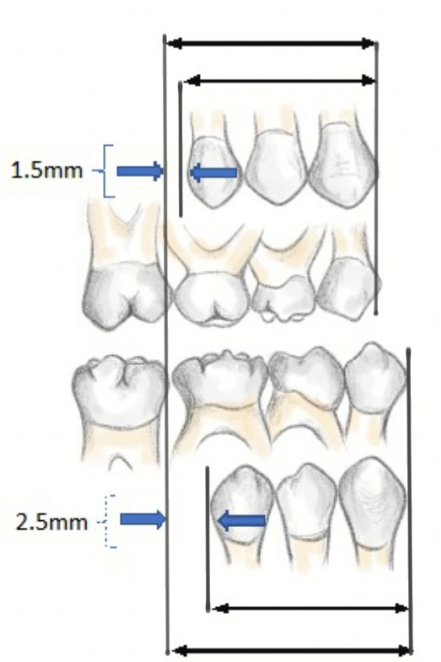

Figure 1.22 Leeway Space

- **Interdental Space** - space between primary incisors
  - Necessary to prevent crowding of permanent teeth due to increased size
  - **Incisor liability** - difference in size between primary and permanent incisors

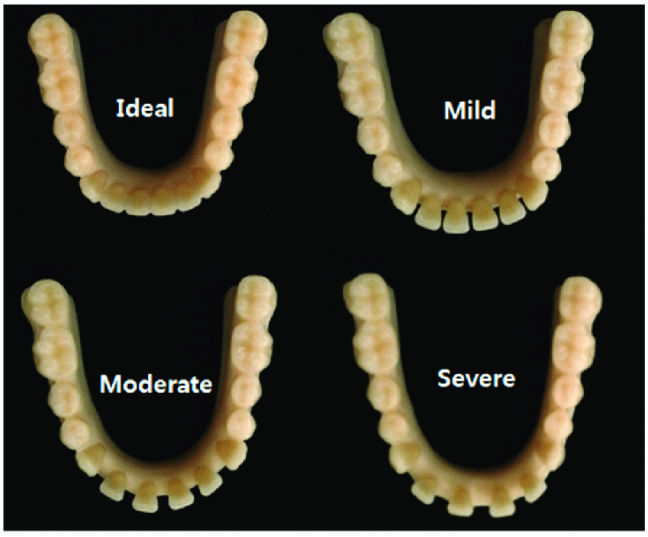

Figure 1.23 Interdental Spacing

2 Mixed Dentition

Mixed Dentition Stage

- Begins with eruption of first primary tooth and ends with exfoliation of last primary tooth
  - 6 years to 12 years
- Closure of dental spacing (interdental, primary and leeway)
- Molar relationship will transition into Class I, II or III
- Anterior and Posterior transition occurs
- Individual will experience the Ugly Duckling Stage

Anterior Transition

- Incisors tend to erupt lingually
  - Due to permanent tooth buds developing lingual and apical to primary teeth
  - Maxillary central incisors are the exception
    - Are pushed labially by the tongue as they erupt and can erupt laterally

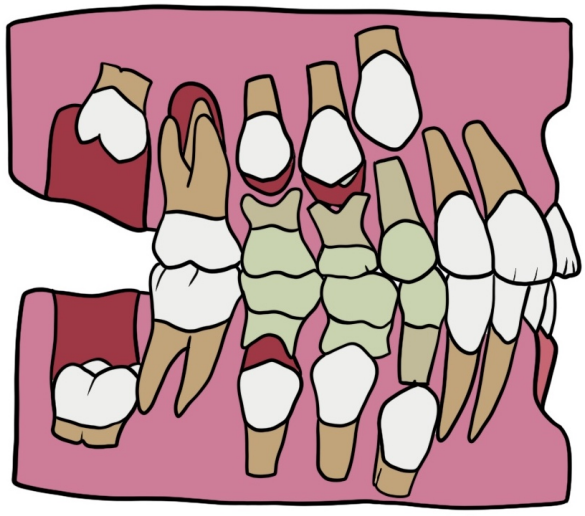

Figure 1.24 Succedaneous Tooth Eruption Positions

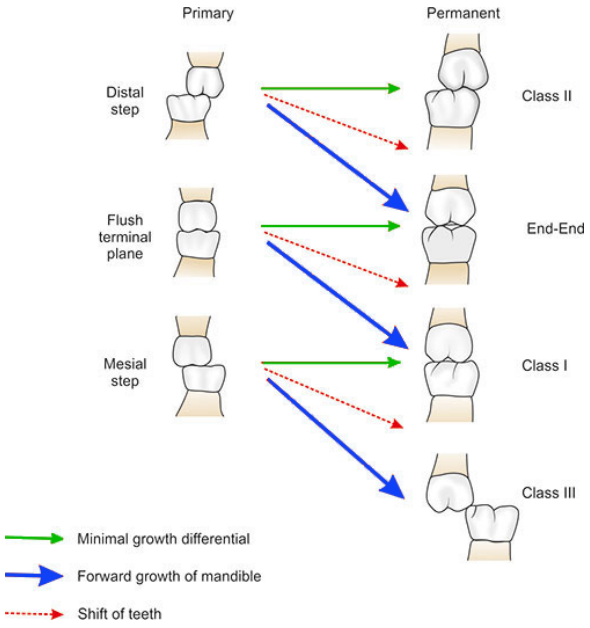

Figure 1.25 Posterior Transition

Posterior Transition

- Terminal plane relationship of primary second molars guide the position of the first permanent molars
- Mesial step → Class I (90%)
  - Class III (10%)
- Distal step → Class II (nearly 100%)
- Flush Terminal Plane → End to end molar relationship (most often)
  - End to End will eventually become Class I or II
  - But Class I, II, III are all possible
- Class I molar relationship from flush terminal plane through differential jaw growth and teeth shift
  - Late mandibular growth
  - **Early mesial shift** - permanent first molars erupt (~6 years) and close the primate space by shifting mesially
    - Usually more mesial shift in mandible than maxilla = net forward movement of mandibular molars = Class I relationship
  - **Late mesial shift** - eruption of permanent second molars close leeway space ~12 years = pushes first permanent molars mesially

INBDE Pro Tip: For posterior transition, the INBDE will most likely ask questions about early and late mesial shift.

The Ugly Duckling Stage

- In maxillary teeth, diastema between central incisors begins to close with the eruption of lateral incisors and should close with the eruption of the canines
  - Original diastema <2mm between central incisors is normal
  - Diastema > 2mm may need additional treatment for closure
- Occurs around 11-12 years

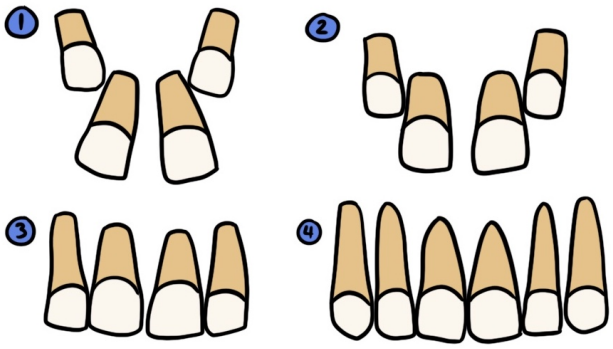

Figure 1.26 Ugly Duckling Stage

Mixed Dentition Analysis

- Used to determine the amount of spacing or crowding in the permanent arch by estimating the mesiodistal width of the unerupted buccal segment of teeth
- Mathematical calculation subtracting space required from space available from the permanent dentition
  - Spacing = positive value
  - Crowding = negative value
  - Permanent incisors should be erupted in order to calculate values
- **Tanaka-Johnson Analysis**
  - Uses sum of width of mandibular incisors
  - **Maxillary buccal segment** = Sum/2 + 11mm
  - **Mandibular buccal segment** = Sum/2 + 10.5mm
- **Moyer's Analysis**
  - Uses sum of width of mandibular incisors to then refer to table of prediction values of buccal segments

3 Permanent Dentition

Permanent Dentition Stage

- Occurs from 12 years to edentulism
- Ideal occlusion
  - 10-20% overbite
  - 1-3mm overjet
  - Class I occlusion
- **Curve of Spee** - curvature of arch in the sagittal plane
- **Curve of Wilson** - curvature of arch in the frontal plane

Changes in Arch Dimension

- Arch dimensions change during the transition from mixed to permanent dentition
- **Arch Length** - ↓ during transition into permanent dentition
  - Due to closure of the leeway space
- **Arch Perimeter** - slight ↑ in upper arch + significant ↓ in lower arch during transition into permanent dentition
  - Net results of labial-lateral eruption of permanent teeth + loss of leeway space
  - More loss of leeway space in mandible than maxilla, hence the difference in perimeter change
- **Intercanine Width** - ↑ during eruption of permanent teeth
  - Stabilizes after canines erupt
- **Intermolar Width** - ↑ during eruption of permanent molars then stabilizes
  - Greater in upper arch (molar erupt more divergently) than lower (molars erupt more conversantly) due to Curve of Wilson

Crowding of Incisors

- Late mandibular growth results in pressure between the lower lip and lower incisors = late lower incisor crowding increases as we age (between 20s to 40s)

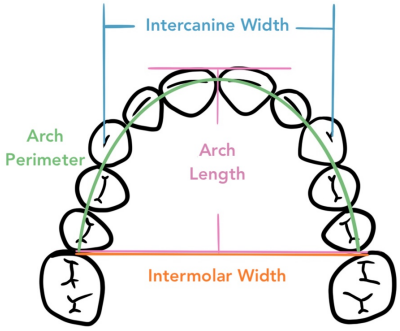

Figure 1.27 Arch Dimensions

Diagnosis & Treatment Plan

1 Dentofacial Analysis

Orthodontics does not only involve the straightening of teeth, but also includes correcting malformations of the face in order to achieve overall harmony and function.

Ackerman & Profitt

Ackerman and Profitt were two orthodontists that first described the objective of orthodontic treatment through the **soft tissue paradigm**

1. **Macroesthetic** → face
2. **Miniesthetics** → smile
3. **Microesthetics** → teeth

Ackerman and Profitt then continued to describe the features of orthodontic patients in 5 categories. These categories have lots of overlap and can be organized into a Venn diagram.

1. **Facial Proportion & Esthetics**
   i. Facial Profile
   ii. Smile arc
   iii. Lip posture
2. **Dental Alignment & Arch Symmetry**
   i. Rotations
   ii. Crowding/spacing
3. **Transverse Plane**
   i. Midline coincidence
   ii. Posterior cross bite
4. **Antero-Posterior Plane**
   i. Angles classification
   ii. Overjet
5. **Vertical Plane**
   i. Curve of Spee
   ii. Overbite

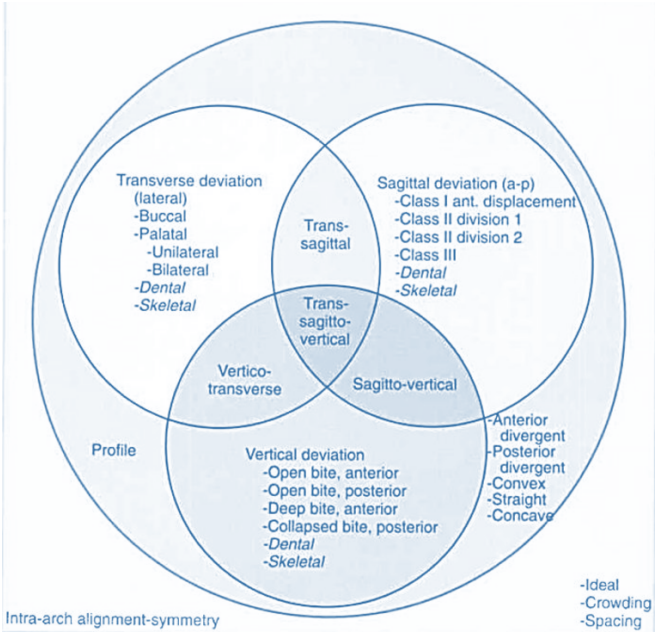

Figure 1.28 Ackerman & Profit Classification

Orthodontic Examination

Orthodontic Exam evaluates 3 different aspects of the patient . We will cover them more in detail in the following sections

1. Extraoral examination
2. Intraoral examination
3. Cephalometric analysis

2 Intraoral Examination

Molar Classification

1. **Class I Normal Occlusion (30-35%)**
   i. MB cusp of maxillary first molars occludes with MB groove of mandibular first molar
   ii. Teeth aligned along line of occlusion in the maxilla and mandible

2. **Class I Malocclusion (50-55%)**
    1. MB cusp of maxillary first molars occludes with MB groove of mandibular first molar
    2. Teeth do not align
3. **Class II Malocclusion (15%)**
    i. MB cusp of maxillary first molars is mesial MB groove of mandibular first molar
    ii. Maxillary arch displaced anteriorly
    iii. Subdivisions - based on inclination of upper incisors
        a. Subdivision 1 - proclined
        b. Subdivision 2 - retroclined
4. **Class III Malocclusion (1-5%)**
    i. MB cusp of maxillary first molars is distal MB groove of mandibular first molar
    ii. Maxillary arch displaced posteriorly

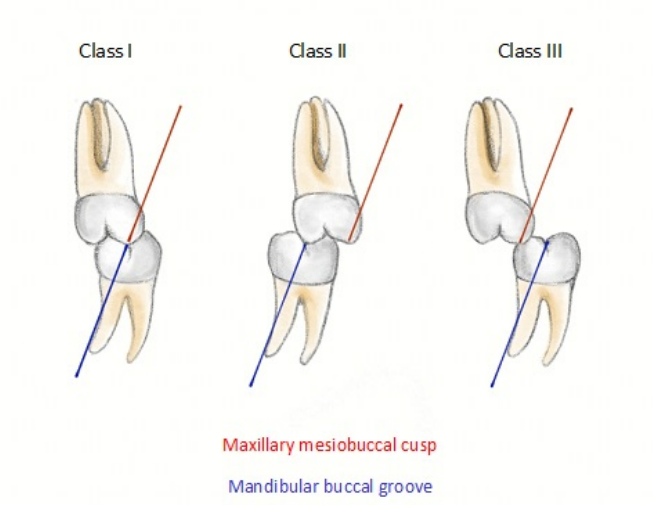

Figure 1.29 Molar Classification

Malocclusion

65% of patients most often exhibit some form of malocclusion in their molar classification compared to normal occlusion (35%). Within the 65% of cases of malocclusion, 60% have an unknown cause, while 5% have a known cause.

- **Malocclusion** - any deviation of the teeth from ideal normal occlusion
    - Spacing
    - Rotations
    - Molar relationship
    - Overjet/overbite
    - Cross bite
    - Crowding
        - 15% adolescents and adults experience severe crowding
        - Genetic predisposition
            - Genetics of tooth size in relation to arch size

Overbite & Overjet

- **Overbite** - vertical overlap of incisor from incisal edge to incisal edge
    - 1-2mm overbite is normal
    - **Deep bite** - too much vertical overlap
    - **Open bite** - space between incisors
- **Overjet** - horizontal overlap of incisors from labial surface to labial surface of incisors
    - 2-3mm overjet is normal
    - **Excess overjet** - overjet over 3mm
    - **Reverse overjet** - lower incisors are in front of the upper incisors

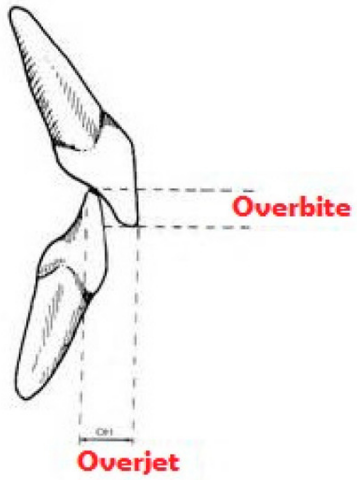

Figure 1.30 Overbite & Overjet

Crossbite

- **Crossbite** - misalignment of teeth where upper teeth occlude behind lower teeth
- **Anterior Crossbite** - maxillary anterior teeth positioned lingual to mandibular anteriors
  - Observed in reverse overjet
- **Posterior Crossbite** - maxillary posterior teeth positioned lingual to mandibular teeth or maxillary posterior teeth are more buccal to mandibular teeth (less common)

Figure 1.31 Posterior Crossbite

Bolton Analysis

- **Bolton Analysis** - calculates tooth size discrepancy to measure relative mandibular or maxillary excess
  - Compares mesiodistal widths of upper and lower teeth
- Smaller teeth may benefit from **buildups**
  - Composites, veneers or crowns
- Larger teeth may benefit from **interproximal reduction** (IPR)
  - More commonly preformed on lower incisors (for mandibular excess

3 Extraoral Examination

Face Proportions

- **Facial thirds** - vertical thirds
  - **Lower third** - menton → subnasale
    - Orthodontist can influence this third the most
    - Can be divided into thirds
      - Upper third - upper lip → subnasale
      - Lower 2/3rds - mention → lower lip
  - **Middle third** - subnasale → glabella
  - **Upper third** - glabella → hairline
- **Horizontal fifths**
  - **Outer fifths** - lateral helix → outer canthus
  - **Medial fifths** - outer canthus → inner canthus
    - Lines should be coincident with the angle of the mandible
  - **Middle fifth** - inner canthus → inner canthus
    - Lines should be coincident with alar base (sides of nose)

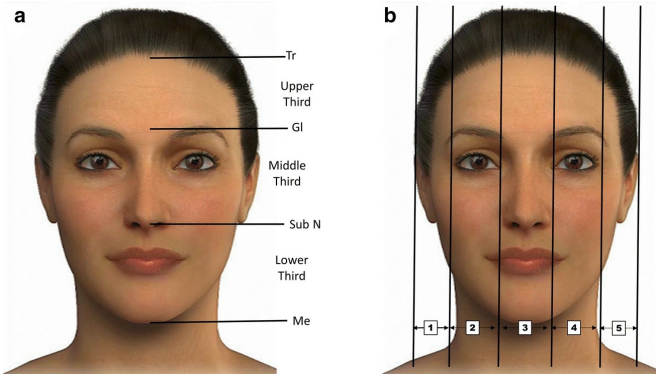

Figure 1.32 Facial Proportions

INBDE Pro Tip: The interpupillary distance should ideally line up with the commissures (corners) of the mouth.

INBDE Pro Tip: The horizontal fifths can be memorized by parts of the face (ear → eye → nose → eye → ear).

Facial Profile

Facial profile refers to the **facial convexity** of the facial plane, which is determined by the landmarks of the **glabella, subnasale**, and s**oft tissue pogonion**.

1. **Straight** - 0-10° facial plane
    i. Often associated with Class I occlusal relationship
2. **Convex** - >10° facial plane
    i. Often associated with Class II malocclusion
3. **Concave**
    i. Often associated with Class III malocclusion

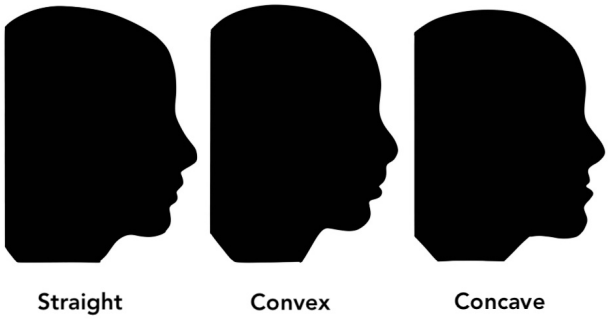

Figure 1.33 Profile Types

Facial Divergence

Facial divergence refers to the relationship of the lower face relative to the forehead. It can be determined by drawing a line straight down from the forehead/glabella and seeing where the subnasale and menton are relative to the line.

1. **Straight** - subnasale and soft tissue pogonion are close to the line
    i. Associated with Class I occlusal relationship
2. **Posterior divergent** - subnasale is posterior to the line and the soft tissue pogonion is even more posterior
    i. Associated with Class II malocclusion
3. **Anterior divergent** - subnasale is anterior to the line and the soft tissue pogonion is even more anterior
    i. Associated with Class III malocclusion

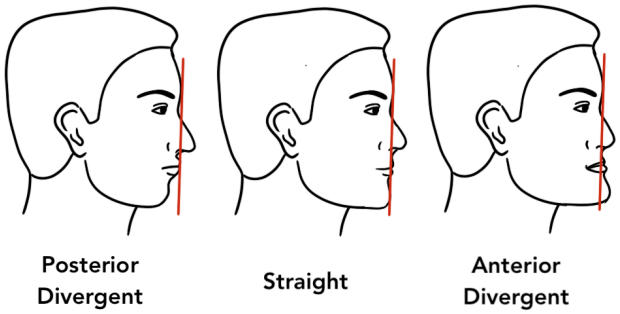

Figure 1.34 Facial Divergence

Incisor Display

- Smiling
    - Minimum = 75% of incisors visible
    - Ideal = 100% incisor visible + 1-2mm gingiva visible
    - Gummy smile >2mm gingiva showing
- At rest, ideal = 2-4mm of incised edge

Figure 1.35 Ideal Incisor Display

Lips

- **Posture** - the ability for lips to close without strain
    - **Competent** - lips can close without strain at rest
    - **Incompetent** - lips separated by 3-4mm at rest and muscles are strain upon closure
- **Proportion** - based on the amount of vermillion visible at rest
    - **Thick**
    - **Thin**

- **Position** - position relative to the tangent line that runs from the nose tip to chin (E-line)
  - **Prominent** - lips in front of the line
  - **Retrusive** - lips behind the line

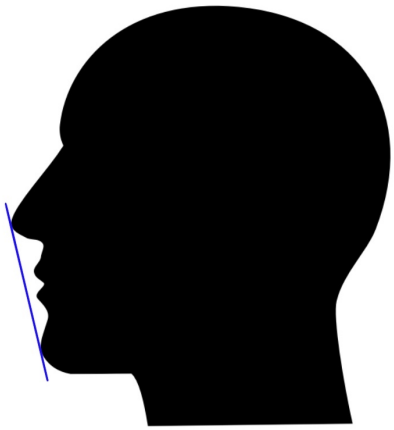

Figure 1.36 E-line

Buccal Corridors

- **Buccal corridor** - the appearance of a gap of space during smiling, between the maxillary posterior teeth and the corner of the mouth
- Wide, medium or narrow
  - Based on the amount of space visible
  - Narrowing of buccal corridors can be achieved through palatal expansion

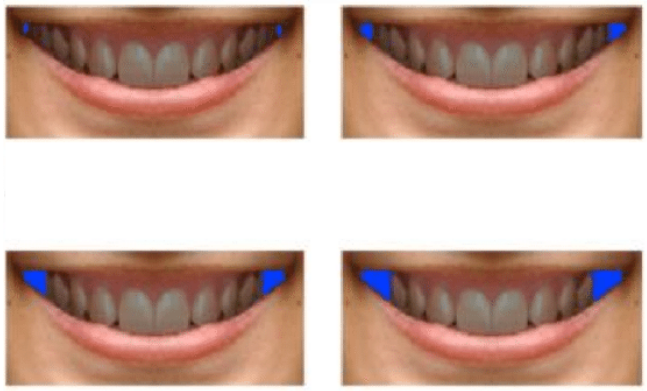

Figure 1.37 Buccal Corridors

Skeletal Classification

Skeletal classification refers to the relationship between the mandible and maxilla in an anterior-posterior position.

1. **Skeletal Class I** - normal relationship with the jaw
2. **Skeletal Class II** - maxilla more anterior to mandible
   i. Prognathic/protrusive maxilla (10%)
   ii. Retrognathic/retrusive mandible (85%)
   iii. Both (5%)
3. **Skeletal Class III** - maxilla more posterior to mandible
   i. Retrognathic/retrusive maxilla (60%)
   ii. Prognathic/protrusive mandible (20%)
   iii. Both (20%)

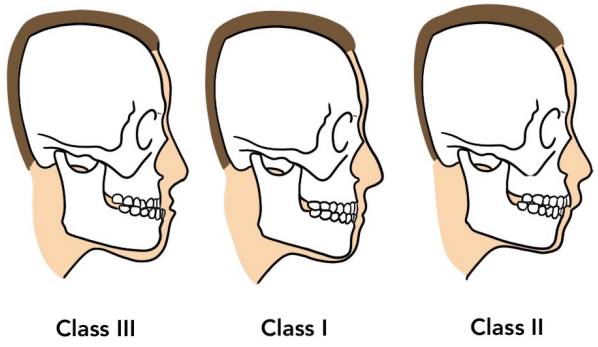

Figure 1.38 Skeletal Classification

Angles of the Facial Profile

1. **Cervicomental angle** - between menton → reflex point → base of the neck
   i. Ideal = 90-120°
2. **Mentolabial angle** - soft tissue pognonion → mentolabial sulcus → lower lip
   i. Aka **mentolabial fold** or **mentolabial sulcus**
   ii. Ideal = 120°
3. **Nasolabial angle** - nose tip → subnasale → upper lip
   i. Ideal = 90°

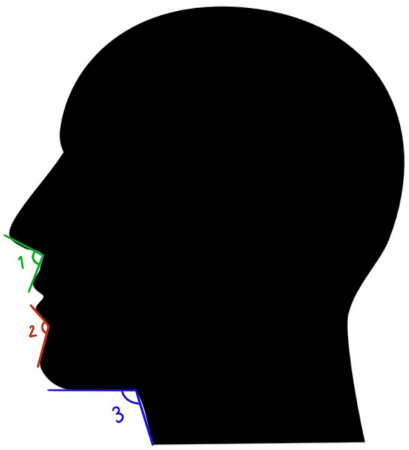

Figure 1.39 Angles:
1) Nasolabial
2) Mentolabial
3) Cervicomental

4 Cephalometrics

Cephalometric radiographs allows dentists and orthodontics to capture the hard and soft tissue structures from the side of the face. Analysis of these structures can then be judged based on the position of various **soft tissue landmarks** and their relationships to each other.

Additionally, cephalometric radiographs of the same patient over different time points can be **superimposed** to evaluate skeletal and dental changes that have occurred due to treatment or growth.

Soft Tissue Landmarks

- **Bolton Point (Bo) -** most superior point of the occipital bone
- **Basion (Ba)** - lowest point of the anterior margin of the foramen magnum
- **Articulary (Ar)** - inner section between zygomatic arch and posterior border of the ramus
- **Porion (Po)** - most superior point of the external auditory meatus
- **Condylion (Co)** - most poster-superior point of the condylar head
- **Pterygomaxillary fissure (Ptm)** - teardrop shaped fissure posterior to the maxilla
- **Sella (S)** - midpoint of sella turcica
- **Orbitale (Or)** - lowest point on inferior margin of orbit
- **Nasion (N)** - anterior intersection of frontal and nasal bone
- **Anterior Nasal Spine (ANS)** - tip of the anterior projection of the maxilla
- **Posterior Nasal Spine (PNS)** - sharp posterior projection of palatine bone
  - Usually underneath the Ptm
- **A point** - innermost point of the contour of the maxillary bone
- **B point** - innermost point of the contour of the mandibular bone
- **Gonion (Go)** - midpoint of contour connecting the ramus and body of the mandible
- **Pogonion (Pog)**- most anterior point of the chin
- **Gnathion (Gn)** - midpoint between the pogonion and menton
- **Menton (Me)** - most inferior point of the chin

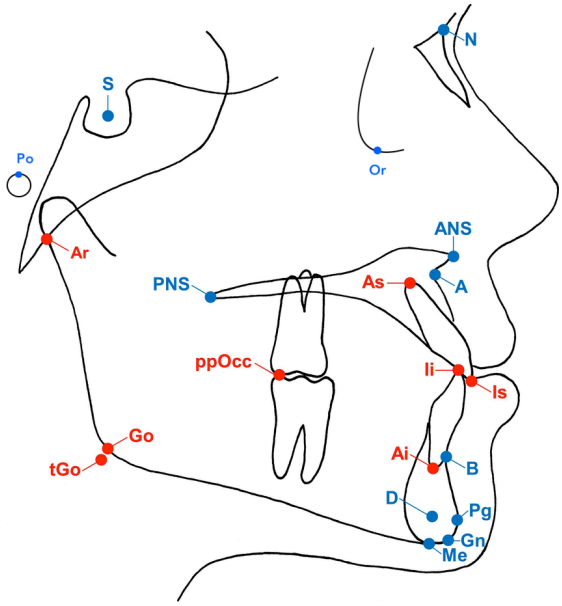

Figure 1.40 Cephalometric Landmarks

Analysis

As previously mentioned, landmarks taken from the cephalometric radiograph can be used to analyze the relationship of the jaws and teeth using linear and angular measurements. The measurements are then compared to their norms according, to age, sex and ethic group.

- **SNA** - angle from Sella-Nasion-A point
  - Represents relationships of maxilla to cranial base
  - Larger angle = maxilla is more forward
- **SNB** - angle from Sella-Nasion-B point
  - Represents relationships of mandible to cranial base
  - Larger angle = mandible is more forward
- **ANB** - angle from A point-Nasion-B point
  - Normal = 2°
  - Skeletal Class III = 0° or less (negative)
  - Skeletal Class II = 4° or more

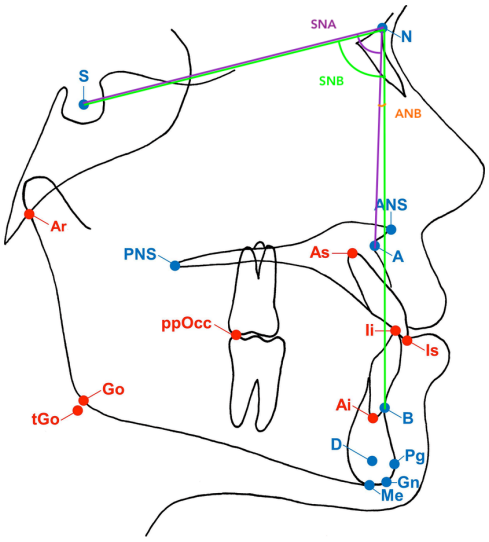

Figure 1.41 Cephalometric Analysis

Reference Planes

Reference planes are created when connecting two landmark points together. All five of the following reference planes should intersect at the back of the head.

- If they intersect earlier, the patient is considered **hyperdivergent**
- If its is farther back, it is considered **hypodivergent**

Landmarks	Plane
Go-Me	**Mandibular**
L6-L1 (occusal edge of lower first molar - incisal edge of lower central incisor)	**Occlusal**
ANS - PNS	**Palatal**
Porion-Orbitale (Po-Or)	**Frankfort horizontal**
Sella-Nasion (S-N)	**Cranial base**

INBDE Pro Tip: Questions asking about ANB measurements are common on the exam.

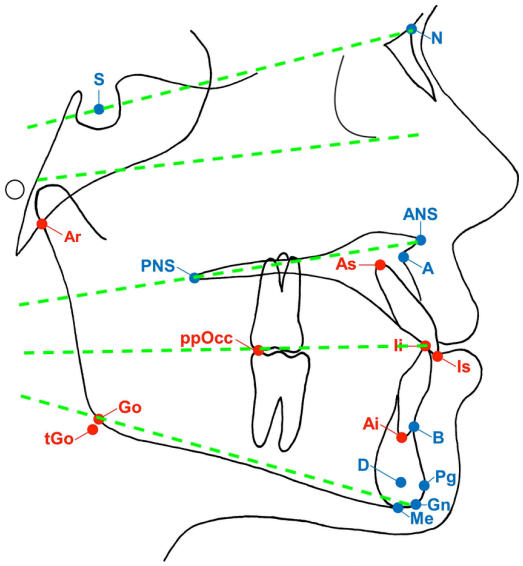

Figure 1.42 Reference Planes

Biology of Tooth Movement

1 Factors of Tooth Movement

Orthodontic tooth movement is the involvement of the movement of a tooth within alveolar bone. The alveolar bone and the PDL play crucial roles in this process. The biology of tooth movement can be divided into 4 general steps.

1. Force applied to tooth
2. Stress of PDL
   i. Compression = osteoclasts active
   ii. Tension = osteoblasts active
3. Bone remodelling
4. Tooth movement

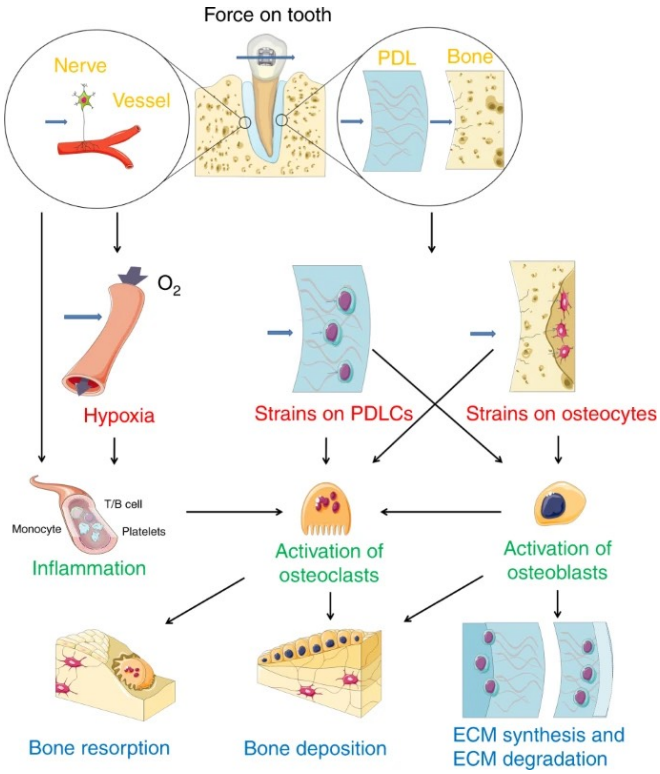

Figure 1.43 Tooth Movement

Light & Heavy Force

Force magnitude is important in determining the biological processes of tooth movement. Different sequences of events will occur depending on if there is **light force** or **heavy force**.

- **Light Force (≤100g)**
  - Seconds
    - No pain
    - Blood vessels distorted - compression side = compressed, tension side = partially dilated
  - Minutes
    - Altered blood flow → O_2 & CO_2 levels change → trigger release of inflammatory mediators (↑PGE, ↑RANKL)
  - Hours
    - ↑ cAMP → cell differentiation within PDL
  - 2 days
    - Osteoclasts recruited for **frontal resorption** - resorption lamina dura (outer surface of bone) to create Howship's lacunae
  - 3-5 days
    - Lamina dura resorbed as tooth moves
  - 1-2 weeks
    - Tooth movement process continues and occurs at a steady pace
- **Heavy Force (>100g)**
  - Seconds
    - Immediate pain from high pressure
    - Blood flow occluded
  - Minutes
    - Blood flow ceases completely on compression side
  - Hours
    - PDL hyalinized from **sterile necrosis** - cell death not caused by a pathogen

- 3-5 days
  - **Undermining resorption** - osteoclasts recruited in nearby bone marrow → lamina dura collapse from the inside until area of bone is removed
  - 1-2 weeks
    - Tooth moves when undermining resorption ends
    - Tooth movement is not steady like frontal resorption - lag period of 1-2 weeks for resorption to take place, then tooth moves quickly

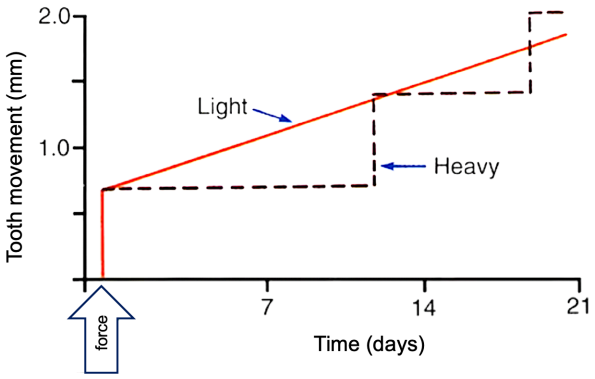

Figure 1.44 Light & Heavy Force

INBDE Pro Tip: It is important to note that light force causes frontal/direct resorption meanwhile heavy force causes undermining/indirect resorption. Light force is preferred in orthodontics because movement is steady and the patient experiences less discomfort, although it is difficult to achieve. Heavy force is more commonly encountered.

Duration of Force

- Threshold for tooth movement = **4-8h**
  - Associated with the amount of time required for cAMP to reach a level to trigger an inflammatory response in the PDL
- Orthodontic appliances must be worn for long enough each day, or else process needs to restart (patient compliance is key)

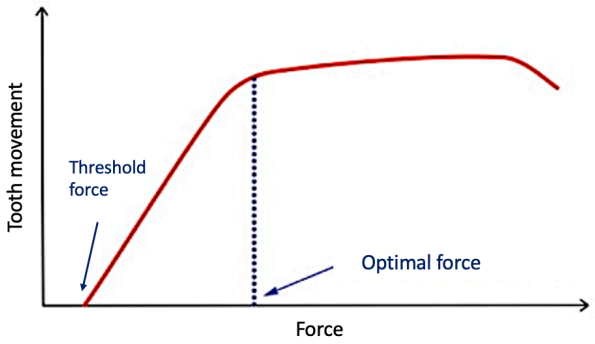

Figure 1.45 Force Duration

- **Force Decay** - natural process that occurs for the force to decrease/tire out an orthodontic appliance
  - **Continuous** - force is relatively constant
    - Example - light wires
      - Force declines slightly overtime, but replacement will restore the force
  - **Interrupted** - force slowly decreases to zero
    - Example - elastic chains
  - **Intermittent** - force abruptly ceases
    - Example - clear aligners

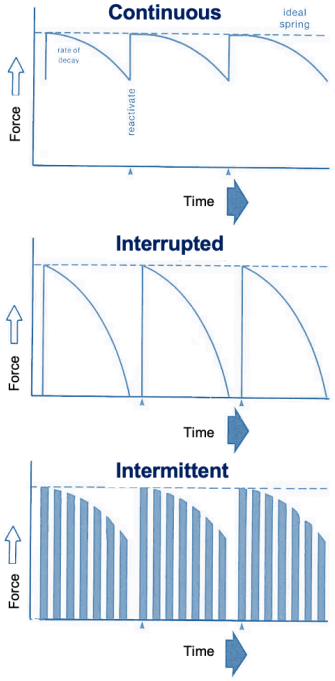

Figure 1.46 Force Decay Types

Tooth Movement Types

The **force distribution** to the tooth and the PDL is important for the process of orthodontic appliances causing tooth movement. **Pressure** (force/area) on the PDL, as a result of the force distribution, should be controlled to allow for stimulation of cellular activity without interfering with blood flow to the area. There are different kinds of movements that can occur according to how force is distributed on the PDL.

- **Bodily Movement**
  - Crown and root move in the same direction equally
  - Ideal force = **100g**
    - Load is applied to entire area of the PDL = equally distributed compression on one side of the root
- **Uncontrolled Tipping**
  - Crown and root forced in opposite directions
  - Ideal force = **50g** (light force threshold)
    - 50% of force is loaded on one side of the tooth, 50% on the other side
  - Most pressure at the crest of alveolar bone and root apex
- **Controlled Tipping**
  - Tooth partially tipped and partially translated
    - Root apex does not tip as much as uncontrolled tipping
  - Ideal force = **75g**
    - 75% of force is loaded on one side of the tooth, 25% on the other side
- **Extrusion**
  - Tooth being pulled out of its socket
  - Ideal force = **50g**
    - 50% of PDL being loaded on any given side
  - Irregularity of root shape causes compression in areas similar to tipping forces
- **Intrusion**
  - Tooth being pushed into its socket
  - Ideal force = **10g**
    - 10% of PDL compressed
  - Successful intrusion requires very light force along long axis of tooth
- **Root Torque**
  - Root moves in direction of force, but crown barely moves
  - Ideal uprighting force = **75g**
    - **75% of PDL being loaded**
- **Rotation**
  - Tooth rotation along its long axis
  - Ideal force = **50g**
    - 50% of PDL being loaded on any given side
  - Irregularity of root shape causes compression in areas similar to tipping forces

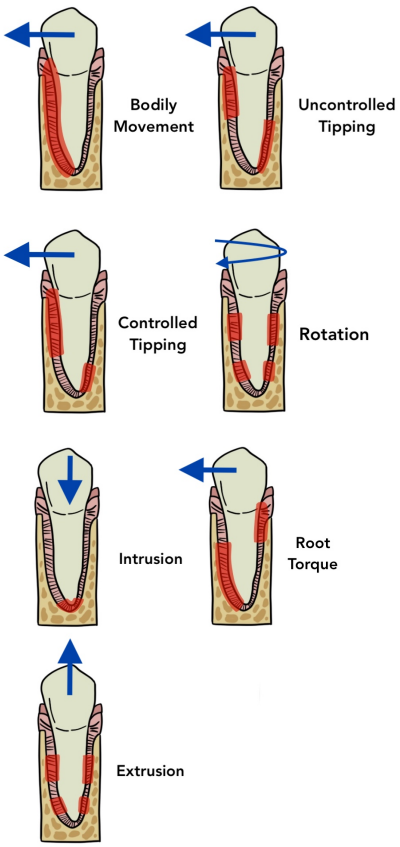

Figure 1.47 Movement Types

2 Inflammatory Response

Regional Accelerated Phenomenon

- Method used to speed up tooth movement by utilizing the inflammatory response
- **Regional** - inflammation occurs at cut site and surrounding bone where tooth movement is aimed at
- **Acceleratory** - agitated inflammatory mediators intensify the bone response
- Tools used for regional accelerated phenomenon
  - **Propel** - punches holes into the gums and bone
  - **Periodontal Accelerated Osteogenic Orthodontic**s - full thickness flap + alveolar corticotomies + bone flap + application of orthodontic force

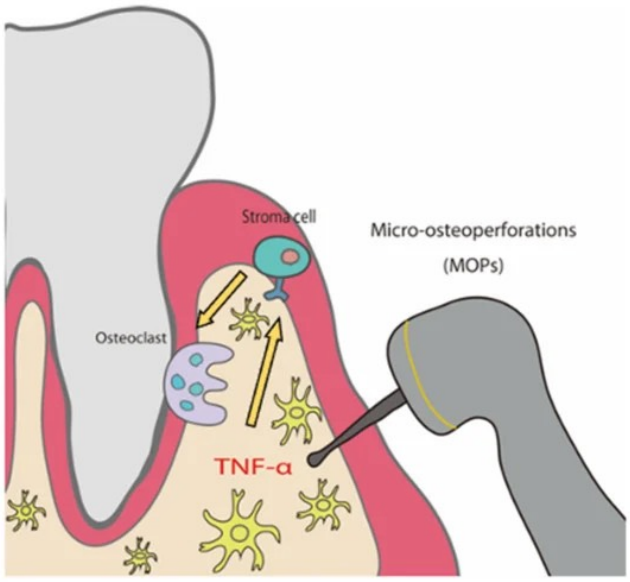

Figure 1.48 Propel

3 Side Effects

Orthodontic forces can results in several deleterious side effects. Generally, more force is associated with more effects.

- Pain - PDL remodelling and necrosis
- Inflammation - can be exaggerated from poor oral hygiene or nickel allergy (rare)
- Mobility - PDL widened (temporarily)
- Pulp vitality loss - from extreme movements or tooth trauma
- Root resorption - cementum adjacent to hyalinized PDL can resorb
  - Increased risk:
    - Genetics
    - Heavy force
    - Large defect
    - Apical defect
    - Single rooted tooth
    - Movement into cortical plate - leads to root resorption
    - Tooth trauma
    - Bruxism and heavy mastication forces

Mechanics of Tooth Movement

1 Mechanical Principles

Force

Force is a linear vector demonstrated with magnitude and direction.

- Orthodontics is made of push and pull force systems applied to teeth
- Force is applied to a location on the tooth (usually at the orthodontic bracket)

Center of Resistance

Center of resistance is fixed point where force must pass through for linear movement of an object.

- Center of resistance of free-floating object = object's centre of mass
- If force is on the object, but not through the centre of resistance, the object may rotate
  - Example - pushing a pencil at the tip
- Center of resistance of tooth movement = centre of root
  - Located on the centre of the portion of the root that is bound to bone
  - If tooth has periodontal problems → center moves apically
  - If there is root resorption → center moves occlusally

Moment of Force

Moment (M_F) describes the tendency for a force to cause rotation at a specific axis on the object. It occurs whenever the force is applied at some distance from the center of resistance.

- **Moment = Force x distance**
  - Similar to torque
- Rotation tendency is stronger the further the distance
  - Example - closing a door is more difficult when pushing the door with the hands closer to the hinges than at the handle

Center of Rotation

Center of rotation is an unfixed point that marks the axis through which an object is rotating. In other words, it's the point where the object seems to have rotated between its original and final position.

- Example - pushing the pencil at the eraser and the center of the rotation is the tip
- In orthodontics, the force is applied at the bracket (crown), although the center of resistance is at the root
  - Therefore, movement around the center of rotation is more common than at the center of resistance

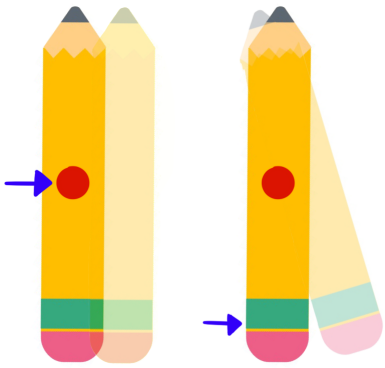

Figure 1.49 Center of Resistance

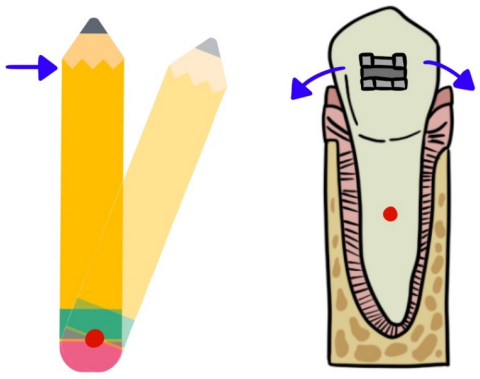

Figure 1.50 Center of Rotation

Force Couple

Couple (M_c) occurs when there is application of equal and opposite non collinear forces (separated by some distance)

- Only rotational movement occurs
- Two points of contact required
- Orthodontic wires engaged into a bracket slot that has two points of contact with the tooth
- They way forces are applied to the bracket by the wire determines the kind of couple that influences the movement of teeth. The wire wants to return to its original shape resulting in forces applied to the bracket.
  - **First-order** = rotation
    - Pulling force on one contact point of the bracket, and pushing force at the other contact point
    - Results in mesiodistal rotation of tooth
  - **Second-order** = angulation
    - Downward force on one contact point of the bracket, and upwards force on the other contact point
    - Results in mesiodistal angulation of tooth
  - **Third-order** - inclination
    - Rectangular wired engaged in the bracket slot to cause buccal-lingual inclination of tooth

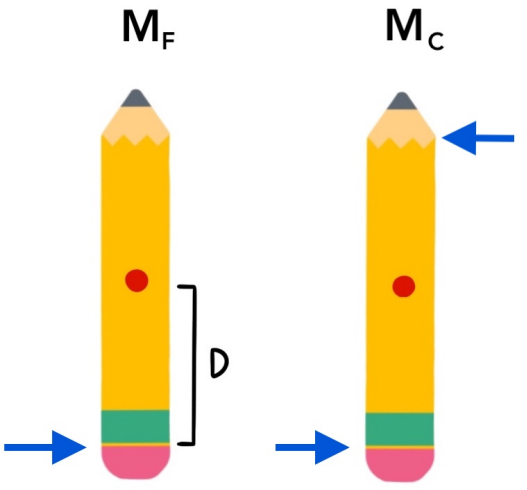

Figure 1.51 Moment of Force & Couple

2 Tooth Movement

Bodily Movement ($M_C/M_F=1$)

- $M_C=M_F$, moment and force couples are equal
- Crown and root move equally in the same direction
- Tooth is translated (bodily), no rotation
  - Center of rotation infinitely distant from the center of resistance
  - Retraction, protraction, intrusion and extrusion
- Difficult movement to achieve
  - Requires force to the crown and a strong couple

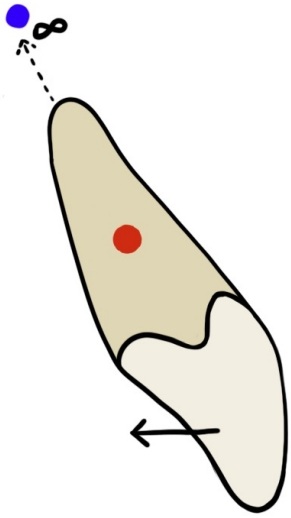

Figure 1.52 Bodily Movement

Uncontrolled Tipping ($M_C/M_F=0$)

- $M_C=0$, no couples
  - Lowest effort and easiest tooth movement
- Crown follows direction of force, root moves opposite to force
  - Resulting from force coming from one point of contact
- Center of rotation slightly apical to the center of resistance

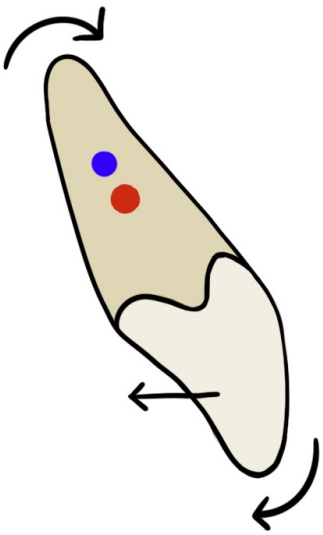

Figure 1.53 Uncontrolled Tipping

Controlled Tipping ($0< M_C/M_F <1$)

- $M_C<M_F$, moment of couple less than moment of force
- Crown tipping in the direction of force, but root remains fixed
  - Seen in third-order couple
- Centre of rotation more apical to center of resistance

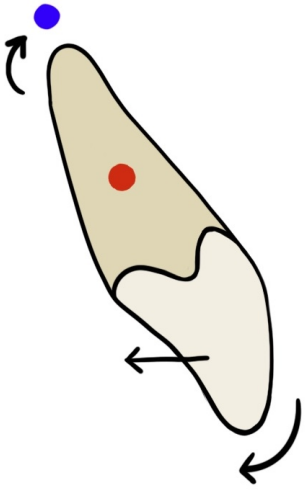

Figure 1.54 Controlled Tipping

Root Torque ($M_C/M_F>1$)

- $M_C>M_F$, moment of couple more than moment of force
- Root is moving more than the crown (crown barely moves) in the direction of force
- Center of rotation moves in opposite direction of root movement, located closer to incisal edge
- Very difficult movement to achieve
  - Moving root through bone while keeping crown steady
  - Very strong couple
  - Likely requires auxiliary appliance

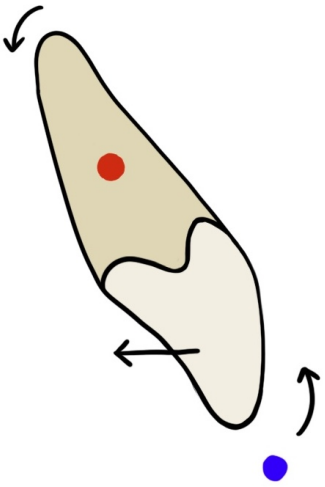

Figure 1.55 Root Torque

Rotation

- M_F does not exist
- Only M_C applied to the tooth
- Tooth rotates around its long axis
- Center of rotation located at the center of resistance

3 Anchorage

Anchorage in orthodontics refers to the tooth's resistance to unwanted movement. As stated in Newton's 3rd Law of motion, for every action there is an equal and opposite reaction. Therefore for every desired tooth movement, there is potential for an equally undesired tooth movement.

- Light force is preferred in orthodontics
  - Has less anchorage toll/unwanted reaction movement.
- PDL surface area of teeth moving determines which movement dominates
  - More PDL area = more anchorage to resist tooth movement
  - Example - anterior teeth are less resistant to tooth movement compared to posterior teeth (more PDL surface area)

INBDE Pro Tip: Anchorage between teeth can resemble a game of "tug of war". Whichever group of teeth has more PDL surface area can be seen as the stronger group and will resist movement more than the other group of teeth. This results in the weaker side experiencing overall net tooth movement.

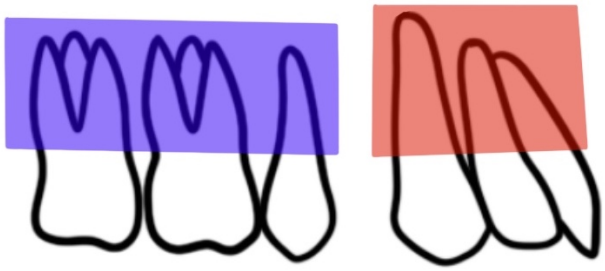

Figure 1.56 PDL Surface Area

Anchorage after Premolar Extraction

In orthodontics, premolar extraction leaves space in the arch where the teeth were previously located. In this case, anchorage can be used to move the anterior or posterior teeth to close the gap.

- **Minimum anchorage**
  - Anchor posterior teeth permitted to move forwards while non-anchor teeth remain fixed
  - Often requires help from skeletal anchor or 2nd premolar extraction (not 1st)
- **Moderate anchorage**
  - Anchor teeth can move 1/4-1/2 into the extraction space
- **Maximum anchorage**
  - Often needed in severe crowding or incisor protrusion
  - Anterior teeth pulled back and posterior teeth being anchored
  - Anchor teeth should only move less than 1/4 into the extraction space

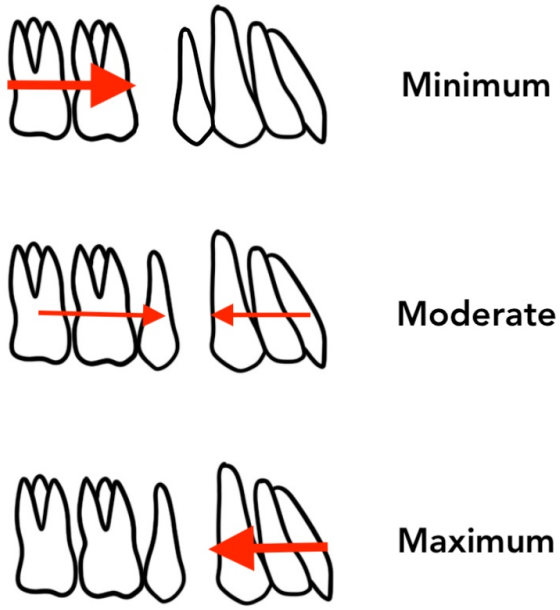

Figure 1.57 Anchorage Demand

Reciprocal Anchorage

- Both units have equal anchorage (PDL surface area is equal)
- Results in equal and opposite tooth movement in each unit
- Useful in diastema closure

Reinforced Anchorage

- Increase PDL surface area of anchor unit by including more teeth to the unit = increased anchorage
- Headgear often used to reinforced anchorage
  - But often poor compliance
  - Heavy intermittent forces due to putting on and taking off headgear are not ideal

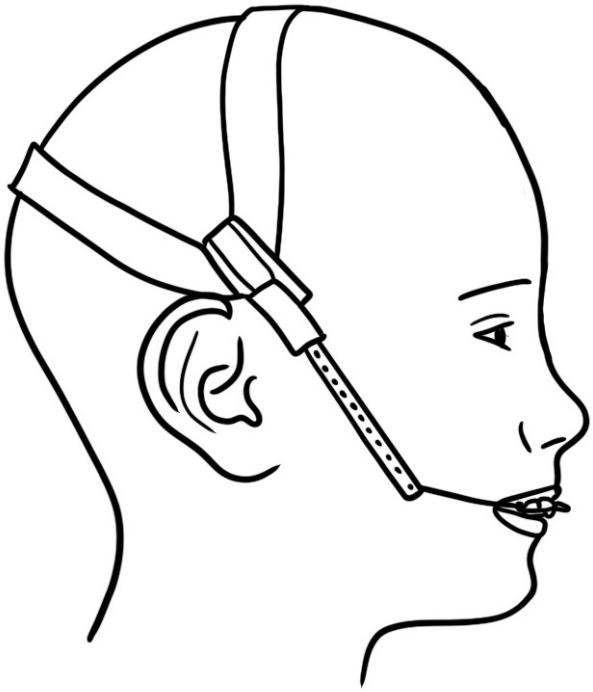

Figure 1.58 Headgear

Skeletal Anchorage

- Uses **temporary anchorage devices (TADs)**
  - Metal stakes that are screwed into bone that should not move and act like ankylosed teeth
    - **Bone screws** - screwed into alveolar used to move individual teeth, less invasive than bone plates
    - **Bone plates** - multiple screws attached to basal bone for extensive tooth movement, more stable than bone screws
  - 11 years is minimum age for TAD placement
    - Bone mature enough to keep TADs stable
  - Useful in moving molars distally or intruding molar

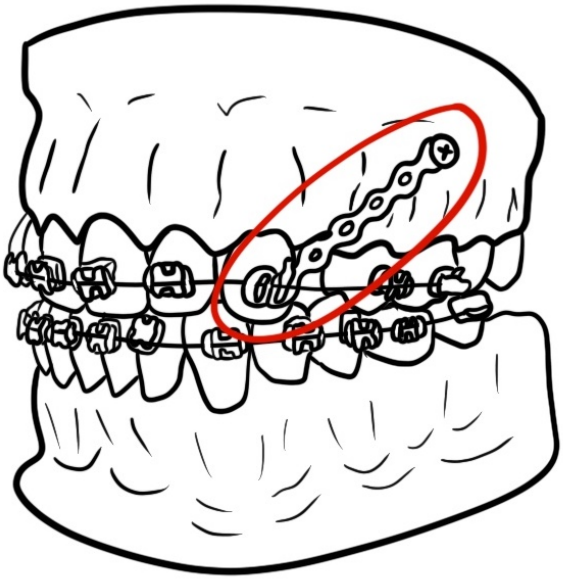

Figure 1.59 Bone Screw

Orthodontics Materials

1 Wires

In orthodontics, braces are made up of a system of wires and brackets. The **wires** do all the work of dictating the movement of the tooth while the **bracket** just acts a handle for the tooth. The function of orthodontic wires can be summarized in four different stages.

1. Wire is out of the package untouched
2. Permanent bends placed in the wire to encourage tooth movement
3. Bend of wire is modified into order to engage into the bracket slot
    i. Wire should experience resistance as it wants to return to its original shape
4. Overtime, wire returns to its original bended shape after the teeth have moved

Therefore, these four steps involve ongoing **activation** and **deactivation** of the wire in order to facilitate tooth movement.

- **Activation/loading** - force applied to the wire in order for it to be engaged into the bracket slot
- **Deactivation/unloading** - force applied to the tooth by the wire in order for the wire to return to its original shape

Stiffness

Stiffness is represented by the slope of the elastic portion of the stress-strain curve. The greater the slope, the more stiff the wire is. Stiffness can also be explained by the following terms.

- **Loading** - refers to flexibility of the wire
- **Unloading** - refers to the amount of force that will be delivered to the tooth as the wire returns to original shape
- Stiffness and flexibility are the inverse of each other

Range

Outside of its range of action, a wire will not return back to its original shape. In orthodontics, a shorter range signifies that the patient will need to come back more often to replace their wire.

- **Loading** - how far the wire can be deflected while maintaining elasticity
- **Unloading** - how far and how long the wire will remain active

Strength

Strength of the wire can be explained by using the following terms:

- **MPa** - unit of stress used to measure strength
- **Strength = Stiffness x Range**
- **Proportional limit** - the point where any amount of stress beyond it will have not have the wire return to original shape
    - Ideally, stress in orthodontics wires should be kept below this limit
- **Yield Strength** - the point where permanent deformation begins
- **Ultimate tensile strength** - maximum amount of stress and force the wire can experience
- **Failure point** - wire breaks
- **Loading** - refers to how easily wire can break
- **Unloading** - refers to amount of force the wire can deliver

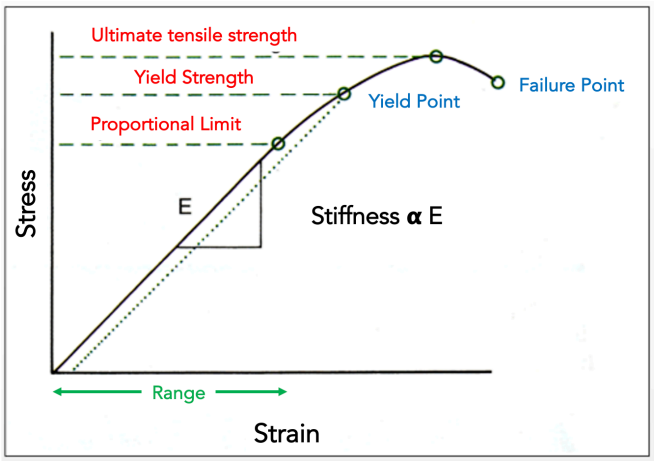

Figure 1.60 Stress-Strain Curve

Resilience

In the stress-strain curve, **resilience** represents the area under the curve until the proportional limit.

- Refers to energy storage capacity of wire

Formability

In the stress-strain curve, **formability** represents the area under the curve from yield strength to failure point

- Refers to the amount of permanent deformation that will occur before failure

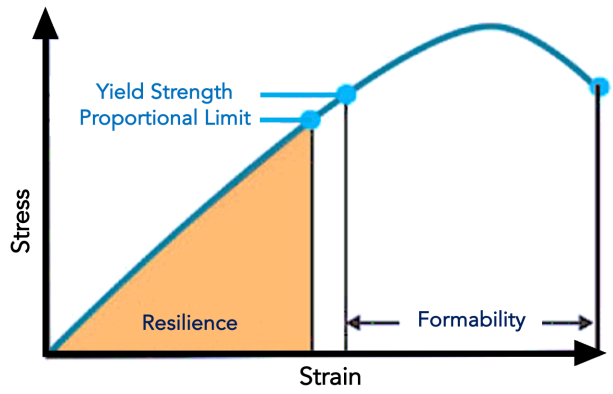

Figure 1.61 Resilience & Formability

Material

- Least to most stiff/strong
  - NiTi < TMA < SS

Geometry

- Stronger and stiffer
  - Rectangular > round
  - Beam > cantilever
- ↑ diameter
  - ↑ strength + stiffness
  - ↓ range
- ↑ length
  - ↓ strength + stiffness
  - ↑ range

2 Brackets

Brackets are placed on the tooth for the wire to leverage on. There are several different types and classification of brackets;

Edgewise Brackets

Edgewise brackets have slots for the wire that open horizontally along the incisal edges of teeth. When the system was first invented, the same bracket was placed on each tooth. Therefore, the wire had to have a lot of bends for the wires to fit in each bracket.

- **First-order bend** - position teeth buccolingually
- **Second-order bend -** mesiodistal angulation
- **Third-order bend** - torque teeth in buccolingual inclination

Pre-adjusted Edgewise Brackets

Today, orthodontists use pre-adjusted edgewise brackets.

- Each bracket has its own design for different teeth
  - Bends are already built into the bracket
  - Not as many bends in the wire required
- Brackets placed in the centre of the facial side of the clinical crown of the tooth

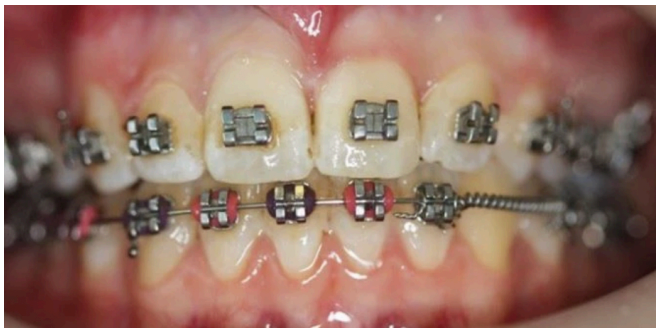

Figure 1.62 Readjusted Edgewise Brackets

Metal vs Ceramic

- Metal
  - Metal is visible, unesthetic
  - Stainless steel material
  - Wire held in place by elastic ring or stainless steel tie place over bracket slot
- Ceramic
  - esthetic, similar colour to tooth
  - More friction = harder for wire to slide through the bracket
  - More prone to fracture

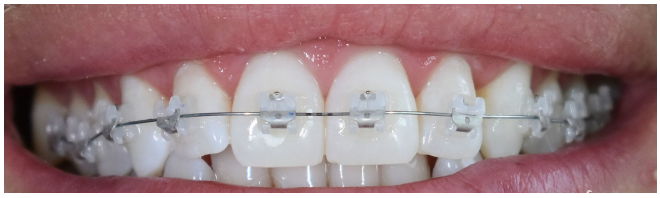

Figure 1.63 Ceramic Brackets

Self-Ligating Brackets

- Built-in door the holds the wire into the slot
  - No need for ligature/elastic ring/stainless steel tie
- More expensive
- Less friction

Figure 1.64 Self-Ligating Brackets

Phase I Treatments

1 Phase I Treatment

Phase I treatment is regarded as early treatment that typically occurs during the mixed dentition stage before orthodontic treatment is given in phase II. There are three main purposes of phase I treatment in orthodontics.

1. Treat problems that are easier to correct earlier on
2. Improve overall oral environment
3. Make phase II treatment simpler in the permanent dentition

Crossbite

- **Anterior Crossbite**
  - If on one to few teeth, can lead to uneven tooth wear and/or gingival strain
    - Treatment → **2x4 braces** (2 molar bracket, 4 incisors brackets), **active retainer**
  - Full underbite leads to skeletal class III
    - Treatment → reverse pull headgear

Figure 1.65 2x4 braces

- **Posterior Crossbite**
  - Usually due to a narrow maxilla
  - Should be treated early if patient exhibits functional shift (mandible shifts as patient bite down), otherwise abnormal growth can be encouraged
  - If no functional shift, can be treated later on
  - Treatment
    - **Palatal expansion** (Haas, Hyrax, Quad Helix)

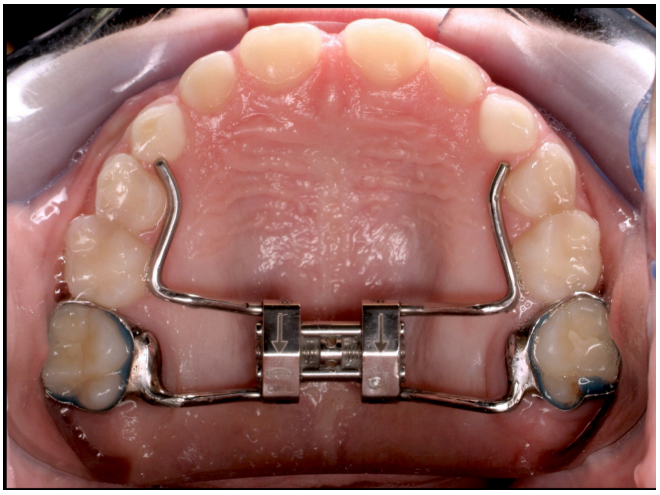

Figure 1.66 Hyrax Palatal Expander

Severe Overjet

- Increases risk for trauma
- Psychological and social problems could arise
- Treatment
  - **2x4 braces** (2 molar bracket, 4 incisors brackets)
  - **Class II headgear** - restrains maxillary growth at the sutures

Palatal Impingement

- Occurs when a deep bite causes lower incisors to impinge on the soft tissue of the palate
  - Soft tissue trauma/damage to gingival attachment
  - Leads to pain and discomfort
- Treatment → **maxillary bite plate**
  - Protects the palate by restricting the deep bite

Figure 1.67 Bite Plate

Anterior Open Bite

- Often caused by thumb sucking or tongue thrusting
  - **Tongue thrusting**
    - Patient places tongue anteriorly during swallowing
    - Generalized spacing + proclined incisors
  - **Thumb sucking**
    - Encourages a posterior cross bite and narrowing of maxilla
    - Proclined maxillary incisors + retroclined mandibular incisors
- Treatment → **rake** or **blue grass** appliance
  - Restricts habitual behaviour

Figure 1.68 Rake Appliance

Impacted Teeth

- Maxillary canines are most commonly impacted (after 3rd molars)
  - Suggested to extract primary canines to open a path of least resistance for permanent canine eruption
- **3Hs** - used to judge chance of canine impaction
  - Horizontal angulation of canine
  - Height of canine position
  - Has the canine crossed the midline of the lateral incisor?
- **Kurol's Rule**
  - If canines have not passed the midline of the lateral incisor, there is 91% chance of self correction and eruption after
  - If canine has passed the midline of the lateral incisor, 64% chance of self correction and eruption

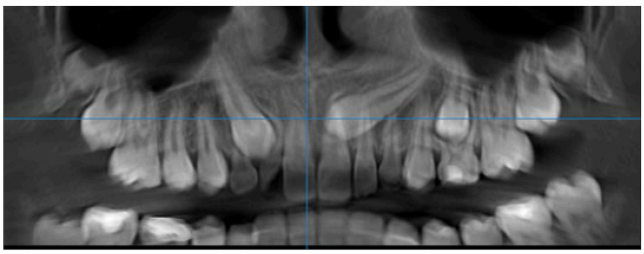

Figure 1.69 Impacted Canines

Crowding

- **Moderate Crowding (≥4mm crowding)**
  - Generally not a big concern
  - Should not extract primary teeth to treat
  - Treatment
    - **Lip bumper** - allows lower incisors to lean forward by moving the lip out of the way
    - **Lower lingual holding arch (LLHA)** - hold leeway space in place by prevent incisors from moving into the space

Figure 1.70 Lip Bumper

- **Severe Crowding (≥8mm crowding)**
  - Treatment = **serial extraction**
    - Consecutive removal of primary teeth in order to prevent impeded eruption of permanent teeth
    - Contraindicated in patient with skeletal class II or III relationship
    - Canine extracted first, then primary first molars, then 1st premolar

Comprehensive Treatment

There are different types of orthodontic treatment that can depends on the source of the problem and the patients growth

- Skeletal correction
  - Patient still growing → **growth modification**
  - Patient stopped growing → **orthographic surgery**
- Dentoalveolar correction
  - **Non-extraction**
  - **Extraction**
- Most treatment includes both skeletal and dentoalveolar treatment
- Adult treatment
  - No growth modification treatment
  - Should treat any periodontal conditions before orthodontic treatment
  - Steel ligatures retain less plaque than elastomeric ligatures (if oral hygiene is a concern

1 Growth Modification

Growth modification can only be done during the period of growth for the patient. In females, this is usually between 8-13 years and for males, 10-15 years (with individual variation).

Headgear

- Treats skeletal class II patients during pre-pubertal growth
- Worn for 12-14h/day
- Restricts growth of the maxilla
  - High-Pull
    - Treats class II open bite patients
    - Distalize and intrude maxillary molars
  - Cervical-Pull
    - Treats class II deep bite patients
    - Distalize and extrude maxillary molars
  - J-hook
    - Retracts canines and incisors
    - ** for dentoalveolar treatment (not growth modifcation)

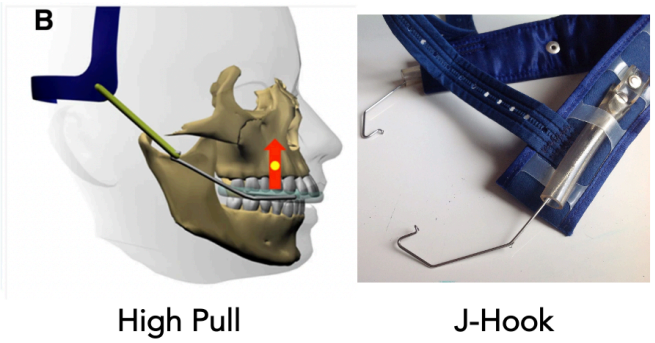

Figure 1.71 Headgear

Reverse headgear

- Treats skeletal class III maxillary deficiency patients as soon as 6-8 years
- Stimulates growth of the maxilla
- Protracts maxillary incisors
- Retracts lower incisors
- Clockwise rotation of mandible

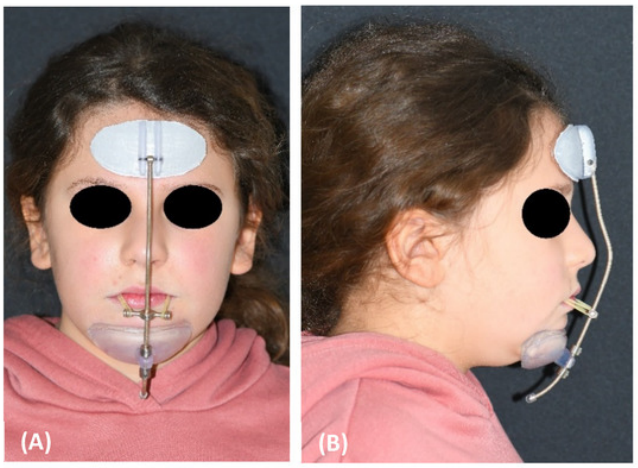

Figure 1.72 Reverse Headgear

Chin cup

- Type of headgear
- Treats skeletal class III patients
- Restricts growth of the mandible
  - But shown to be mostly ineffective

Functional appliance

- Treats skeletal class II patients (mandibular deficiency) by protruding the mandible so that facial tissue and muscles stretching modifies the condyles
  - **Bionator**
    - Teeth guides separated by plastic which enforces advancement of the mandible→ encourages bone growth as condyles to fill in the space at the TMJ
    - Removable, compliance important but often accepted
    - Simple, durable
  - **Activator**
    - Lingual flanges of appliance extends deep into lingual mucosa (approximately at the lower molars) → same effect as bionator
    - Removable, compliance important
    - Less accepted than bionator
  - **Herbst appliance**
    - Mandible pushed forward passively when patient closes mouth through piston and tube device
    - Fixed appliance
    - Breaks easily
  - **Twin block appliance**
    - Inclines of appliance encourages advancement of mandible for closure of the mouth
    - Removable or fixed
    - More positive mandibular changes than activator or bionator
  - **Mandibular anterior repositioning appliance (MARA)**
    - Fixed appliance
    - Durable, less bulky
    - More stable than herbst appliance
    - Twin block and Herbst are more effective for mandibular advancement

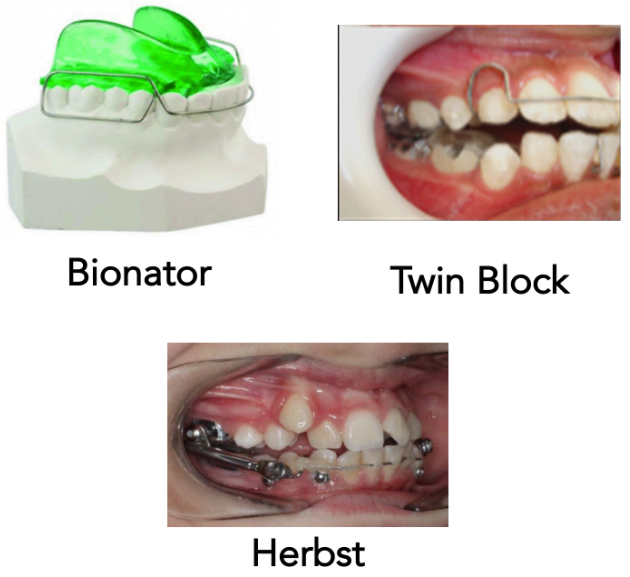

Figure 1.73 Functional Appliances

Palatal Expanders

- **Schwarz**
  - Treats mild posterior crossbite
  - Jackscrew expander at the midline of palate
    - Parent/guardian uses a key to turn the jackscrew to expand the palate by 0.25mm
  - Results in dental tipping mostly
    - Not true palatal expansion
  - Removable
- **W-arch**
  - Slow expansion by applying few hundred grams of force
  - Mostly results in dental tipping (2/3) but also has skeletal expansion (1/3)
  - Effective, comfortable
  - More effective than Schwarz
  - Fixed appliance
- **Quad helix**
  - 4 helical loops that can apply more force than the W-arch in the anterior and posterior
    - Can activate loops depending if you want more anterior/posterior expansion
  - Fixed appliance

- **Hyrax appliance**
  - Uses jackscrew expander with orthodontic bands placed on 1st molars and 1st premolars
    - 100N force for one turn of jack screw to open mid palatal suture
  - Skeletal expansion effective
  - Bulky = removal and placement more difficult
  - Compliance required for key turning
  - Fixed appliance
- **Haas appliance**
  - Uses jackscrew expander with acrylic pads that contact palatal mucosa
  - Skeletal expansion effective
  - More difficult to clean
  - Fixed appliance
- **Transpalatal arch (TPA)**
  - Used for transverse anchorage, but could be used for dental expansion/constriction

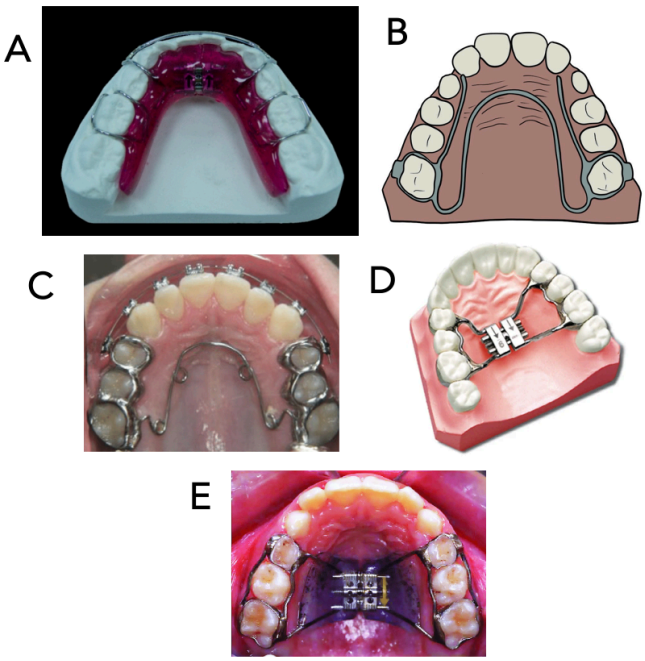

Figure 1.74 Palatal Expanders: A - Schwarz, B - W-arch, C - Quad Helix, D - Hyrax, E - Haas

Other (Dentoalveolar Treatment)

- **Forsus**
  - Teeth pushed by a pushrod
  - Fixed appliance
  - More maxillary restriction than other appliances
  - Heavy maxillary and mandibular archwires
- **Pendulum**
  - Distalizes molars
  - **Pendex** appliance can also add a jackscrew expander for palatal expansion
  - Fixed appliance
  - Only effects the maxillary arch

Figure 1.75 Forsus & Pendulum

2 Mixed Dentition Appliances

Nance

- Used on the maxillary arch as a space maintainer or anchorage device
- Bands on maxillary molars to keep them in their anterior-posterior positions

Lower Lingual Holding Arch (LLHA)

- Used as a space maintainer or anchorage device for the lower arch
  - Prevents mesial drift of lower molars and lingual tipping of incisors
- Wire on lingual surface of incisors

Lip Bumper

- Used on lower arch
  - Transfer lower lip pressure on lower incisors to the lower molars

Figure 1.76 Nance & LLHA

Figure 1.77 Lip Bumper

3 Permanent Dentition Appliances

Braces

- Can be used after permanent 1st molar erupts
- Fixed appliance
- Adults more likely to request invisible ceramic, lingual braces
- Steps for placement
  1. Enamel prophylaxis - clean with pumice to remove pellicle and increase wettabilty
  2. Etch enamel where bracket will be placed
  3. Primer - chemically bonds resin used to bracket
  4. Position brackets - usually on center of the crown, cure with adhesive resin
- Order of corrections
  5. Teeth alignment and levelling the curve of speed
  6. Anterior-posterior positioning of molars and space closure
  7. Finishing and detailing

Aligners

- Series of removable clear tray aligners made by prescription developed by the provider
- Bonded attachments often needed

Figure 1.78 Aligners

4 Dentoalveolar Correction

Extraction

- Severe crowding
- Protrusive lips
- Minimal overbite/open bite
- Acute nasolabial angle
- Anterior recession or thin soft tissue
- Camouflage

Non-Extraction

- Mild or no crowning/spacing
- Retrusive lips
- Deep bite
- Obtuse nasolabial angle

Retention

1 Introduction

Elastic Recoil

- Short-term dental changes
- Soft tissue fibre reorganization takes time after braces are removed
  - PDL = 3-4 months
  - Gingival fibers = 4-6 months
    - Night time retainers recommended to limit relapse
  - Supracrestal fibers = +1 year
    - Night time retainers recommended to limit relapse
- If teeth severely rotated → **Supracrestal Fiberotomy (SCF)**
  - Rare

Differential Jaw Growth

- Long-term skeletal changes
- Relapse may occur from anterior-posterior and vertical growth
- Cheek, lip, or tongue pressure will push teeth into a different position
  - Due to possible late mandibular growth shifting the equilibrium

2 Retainers

Hawley Retainer

- Upper retainer
  - Incisors retention → Labial bow from canine to canine
  - Adam clasps → undercuts for molar retention (keep retainer ins place
  - Acrylic on palate → connector, overbite, control
  - Occlusal surfaces of teeth are free to erupt
- Lower retainer
  - Acrylic on lingual
  - Clip-on bar from canine to canine

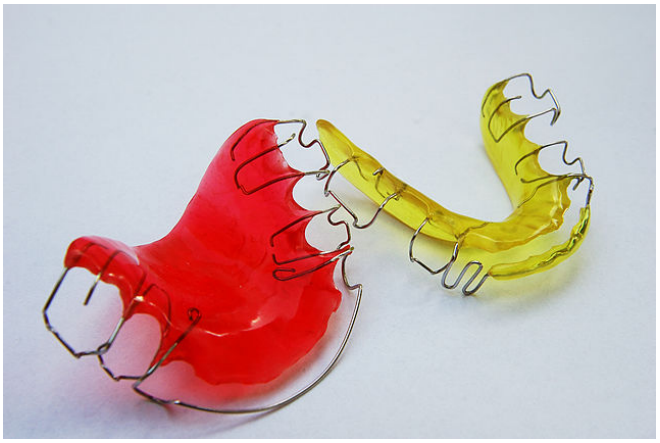

Figure 1.79 Hawley Retainer

Lingual Bonded Retainer

- Wire bonded to the lingual surface of anterior teeth
  - One flexible wire attached to each tooth
  - Rigid wire on two teeth
    - Usually mandibular canines or maxillary central incisors
- Usually placed if large diastema of upper incisors was closed
- Usually placed if repositioned +2mm forward of lower incisors

Figure 1.80 Lingual Bonded Retainer

Vacuum-Formed Retainer

- Clear plastic retainer
- More esthetic
- Posterior occlusion are separated which may influence occlusion

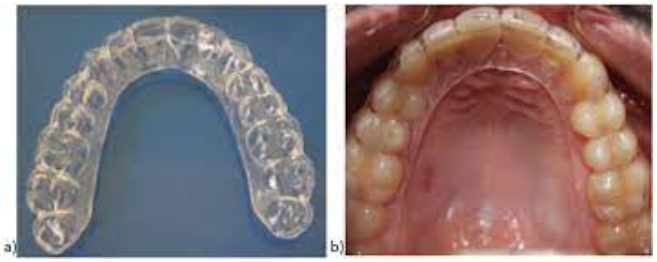

Figure 1.81 Vacuum-Formed Retainer

3 Relapse

Open Bite Relapse

- Prevent relapse by preventing over eruption off maxillary molars and intrusion of incisors
- Retainers recommended
  - Upper Haley retainer with posterior bite block
  - Vacuum-formed retainer with thicker plastic on posterior occlusal surfaces separates the jaw
- Poor oral habits should be controlled

Deep Bite Relapse

- Prevent relapse by preventing overeruption of incisors
- Prevent by using a Upper Hawley retainer with anterior bite plate

Class II Relapse

- Expect some amount of rebound after correcting a class II skeletal relationship
  - Especially when elastics were used
- Compensate by overcorrecting by 1-2mm during treatment
- Need for headgear/bionator + full-time retainer increased by the following:
  - Severity of original Class II skeletal relationship
  - Younger age at the time braces were debonded

Class III Relapse

- Mandibular growth very likely to continue and difficult to restrict after correction
- Compensate by overcorrecting by 1-2mm during treatment
- Surgery after complete growth might be the only solution

Surgical Orthodontics

1 Orthognathic Surgery

Orthognathic surgery is usually indicated when a patient's condition is too severe to be corrected by orthodontics alone. This usually involves skeletal discrepancies. Such severe discrepancies include the following:

- Open bite
- Class III malocclusion
- Asymmetry

Transverse Correction

- Maxilla
  - **Surgical Assisted Rapid Palatal Expansion (SARPE)**
    - Can be done when the mid-palatal suture has not fused
    - If suture is fused, need to cut it back open again
  - Constriction
    - Limited in application and practicality

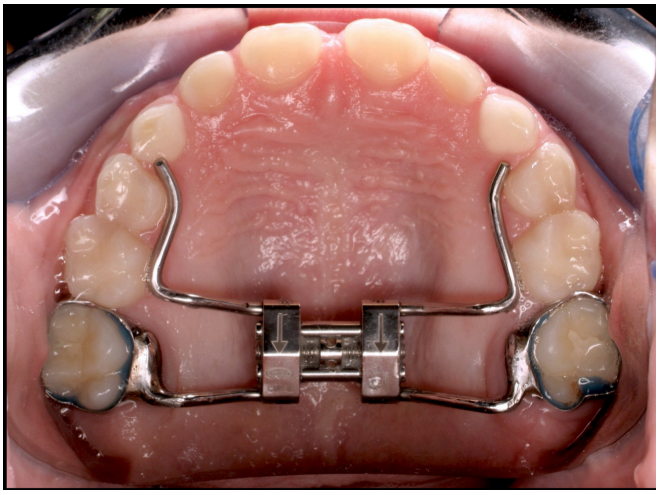

Figure 1.82 Palatal Expander

- Mandible
  - **Mandible Symphyseal Distraction Osteogenesis**
    - Cutting through symphysis of mandible to separate and allow bone to fill in = expansion
  - Constriction
    - Limited in application and practicality

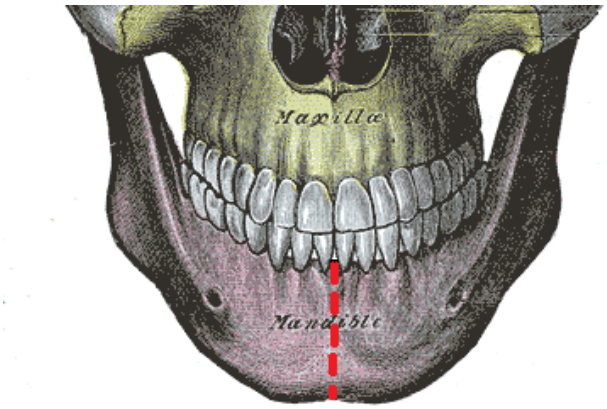

Figure 1.833 Mandibular Symphysis

Vertical Repositioning Surgeries

- **LeFort I Osteotomy**
  - Cut bone of maxilla above apices of teeth →allows for repositioning of entire maxilla
    - **Maxillary superior repositioning** - move maxilla upwards = shortens midface/open bite correction
    - **Maxillary inferior repositioning** - move maxilla downwards = lengthen mid face/ deep bite correction

Anterior-Posterior Corrective Surgeries

- **LeFort I Osteotomy**
  - Cut bone of maxilla above apices of teeth →allows for repositioning of entire maxilla
    - **Maxillary setback** - Class II correction = brings maxilla posteriorly
    - **Maxillary advancement** - Class III correction = brings maxilla anteriorly
- **Bilateral Sagittal Split Osteotomy (BSSO)**
  - Cutting through mandible on one or both sides in order to reposition the mandible
    - Must be cautious of avoiding the inferior alveolar nerve
    - **Mandibular setback** - Class III correction = brings mandible posteriorly
    - **Mandibular advancement** - Class II correction = brings mandible anteriorly

Genioplasty

- Improves the aesthetic condition of the chin
- **Sliding genioplasty** - can move the chin in all 3 dimensions
  - Most common = most stable version of genioplasty

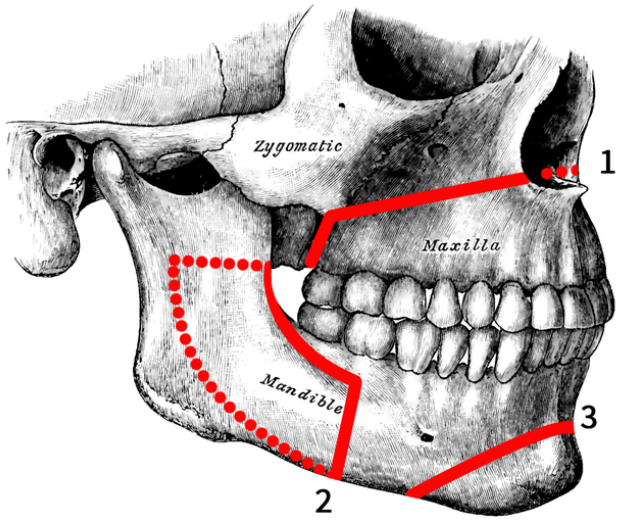

Figure 1.84 Osteotomies: 1) LeFort I, 2) Bilateral Sagittal Split, 3) Genioplasty

- **Condylar sag** - relapse after BSSO
  - More potential for relapse with osteotomy than with distraction osteogenesis (more gradual)

2 Relapse

Relapse can occur after orthographic surgery despite repositioning of the bones. This is because the soft tissues surrounding the bone place pressure on the bones and teeth to return to their original positions. Areas of the jaw have been placed in a **hierarchy of stability** to classify which surgical movements are the most and least likely to experience relapse.

- Most Likely for relapse
  - Maxilla wide or down
  - Mandible back
- Moderate likelihood for replace
  - Maxilla up + mandible forward
  - Maxilla foward + mandible back
  - Maxilla fowards
- Least Likely
  - Maxilla up
  - Mandible foward
  - Chin (any direction)

INBDE Pro Tip: In general, there is more likelihood of relapse when surgery induces a greater amount of change.

3 Envelopes of Discrepancy

Envelopes of Discrepancy is term referring to the extent a tooth's position can be changed through growth, orthodontics, or surgery. It is important to note that the envelopes of discrepancy are additive. That is, the amount of surgical movement permitted accounts for after growth modification has taken place, which is accounted for after orthodontic movement takes place.

Tooth Movement for Orthodontics

With orthodontics alone, teeth can moved up until the following amounts:

- Lower incisor
  - Protraction - 2mm
  - Retraction - 7mm
  - Extrusion - 4mm
  - Intrusion - 2mm
- Upper incisor
  - Protraction - 5mm
  - Retraction - 3mm
  - Extrusion - 2mm
  - Intrusion - 4mm

Growth Modification

- Class II growth restriction
  - Pulling maxilla + upper incisors back
  - Pulling mand + lower incisors forwards
  - Up to 5mm of change
- Class III growth restriction
  - Pulling maxilla + upper incisors foward
  - Pulling mand + lower incisors back
  - Up to 3mm of change

Surgical Changes

- Surgery is most significant when the mandible is being set back

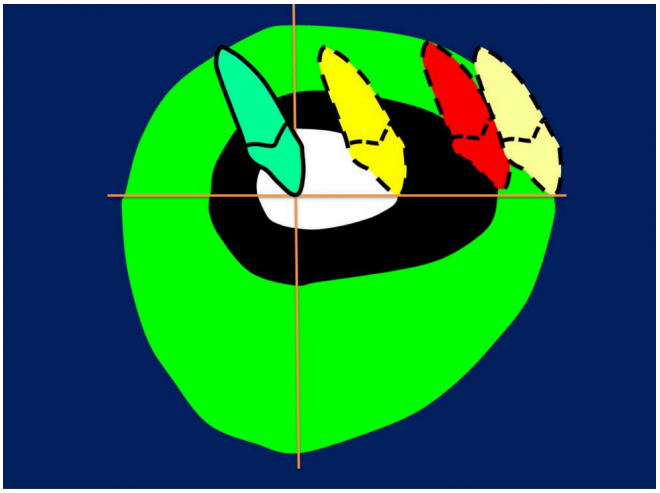

Figure 1.85 Envelopes of Discrepancy (Maxilla):
White = Orthodontics, Black = Growth
Green = Orthodontic Surgery

Dotted lines = original tooth position
Solid line = final tooth position

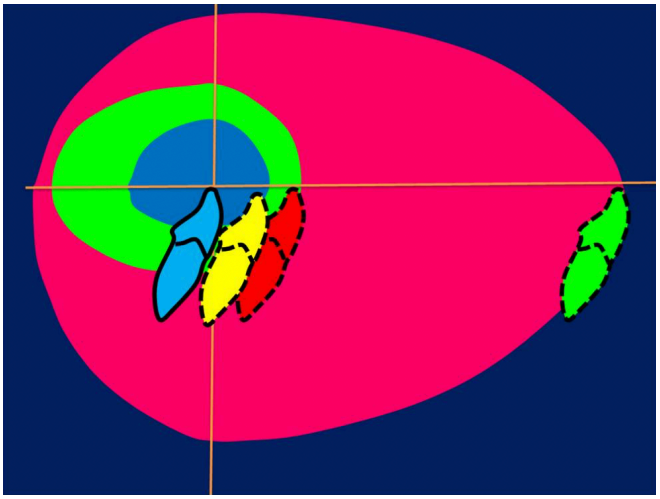

Figure 1.86 Envelopes of Discrepancy (Mandible)
Blue = Orthodontics, Green = Growth
Pink = Orthodontic Surgery

Dotted lines = original tooth position
Solid line = final tooth position