Intro to Ortho

- Tooth size and number decreasing, but slower than jaw size
  - From softer foods, refined sugars, genetics
- Population Stats
  - 45% people have ideal Mx occlusion = 55% people have Mx crowding
  - 35% people have ideal Mn occlusion = 65% people have Mn crowding
  - 45-55% people have ideal OJ, 15% have class II, <5% have class III
  - 50% people have ideal OB, 30% have deep bite, <5% have open bites
    - Problems happen from deep bites, not open bites
- Angle's Occlusion
    - US population, classification of anterior teeth only (did not look at molars)
  - 30% normal
  - 55% class I malocclusion
  - 15% class II
  - <1% class III

Bone Biology

- Flat bones – intramembranous – direct ossification without cartilage template – cranial vault, Mn body, Mx
- Long bones – endochondral – indirect ossification, requires cartilage – femur, cranial base, condyle
  - Complex multistep, sequential formation/degradation of cartilage, postnatal growth and repair
- Ages
  - 0-20y/o = BF>BR
  - 20-50y/o = BF=BR
  - >50y/o = BF<BR
- Osteoclasts needed for bone formation – osteoclastic number (not activity) control bone formation
- Drugs
  - Bisphosphonates – osteoporosis
    - Nitrogen containing = affects ruffled membrane
    - Non-nitrogen containing = causes cell death
  - Glucocorticosteroids – arthritis

Craniofacial Growth/Development 1

- Cephalocaudal gradient (head to tail bone)
  - 2 months = 50% head
  - Birth = 30% head
    - Head bigger than face (small Mn) = easier to get through birth canal
  - 25y/o = 12.5% head
    - Cranium closest to adult size at birth, stops growing first
    - Mn last bone to finish growing
- Scammon's Curve
  - 7y/o – cranial sutures close, neural development finished, ideal time to screen for ortho
  - 10y/o – lymphatics done, start to shrink
  - 10-12y/o – puberty starts, genital and general growth spurts begin
- Growth Patterns
  - Boys start developing 2 years later, develop for longer, and grow larger than girls
  - Growth spurt starts 2 years before sexual maturation
- Apposition – periosteum experiences hyperplasia, hypertrophy, and ECM secretion at surfaces (not internally)

Craniofacial Growth/Development 2

- Cranial vault – intramembranous formation/ossification, growth at sutures and apposition along fontanelles, resorption along internal surface
- Cranial base – endochondral from spheno-occipital, intersphenoid, and spheno-ethmoidal synchondroses
  - Growth stops at age 7
- Mx is displaced anterior inferiorly, with resorption along anterior surface and apposition on posterior surfaces
  - Best age to pull Mx forward is age 7
  - Palatal sutures close around 13-15 y/o
  - Lengthening of Mx arch from apposition along Mx tuberosity
- Mn intramembranous formation
    - Mn ramus = intramembranous ossification, condyle = endochondral ossification
  - Apposition along posterior surface, resorption along anterior surface of ramus (space for 3rd molars)
- For young kids, growth of the alveolar process is most important to accommodate the developing dentition
- Soft tissue – loses collagen with age
  - Sags – decreased exposure of upper incisors and increased exposure of lower ones
  - Thinner, less vermillion displace, less protruded
- Cartilage growth
  - Nasal bone growth stops at age 10, cartilage finishes after adolescent growth spurt
  - Females = stops age 17-19/o
  - Males = stops age 19-21y/o
- Mn crowding – late Mn growth = crowding earlier, but may resolve later on
  - Bones stop growing in width first, then in length. Growth in height is the last to stop

- Adolescence
  o Treat females around 2y earlier than boys
  o Lots of individual variation
  o Mid-palatal suture close 13-15y/o
  o Mn last bone to grow
  o Space for 3rd molars
	- Adults
	  o Facial tissue grows more than hard tissue
	  o Lower incisal crowding
	  o Lip line to upper incisors
	  o Chin accentuation

Development of Dentition 1

- Stages of Development
  - Primary dentition
  - Early mixed – presence of permanent incisors and molars
  - Late mixed – loss of deciduous molars and canines
  - Permanent dentition
- Primary dentition
  - Centrals, laterals, 1st molars, canines, 2nd molars
    - 4 month rule
    - Variations of up to 6m for eruption normal
    - Dentition is stable from 3-6 y/o – development of permanent dentition
  - Primate space = M to canine in Mx, D to canine in Mn
  - Shallow overbite/excess overjet
  - Increased horizontal overlap of anterior teeth
    - Mx grows AP faster than vertically
- 71% Flush terminal plane – class I or II
- 19% Mesial step – class I or III
- 10% Distal step – class II
- Primary dentition less proclined than permanent dentition
  - Permanent arches are more tapered, primary arches are more ovoid
- Leeway space – space from difference in size between primary and permanent teeth
    - C (canine) = 0
    - D (premolar 1) – Mx = 0.0mm, Mn = 0.5mm
    - E (premolar 2) – Mx = 1.5mm, Mn = 2.0mm
  - Mn arch = 5mm leeway space
  - Mx arch = 3mm leeway space
- Mesial shifting
  - Early mesial shift (63% of population) – mesial migration of Mn 1st molar
    - Uses up primate space, occurs around age 6
  - Late mesial shift (100% of population) – mesial migration of Mn 1st molar AFTER primary 2nd molar loss
    - Uses up leeway space, occurs around age 11
- Teeth move occusally, mesially, buccally in adulthood

Development of Dentition 2

- 1st molars, Mn centrals, Mx centrals, Mn laterals, Mx laterals, Mn canines, Mx premolars, Mn premolars, Mx canines, 2nd molars, 3rd molars
- 3 principles of treatment planning impacted teeth
    - Prognosis related to extent of displacement and surgical trauma
    - Eruption should happen through keratinized mucosa
    - Adequate space created prior to surgery
- Transitional midline diastema – closes with eruption of Mx canines
    - >2mm = begin pondering treatment
- Dental arch length decreases with transition from primary to permanent dentition
- Incisor liability – canine eruption, primate spacing, incisor proclination
- Potential problems with eruption
    - Premature loss of deciduous teeth – if primary 2nd molar is lost, ALWAYS maintain the space
    - Interproximal decay, over-retained primary teeth
    - Impaction – contralateral teeth should erupt within 6months of each other
    - Ankylosis – grey in color, dull to percussion
    - Positional anomalies – ectopic eruption (wrong location) of lower incisors
        - Transposition – most commonly upper lateral and canine
        - Palatal eruption – may be genetic
        - Canines erupted in line, but if crowded likely to erupt labially
    - Crossbites (posterior and/or anterior)

Biology of Tooth Movement

- PDL required, acts as a shock absorber
- Physiologic function – fast (<5s) and heavy loading, intermittent
    - Fluids and ligaments stabilize against gross displacement, alveolar bone bends, no pain
- Undermining resorption
    - Heavy forces, rapid pain, compressed PDL decreases bloodflow = necrosis → hyalinization of tissue
    - Takes longer to move tooth – must heal first
- Frontal resorption
    - Light forces, relatively painless, reduced blood flow causing signaling, not cell death, remodeling occurs
    - Tension and compression sides for remodeling
        - Tension = apposition – osteoblasts and fibroblasts, laying down osteoid
        - Compression = resorption – osteoclasts
    - Minimum 4-6h to get orthodontic tooth movement, want around 20-350grams of force
- Tissue changes
    - Enamel = no effect
    - Cementum = localized perforations, repaired from cellular cementum zone
    - Dentin = resorption possible in areas of perforated cementum
    - Pulp = transitory inflammation – loss of tooth vitality in teeth with history of trauma
- Types of movement
    - Tipping
    - Translation
    - Rotation
    - Extrusion
    - Intrusion
- Force types
    - Continuous force – never declines to zero. Think of a NiTi coil spring
    - Interrupted force – declines to zero, then replaced. Think of a power chain
    - Intermittent force – declines to zero, but appliance is removable. Think of headgear or elastics
- Drugs
        - Prostaglandins and IL1β increases quickly in PDL during orthodontic tooth movement
        - Prefer to use Tylenol instead of NSAIDs, as NSAIDs act centrally and block prostaglandins
    - Depress OTM
        - Bisphosphonates, prostaglandin inhibitors (NSAIDs), tricyclic antidepressants, antyarrhythmics, glucocorticosteroids, antimalarials, anticonvulsants, tetracyclines
    - Increase OTM
        - Vitamin D, prostaglandins

Patient Exam and Diagnosis

- Psychosocial
  - Develop rapport with patient
  - Write down the CC verbatim, ADDRESS THE CC
    - Why are you here? Why now? What do your parents say?
    - Why do you think you need braces?
  - MHx/DHx
- 3 major reasons for ortho treatment
  - Impaired dentofacial esthetics
  - Impaired function
  - Enhancement of dentofacial esthetics
- Be problem oriented so as not to fixate on only 1 portion – idea is to create a database for planning
  - Prioritize the problem list – should address primary CC, ensures all issues are addressed, includes pathologic, functional, and developmental problems
- Patient interview
  - Physical growth evaluation – growth charts, sexual maturation, growth prediction
  - Social/behavior evaluation – internal motivation/expectation, documentation of patient compliance, etc
- Clinical Exam
  - Oral health – perio charting, caries, pulpal disease
  - Jaw and occlusion – mastication/speech, habits, breathing, TMD/other dysfunctions
  - Facial/dental appearance
    - Macroesthetics – frontal exam (symmetry, proportions of width/height), developmental age, facial proportions, profile analysis
      - Brachyfacial, mesofacial, dolichofacial
      - Rule of 3rd (forehead, Mx, Mn areas)
      - Rule of 5th (bisecting nose (1/5), eyes (2/5), to edge of ears (2/5))
      - Convex = class II, flat = class I, concave = class III
    - Miniesthetics – teeth, smile framework (gingival display, midlines, etc), crossbites, malocclusion
    - Microesthetics – details on individual tooth
- Not necessary to mount child casts – TMJ is not done developing, hard to find reproducible CR

Classification of Malocclusion

- Andrew's 6 keys
  - Molar relationship
  - Mesial crown angulation
  - Crown inclination – incisor proclination, canine and posterior lingual inclination
  - No rotations present
  - No spaces present
  - Flat (or slightly curved) occlusal plane
- Other components of normal occlusion
  - Normal apical base relationship
  - Good interdigitation
  - Minimum overjet and overbite
  - Smooth/coordinated arch shapes
  - Symmetrical dental arches, matching midlines
  - Normal axial root inclination
  - No crossbites
  - No crowding or spacing
  - No supernumary or missing teeth
  - No oversized or undersized teeth
  - CR/CO shift <2mm
  - Normal curves of Wilson and Spee
- Malocclusion – deviation from accepted norm that presents a hazard to person's wellbeing, associated with dentofacial abnormalities
  - Angle's classification – Mx MB cusp in Mn B groove, first molar analysis only!
  - Ackerman and Proffit classification – transverse plane relationship, AP plane relationship, vertical plane relationship, soft tissue relationship, intra arch dental relationship
- Class II – end to end, or full step (Mx DB cusp in Mn B groove)
  - Division 1 – accentuated OJ – usually end to end
  - Division 2 – acceptable OJ (Mx incisors usually retroclined) – usually full step
  - Subdivision – patient's left or right side
- Vertical dysplasias
  - Supraversion – teeth out of alignment, excessive eruption occlusally – deep bite
  - Infraversion – teeth out of alignment, insufficient eruption (doesn't reach occlusal plane) – open bite
- Etiology
  - Pathological, developmental, accidental, genetic, acquired
    - CLP (embryonic disturbance)
    - Congenital missing/supernumary teeth
    - Ectopic eruption, impactions
    - Early loss of primaries, caries
    - Trauma, habits
- Example Classification
  - Sagittal – class II, Division 1, Subdivision left
  - Transverse – unilateral left posterior crossbite
  - Vertical – anterior open bite

Cephalometrics 1

- Goals – evaluate relationships (horizontally and vertically) of 5 major functional components
  - Cranial base
  - Maxilla
  - Maxillodentoalveolar process
  - Mandibulodentoalveolar process
  - Mandible
- Standard cephalometric arrangement to standardize study of:
  - Skeletal relationships
  - Underlying malocclusion etiology
  - Pattern of craniofacial growth
  - Prediction on timing of maximum growth
- Completion of growth – Nasion-Menton should not change between 6 month cephalometric radiographs
- Cephalometric analysis
  - Soft tissue – facial contour, proportions, lip positions
  - Skeletal – Mx and Mn basal arches, AP and vertical relationships, Mn plane, facial plane
  - Dental – incisor/molar angulation, AP/vertical angulation, occlusal plane angulation, OJ and OB
  - Lateral – AP dysplasia, vertical dysplasia, incisor position/inclination, balance of soft tissue/facial contour
  - Frontal – transverse dysplasia, asymmetries

Cephalometrics 2

- Refer to diagrams in notes

Study Model Analysis

What to look for

- Symmetry – superimpose a plastic grid (or have computer do it), pay attention to subdivisions, look for midline deviations
- Occlusion – count teeth, check for patterns of surface wear
    - Sagittal, vertical, transverse – check for excessive, level, or reversed Curve of Spee
- Intra-arch
    - Space – crowding, spacing
    - Irregularities – size, rotations, translations
    - Tooth size

Space Analysis

- TSALD – tooth size arch length discrepancy
    - Space available – space required = amount of crowding or spacing
- Arch length available – measured with a brass wire, or sum of 4 segments (bilateral – 2 posterior, 2 anterior)
- Arch length required
    - Permanent dentition
        - Merrifield analysis
            - Arch length required = total dental width, measured M-D of each tooth summed
                - Mild = 1-3mm crowding/spacing
                - Moderate = 4-6mm crowding/spacing
                - Severe $\geq$ 7mm crowding/spacing
        - Irregularity index
            - Measure each overlap from M to M of the 2 bilateral first molars and sum the measurements – most commonly used for Mn anterior teeth in relapse studies
            - Reported as a length (mm) – higher the value, more severe the crowding
    - Mixed dentition
            - Must discover size of permanent teeth, and account for changes in arch size by growth
        - Moyer's analysis – based on Caucasians (tendency to overestimate)
            - Sum width of 4Mn incisors/2 – prediction of Mx and Mn Cs, PM1, PM2
                - Widths of C, PM1, PM2 provided in charts – no radiographs required
                - CI = 75% - 75% will have $\leq$ value, STD of $\pm$1mm
        - Tanaka Johnson's analysis – greatest variability of error (usually overestimates 2^{o} teeth size)
            - Sum width of 4Mn incisors/2 + 10.5mm = Mn C, PM1, PM2
            - Sum width of 4Mn incisors/2 + 11.0mm = Mx C, PM1, PM2
        - Radiographic method – need high quality X-rays, no effect of ethnicity
            - Radiographically measure MD width of unerupted permanent teeth
            - Use a scaling coefficient to account for distortion
            - (1^{o} Clinical width / 1^{o} rad width) x (2^{o} rad width) = estimated 2^{o} clinical width
                - Films must be // to MD crown axis (BW or PA, cannot use PAN)
                - Teeth must lie in same Bu/Li plane
                - Has poor estimation of canine M/D widths due to curvature

- Bolton Analysis – estimates tooth size discrepancy between Mx and Mn, related to perfect class I dentition
    - ~5% of population has size discrepancy, discrepancy <1.5mm rarely clinically significant
    - If there is a discrepancy, check for peg laterals
  - Mn excess (deficient OJ) – consider interproximal reduction of Mn incisors, or buildup of Mx incisors
  - Mx excess (increased OJ) – consider interproximal reduction of Mx incisors, or leave extra OJ
    - Class I canine with anterior crossbite or edge to edge bite – probably excess Mn anteriors
    - Class I canine with excess OJ – probably Mn anterior deficiency
    - Class I canine with crossbite – probably excess Mn anteriors – want to open space and restore it
  - Anterior ratio – sum of 6 Mn anteriors / sum of 6 Mx anteriors = 77.2%
    - >77.2% = excess Mn tooth size
    - <77.2% = excess Mx tooth size
  - Overall ratio – sum of 12 Mn teeth / sum of 12 Mx teeth = 91.3%
    - >91.3% = excess Mn tooth size
    - <91.3% = excess Mx tooth size

Removable Appliances

- Can be removed from the mouth by the patient

General Points

- Development in Europe
  - Little influence of Angle's classifications
  - Social welfare system – limited ortho treatment for the masses
  - Scarce precious metals available for fixed ortho work
- Advantages
  - Lab made – reduces dentist chair time
  - Oral hygiene easier – can be removed for cleaning
  - Can be removed for aesthetic occasions
- Disadvantages
  - Success is patient compliance dependent
  - Move only a few teeth at a time
  - Almost impossible to produce complex tooth movements

Take Home Messages

- Removable ortho appliances used for
  - Growth modification
  - Simple tooth movement in kids
  - Retention
- They consist of a
  - Framework
  - Retentive elements
  - Active elements
- Typically cheaper and easier to clean than fixed appliances, but can only create tipping forces
- Can be used as retainers to keep teeth in position after active ortho movement

Common Appliances

- Functional appliances – passive tooth-borne appliance for guiding growth
  - Similar to headgear (treats class II) – headgear moves Mx back, functional appliance moves Mn forwards
    - Each functional appliance, no matter what name, is simply a melding of wire and plastic parts
  - Passive – no intrinsic force generated from springs or screws
  - Changes posture of the Mn, pressures created by soft tissue stretch transmitted to bone – moves teeth and modifies growth (commonly used to correct class II retruded Mn)
    - Capping incisors blocks Mn incisor proclination
    - 1900s – Monobloc
    - 1920s – Activator
      - Block of plastic covers palate and teeth of both arches
      - Advances Mn for class II correction, opens bite by 3-4mm
      - Shelves between teeth provide vertical control, angled flutes in acrylic guide posterior tooth eruption

- 1960s – Bionator
  - Cut down activator with incisor capping and no palatal coverage
    - Omega wire covers the palate
  - Lingual flanges stimulate forward posturing of Mn
- 1960s – Functional regulator
  - Tissue borne, buccal shields and lip pads reduce pressure on teeth
  - Lingual pad dictates Mn position, buccal stretching of cheeks causing alveolar apposition via periosteal stretching
- 1970s – Twin block (popular in Britain)
  - Designed to be worn all day and to be used in function
  - Individual plates with ramps which guide Mn forward when patient closes down
  - Allows nearly full range of movement and reasonable speech
  - Mx plate usually includes expansion screw (expand as patient grows)
  - Also, grind down posteriors to allow supraeruption, add braces, fine tune
- Components approach – combine appropriate components that deal with specific aspects of patient's problems for custom designed appliance for individual

- Active plates – tooth borne appliances for tipping motion
  - Retention
    - Clasps – fits into undercuts for good retention, needed for plate retention
      - Adam's clasp – most useful and versatile for removable appliances
        - Molars and premolars, 0.7mm stainless steel wire
      - Arrow clasp – simple retention for removable appliances
        - Used in continuous row of teeth, 0.7mm stainless steel wire
    - Labial bow – retention of plate when in undercuts, limits tooth movement from springs, can be used for tooth movement when activated
      - Horizontally follows curvature of incisors
      - Vertically positioned in middle third of clinical crown
      - U-loops in canine region allow for activation – close loop to tighten the bow
  - Baseplate – complete or segmented
    - Made of acrylic – palatal coverage = main source of appliance anchorage
    - Can be configured to serve as a bite plane
    - As thin as possible for patient comfort
  - Active elements – screws and springs
    - Screws – opening with a key separates sections of the plate
      - Heavy rapidly decaying forces – not ideal for tooth movement (uncontrolled)
      - If force level is too high, the appliance gets displaced
    - Springs – contacts tooth at single point, creating tipping forces
      - Light continuous forces, must be guided to only exert action in desired direction
  - Early/interceptive treatment
    - Arch expansion – corrects posterior crossbite
    - Incisor tipping – corrects anterior crossbite
    - Space maintenance
  - Regular treatment
    - Simple cases needed only tooth tipping movement

- Retainers – usually passive and used after active treatment
    - Allows for small movements only because the rest of the retainer should be passing
    - Tooth borne appliance to prevent intra-arch instability after ortho treatment
        - Passive or active
        - Removable or fixed
    - Hawley Retainer – molar clasps and outer bow with adjustment loops from canine to canine
        - Preferred retainer in Mx, especially after palatal expansion
        - Minimal wirework crossing occlusion – allows for vertical settling
        - Horseshoe shaped baseplate – improved speech
        - Must consider pre-treatment situation before designing retainer – prevent relapse
    - Active removable retainer – realignment of incisors with spring retainer fabricated on a lab model where teeth were reset into alignment
    - Vacuum-formed retainers – cheap, less lab time
        - Occlusal coverage – blocks vertical settling (this is NOT good)
        - Should block 2nd molars – prevent anterior open bite from over eruption
        - Thickness of material may prove uncomfortable
        - Appliance bulk distal to canine prone to fracture
- Clear aligners/invisalign
    - Vacuum-formed sheets on casts with slightly reset teeth to fix mild irregularities
    - Sequence of casts can be made to incrementally correct irregularities with new vacuum-formed retainers made for each resetting
    - Invisalign – Align Technologies in 1990s, heavy marketing to public
        - Only treats mature dentition – growth changes cannot be predicted (not designed for kids)
        - Success requires patient to wear aligners 20-22h/day
            - If not worn, next set of aligners will not work – new set will be required
        - Tooth-colored composite attachments allow correction of severe malpositioned individual teeth

Good for	Bad for
- Mild crowding with IPR or expansion - Posterior dental expansion - Correction of mild spacing - Absolute intrusion of individual teeth - Lower incisor extraction for severe crowding - Simple movements only, not complex	- Dental expansion of blocked out teeth - Extrusion of incisors - Severe rotations - Relative intrusion - Molar uprighting - Molar translation - Closure of premolar spaces after extraction

    - Production Process
        - CT scan of impressions – create accurate 3D digital model
        - Digital sectioning of teeth
        - Movement of teeth following clinician's instructions
        - Preliminary plan placed online for clinician review as a ClinCheck
        - Transfer of digital models to a cast production facility where stereolithographic model for each step fabricated
        - Clear plastic retainers formed over each model
        - Aligners shipped to clinician

Fixed Appliances I

Configurations

- Standard edgewise – brackets at 90° to the wire (no tipping, torqueing, or in/out variations), all teeth get standard brackets
    - Most contemporary braces use standard edgewise
    - Wire bends to adapt to tooth/teeth malposition
- PreAdjusted (straightwire) edgewise – built for averages, may require small adjustments
        - Better than large adjustments starting from a scratch wire
    - Tip (mesial/distal) – angulation
        - Rhomboid shape, with the slot's angulation positioned to match roots/long axis of tooth
    - Torque (buccal/lingual) – inclination
        - Values are more negative as you move posteriorly in the Mn – want natural lingual inclination
    - In-out (distance between surface of tooth and bracket (thickness)) – offset
- Slot sizes – two types
    - 0.018" x 0.025" – stainless steel, but people used to gold dimensions preferred to keep 0.022"
    - 0.022" x 0.028" – originally for when gold wires were used

Types of Tooth Movement

- Occlusal/gingival
- Mesial/distal rotation
- Buccal/lingual (in/out)
- Mesial/distal angulation (tipping)
- Buccal/lingual inclination (torque)

Type of Archwire Bends

- First Order – visible from occlusal view
    - Adjusts in/out (buccal/lingual position)
    - Adjusts mesial/distal rotation
- Second Order – visible from lateral/frontal view
    - Adjusts occlusal/gingival (up/down)
    - Adjusts mesial/distal angulation (tipping)
- Third Order – twist in the wire
    - Adjust buccal/lingual inclination (torque)
    - Only possible with rectangular wires (not possible with circular ones)

Components

- Bracket (bonded or banded) – important to keep organized, so proper bracket goes on proper tooth
    - Archwire slot
        Closed – self ligating Open – requires ligatures
    - Tie wings – undercuts for elastic ligatures
    - Bracket base – bonded to tooth or band
    - Indicator dot – ALWAYS oriented to the distal gingival
    - Buccal tubes (for molars)
        - Mx – triple tube – auxiliary tube, main archwire tube, headgear tube
        - Mx – double tube – auxiliary tube, main archwire tube
- Archwire – energy is stored in the archwire for tooth movement
        - Wire gets distorted to fit malocclusion → slowly releases energy to move teeth as it restores itself to normal form/straightens out

Metal Alloys	Sizes – many different sizes
- Stainless steel – stiffest - TMA (β-titanium) – half as stiff as stainless steal - NiTi – half as stiff as TMA	- Rounds – 0.014", 0.018", 0.020" - Rectangular – 0.016x0.016", 0.016"x0.022", 0.019"x0.025"

- Ligatures
    - Elastic chain form
    - Wire ties

Fixed Appliances II

Auxiliaries

- Transpalatal Arch – removable or fixed (soldered) – spans between banded Mx first molars
        - Fisrt molars require banding with lingual auxillary tubes
    - Anchorage support
    - Molar rotation
    - Arch width adjustment
- Nance appliance
    - Acrylic button used to anchor Mx molar position
    - Typically used in mixed dentition to hold space
- Lower Lingual Arch – similar to TPA in concept
    - Arch width control
    - Anchorage control
    - Arch length management
    - May (or may not) contact incisors
        - If it doesn't contact incisors, allows for incisor movement to increase arch width
- Lip Bumper
    - Uses muscles to hold molars in place or tip them (usually to upright them)
    - Difficult to create molar translation, but tipping forces are possible

- Coil springs (stainless steel or NiTi) – placed over archwire
    - Used to open or close spaces
    - Can be combined with temporary alveolar implants for closing spaces
    - Metal wire ligatures on either side of the coil spring to prevent tooth rotation (remember, bracket is on facial of tooth, so forces applied through facial surface)
- Power thread (zing string) – elastic monofilament coil spring
    - Very technique sensitive – requires perfect square knot for attachment to coil spring
    - Must be active AFTER tie is completed; if tied incorrectly it is often passive after tie completed
    - Tooth attached to a [gold] chain and tied to the coil spring via a thread to activate the tooth
- Expanders
    - RME/RPE – rapid maxillary expander/rapid palatal expander (they are the same thing)
        - As rigid connection as possible to minimize tooth movement when active
        - Increase arch by separating mid-palatal suture
    - Quad helix (4 circles) – activated in the office, not at home (spring appliance, does not have a screw)
    - Pendulum appliance – moves molars backwards, can move other teeth distally afterwards
        - Always bonded to premolar occlusal surfaces for anchorage
- Herbst Appliance
    - Bars attached from posterior Mx to anterior Mn – forces Mn to occlude anteriorly

Elastics

- Class I – intra-arch – closes spaces inside an arch
- Class II – class II malocclusion – pulls Mx back and Mn forward
    - Control the vertical force component, or may cause supraeruption and give patient a gummy smile
- Class III – class III malocclusion – pulls Mx forward and Mn back
- Vertical – used to correct open bites
- Anterior cross elastics – used to correct crossbites
    - Do not use for a long time (3+ months) or patient's occlusal plane may kant
- Posterior cross elastics
- Posterior box – used to close larger vertical open areas

Separators

- Metal springs/elastics placed into proximal contacts
- Coil springs attached to temporary alveolar bone implants
    - Stretched – closes spaces as it comes together
    - Compressed – opens spaces as it pushes apart

Construction, Debonding, Debanding

Separators

- Brightly colored radiopaque separators used to open proximal contacts to allow for band seating
- Should not be used for longer than 2 weeks (usually 2-7 days, longer may cause attachment loss)
- Elastic separators work 95% of time – if elastics separators don't work, use elastic springs
    - Place between beaks of separating pliers, stretch, snap one side through contact
    - Use 2 loops of floss, stretch separator, snap floss through contact and pull separator underneath contact, pull separator up to snap one side through contact, remove floss

Banding vs Bonding

    - Until 1980s, only way to secure a bracket was to band the tooth
    - Now, only routinely banded teeth are Mx molars
- Banding Indications
    - Teeth receiving heavy intermittent forces against attachments – headgear
    - Require attachment of intraoral or extraoral auxiliaries – transpalatal arch
    - Need both labial and lingual attachments
- Ideal band position
    - Parallel to cusps and marginal ridges – all cusps are equally visible
    - Band margins just below marginal ridges and above contact points
    - Tube straddles buccal groove mesial-distally, perpendicular to long axis of the tooth
- Adhesives for Bands
- Ideal bracket position (use of a PANO helps locate roots and gives better idea for ideal placement)
    - Center of clinical crown
    - Bracket slot parallel to incisal edges/marginal ridges
    - Tie wings parallel to long axis of tooth
    - Inaccuracies
        - Horizontal error – unwanted tooth rotation
        - Axial error – unwanted tooth tipping
        - Thickness error – improper torque/rotation
        - Vertical error – extrusion/intrusion, torque error, in/out error
- Adhesives for bands – light cure adhesive systems used in ortho
    - RMGIC for othro use – light cured, greatly reduces problems with leakage beneath bands and allows for control of working time
    - 2part powder/liquid GIC for ortho use – dual cure from visible light and chemical causes rapid set, better bond strength than light cured cements
    - Sandblasting – increases bond strength and mean survival time, reduces clinical failure rate
    - Bonding to non-enamel – roughen surface with micro-etch, diamond, or green stone
        - Bond metals and ceramic brackets to enamel
        - Resin based primer penetrates into enamel rods
        - Possible to add pontics to fill spaces temporarily – for patient esthetics

- Bonding – >90% of orthodontists in USA use direct bonding with light cured resins with a median fail rate of 5%
    - Clean the tooth – pumice to remove plaque and organic pellicle
    - Pre-select appropriate band size using patient plaster casts as a guide
    - Remove separators, trial seat and adapt the bands to the teeth
    - Remove bands and thoroughly clean and dry teeth and band before bonding
    - Cover occlusal openings with tape, fill attachments and tubes to prevent obturation with cement
    - Label bands, mix cement, apply to inner surfaces of bands
    - Seat bands in ideal position, clean off excess cement with cotton rolls, pellets, and scalers
    - Keep cement layer between tooth and band as thin as possible
- Enamel surface preparation
    - Use cheek retractors and saliva ejector to keep area dry, better environment for adhesives
    - Etch 37% phosphoric acid (blue to contrast with tooth, gel so it stays on tooth) for 15s anterior, 30s posterior, rinse thoroughly, dry thoroughly – etched areas should appear frosty white (if not, etch again)
    - Apply thin coat of primer
    - Have adhesives on bracket before placement – adhesive pre-coated brackets are available
    - Place slight excess adhesive on bracket base, place bracket on tooth in correct position
        - Bracket at midpoint of clinical crown, tie wings parallel to long axis
        - Push bracket firmly toward tooth surface – extrudes excess cement
        - Remove excess adhesive with explorer or scaler
        - Check vertical position using a bracket gauge
    - Light cure from ALL sides – time depends on bracket type, adhesive, and light source
    - Recheck bracket position
    - Tie in archwires

Debanding/Debonding

- Debanding – band remover pliers
- Debonding metal brackets
    - Debonding pliers – used to deform metal base to collapse bracket
    - Lift-off debonding pliers – high risk of enamel damage
    - Weingart pliers – used to deform metal base to collapse bracket
    - Ligature wire cutter
- Debonding ceramic brackets – increased risk of shattering (danger to eyes)
    - Position tips against mesial and distal sides of brackets
    - Gently squeeze bracket until it collapses
    - Gently rock mesial/distally to completely separate from enamel
    - Ideally, adhesive stays on the tooth (bond between bracket/adhesive should be weaker than between tooth/adhesive)
- Post-debonding polishing
    - Spiral fluted carbide finishing bur in low speed with light pressure and painting motion
    - Prophy paste or pumice slurry with rubber cup
    - Brown and green polishing cups for highly polished final clinical appearance
    - Prophy polisher for enamel polish – optimum at 6,000rpm, no air/water spray necessary for cooling

Clinical Example

- Remove bracket by creating fracture between adhesive and bracket base
    - Keep archwire in place – pop off brackets THEN remove the bands (holds everything in 1 piece)
- Break cement attachment, life band off tooth by elevating buccal and lingual surfaces with band-removing pliers
- Remove excess adhesive, polish tooth

Polishing Effects

Surface cleaning	Acid etch	Low speed	High speed	Polish	Enamel thickness
5um	7-20um	10um	20-25um	10um	1500-2000um

Take Home

- Separators create space between teeth for band fitting and cementation
- Bands routinely used only for teeth that require attachment of intraoral or extraoral appliances
- Brackets used on all other teeth, can be bonded to enamel and non-enamel surfaces
- Ortho fixed appliances causes minimal enamel wear/loss

Treatment Timing

- 2 phase treatment for problems that are appropriate for early referral/treatment
- 1 phase treatment for problems solvable in early permanent dentition

Progressive Discrepancy

- Increase in problem severity/treatment difficulty over time
  - Recommend 2 phase treatment
- Habits (thumb/finger sucking) – hard to break habit after age 9, especially in females
- Anterior crossbite – fix before incisal facial wearing affects esthetic appearance
- Mild/moderate class III – palatal arch expansion/headgear
  - Severe class III requires surgery
- Moderate/severe space deficiency – arch expansion
  - Extraction of primary teeth for temporary solution
- Unilateral posterior crossbite with shift – Intervene before TMJ remodels
  - If the TMJ remodels, will make shift permanent

Stable Discrepancy

- No increase in problem severity or treatment difficulty over time
  - Recommend 1 phase treatment
- Mild/moderate crowding
- Most class II problems (with mixed dentition and no significant spacing concerns)
- Deep bite – only if you see a soft tissue effect
- Mild open bite

Biomechanics

Important Concepts

- Force = mass x acceleration = load applied to an object that tends to move said object
  - Major components
    - Magnitude (N) = in ortho, measured in grams [negligible in tooth movement]
      - Varies with type of tooth movement
      - Light, continuous forces considered most effective in inducing tooth movement, undermining resorption occurs if too great a force is applied too fast
        - Tipping = 35-60gm
        - Translation = 70-120gm
        - Root uprighting = 50-100gm
        - Rotation = 35-60gm
        - Extrusion = 36-50gm
        - Intrustion = 10-20gm
    - Direction – X, Y, Z components
      - Force is a vector, can be broken down into its directional components
    - Point of Application – one point along line of action (ortho bracket)
      - Moment = tendency of a body to rotate when force is applied
        - Units = Nmm (gmm), direction is either clockwise or counterclockwise
- Center of Resistance
  - Ideally 1/3 distance from alveolar crest to apex
  - For multirooted teeth, center of resistance is just apical to the furcation
  - For individual tooth, center of resistance doesn't change unless apex or crestal bone changes
  - Consider
    - Number of roots
    - Degree of crestal bone loss
    - Root/apical resorption
- Center of Rotation
  - Point at which rotation occurs
  - Most often does not match center of resistance, but is possible

Results of Force Application

- Pure translation
  - Center of rotation at infinity (far away from the tooth) – essentially no rotation
  - All parts (root and crown) moving in the same direction
- Pure rotation
  - Center of rotation = center of resistance
  - Root and crown move in opposite directions
- Controlled tipping
  - Center of rotation just apical or matching root apex
  - Tipping, both crown and root moving in same direction
- Uncontrolled tipping
  - Center of rotation between center of resistance and root apex
  - Tipping, crown and root moving in opposite directions

Fixed Appliances

- Type of movement depends on moment to force ratio
- Most forces applied to crown = causes tipping motion
    - To get desired motion:
        - Increase magnitude
        - ID center of rotation, place in desired location (control moment/force ratio)
- Moment/force ratio
    - Translation – create a moment and apply it so it cancels out the moment caused by primary force
        - Using a thicker wire fully engages slot – allows placement of center of rotation more towards infinity (further from the root)
    - Final result ultimately based on biological response of teeth and tissues (perio, bone, etc)
    - Magnitude of force is vital

Removable appliances

- Only tipping motions, usually uncontrolled tipping

Biomechanical Examples

- Intrusion arch – used when there is a deep bite promoted by all teeth (very rare)
    - Fx – proclines incisors, distally tips molars (not seen in type 1)
    - Fy – anterior intrusion, molar extrusion
    - Fz – not significant
- Power chain space closure
    - Fx – canine moves distally, molar moves mesially
    - Fy – not significant
    - Fz – canine rotates distolingually, molar rotates mesiolingually
        - Always use 2 parameters when describing rotation – surface/cusp and direction it is moving
        - Prevent rotation with stainless steel ties
- Class II elastics
    - Fx – Mx canine moves distally, Mn molar moves mesially
    - Fy – extrusion of both canine and molar
    - Fz – Mx canine rotates distolingually, Mn molar rotates mesiolingually
        - Place elastic on lateral incisor and 2nd molar – greater X component, smaller Y component
- Class III elastics
    - Fx – Mn canine moves distally, Mx molar moves mesially
    - Fy – extrusion of both canine and molar
    - Fz – Mn canine rotates distolingually, Mx molar rotates mesiolingually
- Molar uprighting from orthodontics – takes 6-12 months
        - Improves direction and distribution of occlusal loads (increases restoration durability)
        - Decreases tooth reduction needed for parallel abutments
        - Decreases probability for endo, perio, or advanced prosth procedures
        - Removes plaque-retentive areas – increases perio health
        - Improves alveolar contour and crown/root ratio
    - Fx – not significant
    - Fy – anterior intrusion, molar extrusion
    - Fz – uprights molar, proclines anterior segment

Anchorage

Principles

- Differential force theory – rate of tooth movement related to force/unit area of root surface
  - Tooth with more root surface area have higher resistance, therefore higher anchorage
- Relationship between surface area and tooth movement is NOT linear
- Tooth movement increases with increased applied force, but has a maximum
- Optimal level exists after which there is no increase in movement, only in strain on anchor units

Assessing Requirements

- Anchorage available in an arch is related to space in that arch, usually an extraction space
  - How much space is needed to complete the correction?
  - How much might the anchor teeth move?
- Group A – anterior retraction
  - High anchorage needed in posterior – maximum posterior anchorage
  - Retraction of anterior teeth without mesial posterior tooth movement
- Group B – equivalent retraction/protraction – reciprocal anchorage
  - Moderate anchorage needed in posterior
  - Equal movements of anterior and posterior movements distal and mesial, respectively
- Group C – posterior protraction – maximum anterior anchorage
  - No anchorage in posterior
  - Protraction of posteriors without distal movement of anterior teeth

Anchorage Control

- Differential response to pressure allows for moving some teeth more than others, though unwanted tooth movements will still occur

1. Reinforcement
   - Addition of teeth to anchorage unit – increases root surface area, dissipating force over more teeth
   - Addition of teeth from opposite arch via elastics (intermaxillary traction)
2. Subdivision of desired movement
   - Pit resistance of a group of teeth against movement of single toth
     - Move canine back individually, add it to anchorage group, then move back incisors
3. Friction control strategies

Supplemental Anchorage

- Extraction decision
- Non-dental sources of anchorage – if structures other than teeth are used for anchorage, possible to produce wanted movement without creating any unwanted movement
  - Intraoral sources
    - Mucosa and underlying bone
      - Pendulum/pendex appliance – moves posterior teeth back without moving other teeth too far forwards
      - Nance appliance
    - Soft tissue and perioral musculature
      - Lip bumper

- Extraoral sources
  - Forehead, basal bones
    - Protraction facemask – reverse pull headgear, anteriorly pulls Mn forwards
  - Cranial vault, occipital bone, neck
    - Headgear – posterior forces Mx back
      - Has an inner and outer bow
      - Inserts into headgear tube on molar band
      - Exerts distal force on molars
- Skeletal (absolute) anchorage
  - Temporary anchorage devices
    - Osseointegrated implants
      - Palatal implants need 3-6 months to osseointegrate
    - Miniscrews – titanium screws that penetrate through gingiva into alveolar bone, but no osseointegration needed (can be loaded immediately)
      - Distalize anterior teeth w/o moving molars forward (good for severe class II)
      - Absolute intrusion – must be placed on both B and L to avoid tipping tooth
    - Miniplates/bone anchors – placed beneath soft tissue, usually in zygomatic buttress area of Mx

Uses of Headgear

- Orthodontic anchorage
  - 100g/side
  - Hold position of Mx posterior teeth in the arch
- Tooth movement
  - 150-250g/side
  - Distalize Mx molars
- Growth modification
  - 500g/side
  - Create differential growth between Mx and Mn
- Vertical effects of headgear can negate forward Mn growth

- High pull – occipital
  - Level of force through the center of resistance = backward upward translation of molar
    - If combined with short facebow and a Mx splint, causes Mx rotation
  - Level of force below or above center of resistance = crown or root tipping
- Low pull – cervical
  - Level of force through center of resistance = backward downward translation of molar
  - Level of force below or above center of resistance = crown or root tipping
  - Negative effect = clockwise movement of Mn
- Straight pull – both occipital and cervical
  - Level of force through center of resistance = backward translation of molar

Class I Treatment

US Population

- 30% normal occlusion
- 50-55% class I malocclusion
- 15-20% class II malocclusion
- 1% class III malocclusion

- Etiology – genetics, tooth size discrepancy (Bolton analysis), big/small jaws, # of teeth, shape of teeth, inappropriate function, rotations, vertical problems, condylar fractures, congenital anomalies, etc

Treatment Planning Factors

- Chief complaint
- MHx, medications
- Internal motivation, realistic expectations
- Perio, prosth, restorative, other dental needs
- Crowding, incisal position/inclination, Bolton discrepancy, OJ, OB, transverse and vertical relationships
- Facial proportions, soft tissue
- Growth potential
  - Class I malocclusion patients don't need any growth modification

Treatment Timing for Class I

- No need to modify growth
- Usually best started in late mixed/permanent dentition stage
  - Minor problems can be fixed later (Adult stages – avoid uncompliant teen stage)
- Transverse problems (orthognathic problems) should be treated earlier
  - Orthopedic palatal expansion before palatal suture closes
  - Lateral and anterior shifts treat immediately before TMJ remodeling to avoid permanent assymetry
  - Lateral shift – unilateral crossbite where there is actually bilateral crossbite, bit hidden by shift
- Vertical growth problems (habits) may need to be addressed earlier
  - Open bites are more problematic than deep bites, unless there is perio damage or palatal impingement
- Severe crowding (>10mm) may benefit from serial extraction in mixed dentition stage

Potential Problems and Treatments

- Arch-space discrepancy
  - Crowding – IPR, extractions, dental and/or skeletal expansion
  - Spacing – close spaces (retention, Bolton analysis, anchorage requirements, restorative plan)
- Antero-posterior discrepancy – no posterior discrepancies in Class I malocclusion (molar relationship), so problems are in anterior region
    - Skeletal class I – normal ANB and facial convexity
    - Dental class I – class I molars
  - Bimaxillary dentoalveolar prognathism (Jaws are in Class I, but are prognathic to cranial base – common in African Americans) – extraction
  - Anterior crossbite – extraction, incisor advancement, Bolton
  - Excessive OJ – incisor advancement, space closure, Bolton

- Transverse discrepancy
  - Posterior crossbite (buccal and lingual crossbites) – lingual crossbites more common
    - Skeletal posterior crossbite – Mx expansion via opening of midpalatal suture
    - Dental posterior crossbite – removable appliances, expanding archwires, cross elastics
  - Bilateral buccal crossbite (scissors bite) – Mn completely tucked under Mx – very rare
    - Scissors bite – dental expansion of Mn arch, constriction of Mx arch, surgery
- Vertical discrepancy
  - Deep bite
    - Incisor intrusion, leveling curve of Spee, extrusion of posteriors to open the bite
  - Anterior open bite
    - Extraction mechanics usually deepens bite (wedge theory)
    - Surgical impaction of Mx for gummy smile, reduce lip strain
    - Incisor extrusion, level curve of Spee, intrusion of posteriors to deepen the bite
- Tooth anomalies (form, #, position)
  - Open/consolidate space of missing teeth
  - Create space for impacted teeth, then expose/bond and bring into the arch
    - Open the space first before asking the surgeon to expose the canine
- Soft tissue problems
  - Bimaxillary dentoalveolar prognathism
  - Lip/mentalis strain (strain when lips are sealed together) – 1st premolar extraction. retract anteriors
  - Gummy smile
    - Short upper lip – nothing can be done to treat, everything looks good but when they smile there's lots of gingiva displayed
    - Upper lip hypermobility – treat with botox
    - Gingival hyperplasia – perio surgery

Extraction vs Non-Extraction

- 0-4mm crowding = IPR, expansion, incisor advancement and proclination
  - Only extract if there is severe incisor protrusion or severe vertical discrepancy
    - Also for patients with bimaxillary prognathism who want their "full lips" corrected
- 5-9mm = both non-extraction and extraction techniques
  - Extraction dependent on patient's hard and soft tissue characteristics, incisor position/angulation
  - Nonextraction requires transverse expansion across molars and premolars
- >10mm = premolar extraction needed

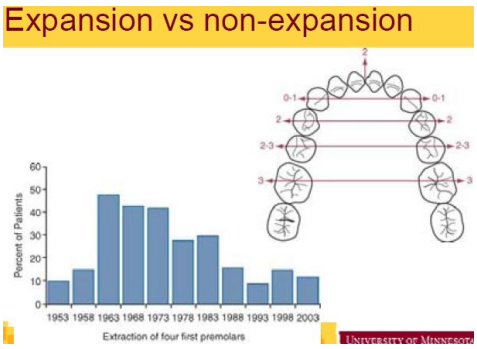
Extraction Options

- Option 1 – extract 4s (1st premolars)
  - Maximum posterior anchorage, maximum retraction of anterior teeth
  - Good for bimaxillary prognathism
- Option 2 – extract 5s (2nd premolars)
  - Less anchorage, less anterior teeth retraction
  - More difficult to correct anterior crowding
  - Can help treat open bites – "wedge theory" = 5s are closer to hinge; let molars move mesial to close anterior openbite
  - Good for open bites and hyperdivergent Mn (steep Mn plane)

- Serial Extraction – patients who fit all criteria are very rare
    - First extract certain deciduous teeth, then later on some permanent teeth
        - Does NOT avoid braces – avoids CROWDING
    - Common for people with congenitally missing 2nd premolars with crowding
    - For skeletal class I, normal OB (or open bite tendency), severe crowding (>10mm), all teeth present radiographically with good eruption positioning
    - Patients between 8-9y/o, incisors are crowded
    - Subsequent orthodontic treatment REQUIRED
- Dewel's Method
    - Very simple, but has lots of risks – rarely done because of the risks
    - Extract deciduous canines to create space for incisors (tongue pressure will usually align incisors)
    - Extract deciduous first molars to aid in quick first molar eruption
    - Extract first premolars to create space for canines
    - Modified Dewel's
        - First premolars are enucleated during extraction of first deciduous molars – expedite eruption of canines (more often used in Mn)
    - Risks
        - Deepening the bite
        - Possible loss of space via mesial migration if there is an eruption delay
        - Poorly executed serial extraction may worsen the case

Other methods to resolve crowding

- IPR – consider when, how, and where to do IPR
- Mx Expansion – requires seeing if the palatal suture is closed already (age 13-15)
    - Slow? Rapid? Surgicall assisted (SARPE – surgically assisted rapid palatal expansion)?
    - True expansion? Dental expansion?
    - Other considerations – appliance design, nasal cavity, retention, etc



Appliances

- Fixed
- Removable
    - Invisalign – alone or combined with regular braces
    - In-house active trays
    - Spring aligners
    - Active retainers

Class II Treatment

Treatment Planning Factors

- Same etiology as Class I, except there is an A-P posterior dysplasia
  - Requirement to ID which jaw is at fault
  - Need to understand growth potential and patient compliance
- For othognathic patients, need to ensure growth completed before surgery
  - Take cephalometrics every 6 months and superimpose to check for completed growth

Potential Problems

- Antero-posterior discrepancy
  - Increased ANB and facial plane
- Class II Division I
  - Dental problems
    - Class II molars and canines
    - Excessive overjet, often flared incisors
    - Can be deep, normal, or open bite
    - Subdivisions (left or right)
  - Skeletal Problems
    - SNA and SNB
      - Greater SNA – Mx prognathism
      - Greater SNB – Mn retrognathism
      - Can also have combination
    - ANB > 4^{o}
    - Facial convexity greater than 15^{o}
  - Habits
    - AAPD – thumb sucking for $\geq$ 3 years to cause malocclusion
- Class II Division II
  - Dental problems
    - Class II molars and canines
    - Incisors retroclined, limited overjet
    - Lateral incisors/canines flared labially
    - Subdivisions (left or right)
  - Skeletal problems
    - SNA and SNB
      - Greater SNA – Mx prognathism
      - Greater SNB – Mn retrognathism
      - Can also have combination
    - ANB > 4^{o}
    - Facial convexity greater than 15^{o}
    - Often with hypodivergent growth pattern and DEEP bite

Class II Treatment Strategies

- Growth stimulation – larger than what would normally be, causes MORE growth in a period than would have been expected without treatment
  - Does NOT occur in orthodontics
- Growth modification – differential acceleration of growth (functional appliances) or restraint of growth (headgear) – headgear effect = functional appliances tightens lips, restrains Mx growth
  - THIS is used in orthodontics

- Differential growth
  - Facilitation of growth – functional appliances worn for 16-20h/day
  - Restraint of growth – headgear worn for 12-14h/day (better/easier compliance)
    - 150g force to move molars
    - 500g force to cause skeletal effect
    - High pull – good for open bite, moves teeth posteriorly and intrudes them
    - Cervical pull – good for deep bites (hypodivergent, flat Mn plane, horizontal growth), moves teeth posteriorly and extrudes them
    - Combination – for people with a good bite, moves teeth backwards only
- Dental movement
  - Dentoalveolar compensation
    - Used when extractions are not indicated
    - For mild problems (50% for class II molars)
    - Better for growing instead of non-growing patients
    - Class II mechanics – tends to bring forward Mn and procline Mn incisors
    - Is UNSTABLE if excessive tooth movement occurs
  - Molar distalization
    - Headgear, fixed molar distalizers, trans-arch distalization
    - Mild skeletal problems, designed to finish with class I molars and canines
    - Only used if facial height permits

- Extraction therapy
    - Mild/moderate compromised skeletal relationship
    - Usually involves upper first premolars
    - Designed to finish in Class I OR class II molars, only class I canines
        - Decisions options – facial appearance, degree of crowding/protrusion and proclination of Mx incisors, open bite tendency
    - Extraction of Mx 4's – correct malocclusion while making the soft-tissue discrepancy less apparent
        - Resolve Mx crowding, less compliance required
        - Finish in Class I canines, class II molars
    - Extraction of Mx 4's and Mn 5's
        - Lower anteriors with moderate crowding or proclined
        - Lower 2nd premolar space used for correcting crowding/retraction of anteriors as well as to mesialize into Class I
        - Finish in Class I canines and class I molars
    - Extraction of Mx 4's and lower incisors
        - Adults with moderate/severe lower anterior crowding
        - Resolves crowding to get class I canines
        - Bolton discrepancy created – may finish with excessive overjet
- Orthognathic therapy
    - For patients who have stopped growing and/or to camouflage extraction treatment is not indicated
    - Pre-surgical orthodontics (decompensation) for 12-18 months, then post-surgical treatment to finalize occlusion (6 months)
    - Importance of clear treatment plan – direction of tooth movement and extraction pattern, definitive and cannot be reversed
    - Typical procedures include BSSO and/or LeFort I Maxillary impaction
    - Mandibular advancements up to 12mm are possible
    - For severe problems, mandibular advancement can be done at age 14-15 (psychosocial aspect)

Summary

- Extraction treatment can be effective if used when indicated
- Non-extraction treatment with excessive movement of teeth within their bony bases is unstable
- Orthognathic surgery when problems are severe or not suitable for growth modification (adults) or extractions

Class III Treatment

Treatment Planning Factors

- <1% of the population, same etiology as others, except there is a strong genetic/hereditary component
  - Check for mom and dad's history of ortho treatment, compliance, etc
- Mesial relationship of Mn teeth to Mx arch
    - Know the cusp/fossa relationships of class I, II, and III
  - ANB <2^{o} – overjet is end-to-end or negative
  - Straight to concave profile
- Potential dental compensations – because of function (eating, speech). May be associated with GERD, may have speech pathology
  - Proclined Mx incisors
  - Retroclined Mn incisors
- Very common conditions in craniofacial patients

Potential Discrepancies (Not just these 3, best to intervene early)

- Class III dental – anterior crossbite, retroclined Mn incisors, pseudo class III
  - Treat early
- Class III skeletal (growing patient) – Mx retro, Mn prognathism
  - Treat early, growth modification, Mx protraction/chin cup
- Class III skeletal (non-growing patient) – Mx retro, Mn prognathism
  - Treat later – potential surgery

Treatment Planning Factors

- Chief complaint
- Medical history/medications
- Internal motivation, compliance, realistic expectations
- Perio, prosth, restorative, other restorative needs
- Crowding, incisal position/inclination, Bolton discrepancy, OJ/OB, transverse and vertical relationships
- Facial proportions and soft tissue
- Growth potential
- Growth modification should be done early, treat before age 10
  - Need to differentiate true Class III from pseudo class III (class I with anterior shift when closing, causing appearance of class III)
- More significant skeletal discrepancies may need to be monitored until growth is completed
  - Skeletal assessment – 6 month serial cephalometrics, no skeletal changes is gold standard
- Continued Mn growth during treatment or after treatment makes prediction of class III treatment difficult
  - Class III treatment is potentially the most complicated and difficult treatment
  - Post-pubertal Mn growth can mis-align jaws/teeth, even after ortho therapy. Some orthos leave excessive overjet (similar to class II) to compensate for future post-pubertal Mn growth
- Pseudo Class III – CR/CO discrepancy, anterior shifting of the Mn forward, commonly due to anterior interference even though patient is class I

Class III Treatment Strategies

- Consider questions
  - Skeletal discrepancy, dental, or both?
  - Is a shift present?
  - Which jaw is at fault? Or both?
  - Mild, moderate, or severe?
    - For severe cases, intervene quickly with growth modification, or else expect an orthognathic case – mild/moderate is case dependent
  - Growth and growth potential?
- Differential growth
  - Differential promotion of growth – protraction facemask (reverse pull headgear)
    - 250-450g, 12-14h/day, downward and forwards force
      - Promotes forward movement of Mx teeth relative to Mx, downwards ad backward rotation of Mn
    - Create hyperdivergent Mn plane, hard to treat Class III open bites because of this
      - Indicated for normal positioned teeth, retrusive upper incisors, brachyfacial (short face form)
  - Differential growth restraint/redirection – chin cup, functional appliance
    - Chin cup – 350-450g, 14-16h/day, redirected Mn growth downwards
      - Increases facial height for decreased chin prominence, works best for brachyfacial patients (best for Class III with deep bite)
    - Functional appliance
      - Similar to chin cups – rotates Mn downward and backwards
        - Only redirects growth, doesn't stop/promote growth
      - Requires 20-24h/day, is a compliance problem
- Dental movement
  - Dentoalveolar compensation – elastics, only for moderate tooth movement within the socket
    - Mild problems
    - Finish up treatment
    - Can be used on growing or adult patients (works better on growing patients)
    - Results are unstable if used to create excessive tooth movements
  - Mx dental protrusion/Mn dental retrusion
- Extraction therapy
  - Mild to moderate compromised skeletal relationship
  - Usually involves lower first premolars
    - Finish in class I molars and canines OR class I canines and class III molars
  - Extraction of Mx 5's and Mn 4's
    - Lower anteriors with moderate/severe crowding/proclination
    - Upper 2nd premolars used to mesialize molars to class I
    - Finish with canine and molar class I
  - Lower incisor extraction
    - Often in adults with moderate/severe lower anterior crowding
    - May or may not mask skeletal apperanace
    - Creates a Bolton discrepancy – only corrects anteriors, ends with class III molars

- Orthognathic surgery
    - For when patient has stopped growing, or camouflage extraction treatment is not indicated
    - Pre-surgical orthodontics (decompensation) for 12-18months
        - Patient will look worse before they look better because of decompensation
            - Ortho to correct teeth in relation to jaw, then orthognathic surgery will relate jaws correctly
            - Post-surgical, keep braces on for minor modifications, will use lots of elastics
    - Post-surgical finalization for 6 months
    - Importance of clear treatment plan – direction of tooth movement and extraction pattern