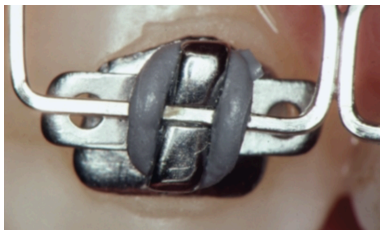
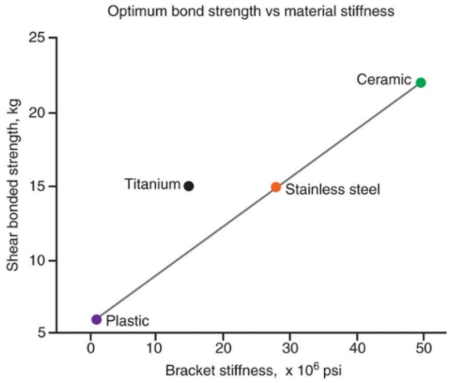
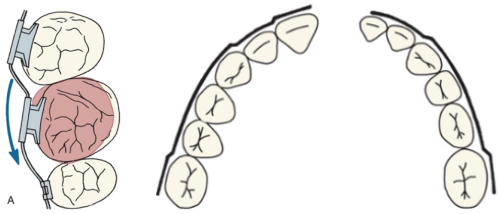
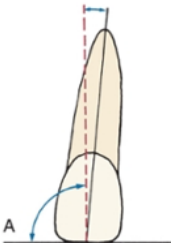
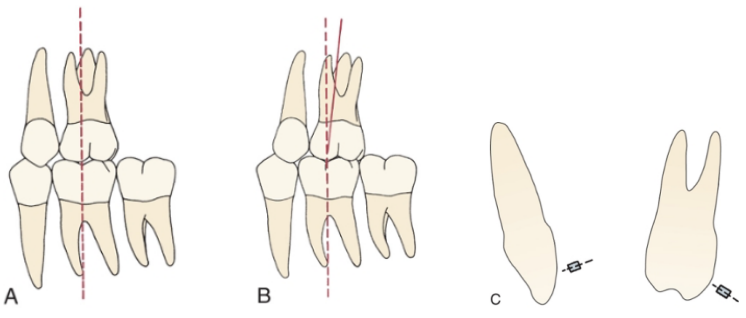
	• Twin 10 mil steel archwires for alignment of the incisors, protected by long tubes which extended forward from the molars to the canines. - <u>Begg Appliance: (Australia, 1940-1950)</u> • = Modification of the ribbon arch attachment: ○ Precious metal ribbon arch replaced with high-strength 16 mil round stainless steel wire. ○ Brackets turned upside down → Bracket slot pints gingival. ○ Auxiliary springs for control of the root positions. • Minimal friction (small contact between the archwire and the bracket). • Binding minimized with the technique of tipping / uprighting = angle of contact between the wire and the corner of the bracket minimized.  • Anchorage control similar to Tweed: 2 steps to compensate for resistance to sliding. • Popular in the 1960s, because it was more efficient than the edgewise appliance of this time. • Still in use, but often in a hybrid form with brackets that allow the use of a rectangular wire. - <u>Charles Tweed (US, 1940-1950):</u> • Adapted Angle's edgewise appliance to extraction tx. • Anchorage control with the subdivision approach: 2 steps to compensate for resistance to sliding.
Contemporary edgewise	- More efficient than the Begg appliance. - Automatic rotational control: • Use of twin brackets or single brackets with extension wings that contact the underside of the archwire.  • No use for additional ligatures (compared to Angle). - Alterations in bracket slot dimension: Mainly 18 or 22 mil. - <u>Straight-wire prescriptions by *Andrews (1989)*</u>: Bracket modification for specific teeth to eliminate the many repetitive bends in archwires: • **First order / in-out bends:** Built in the bracket base itself by varying the thickness of the base. Faciolingual bends are not completely eliminated because of individual variations in tooth thickness. • **Second order / tip bends:** Mesiodistal position of the root given by the angulation of the bracket or bracket slot in relation to the long axis of the tooth. • **Third order / torque bend:** Bracket slots are inclined to compensate for the inclination of the facial surface. • Angulation and torque values built in the bracket = **appliance prescription.** → Precise position only of average teeth.

Bands for attachments	- <u>Indications for banding:</u> • Teeth that will receive heavy intermittent forces against the attachments (e.g. HG): → Better resisted by a steel band than by a bonded attachment. • Teeth that need both labial and lingual attachments. → Isolated lingual attachments are at risk to be swallowed or aspirated if something becomes loose. • Teeth with short clinical crowns: → Bands can slightly displace the gingiva as they are carried into proper position • Teeth with extensive restorations (low bond strength on porcelain…) - It is not appropriate to place routinely bands on all teeth! - Avoid bands in periodontal compromised patients. - Trend to bond attachments on all teeth instead of bands. - <u>Steps in banding:</u> 1. Separating spring 1 week or elastomeric separators for several days (not >2 w). 2. Place the band by hand on the m/d surface, bring it down close to the height of the marginal ridge. 3. Drive the band into place by pressure on the mb and distolingual surface. (preformed bands are designed to be fitted in a certain sequence by the manufacture's instruction) 4. Bite force on the distolingual corner. The force should be supplied by the masticatory muscles of the patient → Patients can bite harder and with more control. 5. Cement: composite of glass ionomer and resin material. Coat all interior surfaces. Cover the collar surface so that the cement is expressed from the gingival and the occlusal margins. - Fitting a band involves stretching the ss over the tooth surface. → This simultaneously contours and work-hardens the initially rather soft band.
Bonded attachments	- Bonding is based on mechanical locking of an adhesive to irregularities in the enamel surface and mechanical locks formed in the base of the orthodontic attachment. - Preparation of the tooth surface: 1. Remove pellicle. 2. Etch 20-30 s with 37% unbuffered phosphoric acid: → A small amount of the softer interprismatic enamel is removed and pores between the enamel prisms opened. Immediate remineralization in case of contamination with salvia. - Surface of attachment: Bracket base is manufactured to achieve a mechanical interlock between the bonding material and the attachment surface. - Ceramic brackets: Chemical bonding or mechanical interlocking is possible. → <u>High strength of chemical bonding can become a problem for debonding.</u>
Bonding materials	- Characteristics: ○ Dimensionally stable. ○ Quite fluid that it penetrates the enamel surface. ○ Excellent inherent strength. ○ Easy to use clinically. - Standard: = light-activated acrylic resins (bis-GMA). - Trend towards self-etch primer adhesive resin cements. (difficult to receive enough bond strength up to now) - **Modified glass-ionomer cements:** ○ Less decalcifications around the brackets due to fluoride release. (no RCT available, but convincing indications in other studies) ○ Cave: Less strength even when some composite resin is included in the bonding material ○ Increase of bond strength: ▪ 1. 25-30 s phosphoric acid etching

	▪ 2. **5% NaOCl** to deproteinize the enamel surface ▪ 3. 15-20 s phosphoric acid etching o The glass-ionomer part of an adhesive takes 24 h for settling.
Direct bonding	- = Bracket position is determined intraorally by the clinician. - Pro: Efficient for reposition of a single bracket, easier, faster, less expensive. - Contra: Not as accurate placement of the brackets, less opportunity for precise measurement of the bracket's position.
Indirect bonding	- = Placing the brackets on dental casts. Use a template / try to transfer the bracket positions to the patient. - Bonding material: o **Chemical cures resin:** - All brackets cure simultaneously. - Risk of excessive resin. o **No mix" chemical activated materials** (composite resin on the tooth surface in unpolymerized form, polymerization catalyst on the back of the brackets) - Excessive resin around the brackets' bases does not polymerize. - Bond failures ↑ (polymerization depends on diffusion). o **Flowable light-cured materials** with a transparent try - Polymerization takes more time than using a chemical cure. - The poorer the visibility in the mouth, the greater the indication for an indirect bonding approach. - Some companies provide transfer trays based on bracket's position determined from a digital tx simulation. → Ensures that the bracket's position will provide optimal alignment.
Debanding	- Bands are retained by the elasticity of the band material as it fits around the tooth. This is augmented by the cement, which seals the space between the band and the tooth. - No cement bonds strongly to the enamel. - If a band is distorted by force → Cement breaks away from the band or the tooth. No chance of damaging the enamel surface.
Debonding	- Failures at one of 3 interfaces while debonding a bracket: • Bonding material / bracket = usual failure site created by distortion of the bracket. • Bonding material itself • Bonding material and enamel surface → Undesirable, bonding material may tear the enamel surface. - Brackets removed without damage → Can be cleaned and reused. - Ceramic brackets: • Cannot be distorted → brackets break before they bend. • Chance of enamel surface damage, as the bond between the adhesive and a chemically treated bracket can be so strong that no failure occurs.
Prevalence of enamel decalcification	- Risk factors: o Young age at the beginning of tx. o Poor hygiene before tx start and during tx. - Some natural remineralization occurs → better prognosis if the surface is porous. Complete remineralization by themselves is not likely. - 0,05% sodium fluoride rinse is effective for prevention + fluoridated toothpaste. - Fluoride release from bonding agents happens only during a short time. - Fluoride release for 25 d from elastomeric modules that are changed at every appointment are maybe helpful.
Tx for white spots	- Natural remineralization for 6 months. - Avoid fluorides in high concentrations. (can arrest remineralization and lead to staining) - Better prognosis for active lesions with a dull, pitted and porous surface to regain normal enamel translucency than arrested lesions with a flat or shiny surface. - External bleaching for camouflage. - Acid microabrasion: Repeated application of a pumice-hydrochloride acid slurry. Cave: teeth may appear darker after tx due to enamel loose (rarely more than 250 microns). - Infiltration with ICON®. - Restorative tx with resin or porcelain veneers.

Bracket material	- <u>Production of steel edgewise bracket/tubes:</u> • Casting. (Bracket production by casting tends to increase nowadays) → Better precision of bracket slot size is achieved by milling the slot of a cast bracket) • Metal-injection molding (MIM). Major production of brackets. • Milling. • 3D printing: better slot precision. - <u>Titanium brackets:</u> • Nickel free → allergic potential ↓, biocompatible. • Bond reliability ↑ compared to SS brackets = less bond failures. (strength of titanium is similar to ss, but the stiffness only ½ → titanium has a higher resiliency | strength = stiffness x resiliency) • Surface chemical active and rougher: → Resistance to sliding ↑ (no problem if small wires are used). - <u>Stainless steel:</u> • Sign. nickel content 8%. → Mucosal allergic reaction to nickel are less prevalent than cutaneous reactions. Most patients with a skin reaction tolerate stainless steel orthodontic appliances. • Failure rate of ss brackets = ~3% *Optimal bond strength vs. material stiffness*  The graph illustrates the comparable bond strength with titanium and ss brackets and the lesser stiffness of a titanium bracket. This allow it to absorb more of an impact against the bracket and makes it more resistant to inadvertent debonding. - <u>Gold:</u> • Too expensive. • Bad performance. - <u>Nonmetallic appliance materials:</u> • **Plastic brackets:** ○ Staining / discoloration. ○ Poor strength: Brackets are likely to break when large wires are used. ○ Poor dimensional stability. → Not possible to provide precise bracket slots or build in all the straight-wire features. ○ High friction between the plastic brackets and the metal archwire. → Difficult to slide teeth in a new position. → Metal slots help to overcome some of the problems. → Useful only if complex tooth movements are not required. But: Composite plastic with better physical characteristics than steel exists. Engineering problems must be overcome to produce competitively priced brackets with better mechanical properties. • **Ceramic brackets**: ○ Produced from alumina as a **single-crystal** (provides great strength until the bracket's surface is scratched, smoother surface) or **polycrystalline unit** Pro: ○ Durable ○ Resist staining ○ Dimensionally stable

	Cave: ○ Fractures of brackets. Cracking of the bracket when torque forces are applied or brittle of bracket parts during wire changes or eating. ○ Friction within the bracket slot. ▪ Even with smoot surfaces of monocrystalline brackets. ▪ Possible chemical interaction between the wire and bracket material: → Metal slot was integrated overcome the problem. ▪ Nowadays the metal slot in most brackets is replaced by using corner-rounding and surface-smoothing techniques (limited evidence of the effectiveness). ○ Abrasion on teeth contacting a bracket: → Place ceramic brackets only in the mx arch. ○ Enamel damage at bracket removal. ○ Bulkier due to the smaller fracture toughness compared to steel. ○ Polycrystalline brackets: Relatively rough surface.
Straight wire concept in bracket / tube design	- Modern brackets are custom made for each tooth: → Minimizing the number of bends in the archwires necessary. - <u>Compensation for first order bends:</u> ○ Varying the bracket's thickness. ○ Offset position of the molar tubes: Flat molar surface would otherwise produce e mesiolingual rotation: ▪ 6+6, 7+7: Minimum 10° Offset ▪ 6-6: 5-7° (½ of 6+6) ▪ 7-7: Offset minimum as large as 6+6  - <u>Compensation for second order bends = artistic positioning bends:</u> ○ Built in tip (= inclination of the bracket slot) for maxillary incisors. Necessary because the long axis of these teeth is inclined in relation to the incisal edge.  ○ Distal tip of the upper first molar. Good occlusion cannot be achieved if the molar is positioned to upright even an apparent cl.I relation exists. 

- Compensation for third-order bends:
  - Cutting the bracket slot into the bracket at an angle or forming the base so that the face of the bracket is at an angle.
    = Placing torque in the bracket or into the base.
  - Torque is positive for incisors, negative for the molars.
    Influenced by:
    - Torque values chosen by the developer as the average normal.
    - Position of the bracket on the labial surface of the tooth.
    - Play in the bracket slot between the wire and the slot:
      → The expressed torque produced by undersized rectangular wires is far less than the bracket slot prescription might lead to expect.

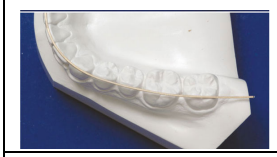
TABLE 10.3 Bracket/Tube Prescription: Incisors Through Premolars, Bracket Prescription

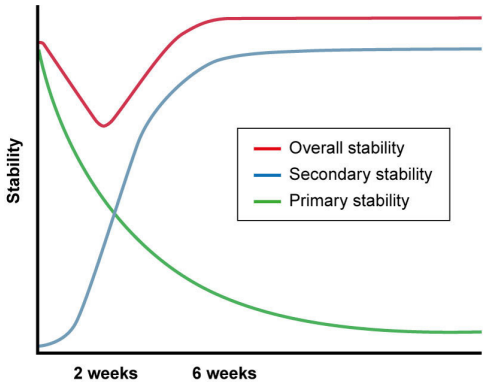
	CENTRAL		LATERAL		CANINE		FIRST PREMOLAR		SECOND PREMOLAR	
	Torque	Tip	Torque	Tip	Torque	Tip	Torque	Tip	Torque	Tip
Maxillary										
Alexander	15	5	9	9	−3	10	−6	0	−8	4
Andrews	7	5	3	9	−7	11	−7	2	−7	2
Damon (standard torque)	15	5	6	9	7	5	−11	2	−11	2
MBT	17	4	10	8	−7	8	−7	0	−7	0
Ricketts	22	0	14	8	7	5	0	0	0	0
Roth	12	5	8	9	−2	9	−7	0	−7	0
Mandibular										
Alexander	−5	2	5	6	−7	6	−7	0	−9	0
Andrews	−1	2	−1	2	−11	5	−17	2	−22	2
Damon (standard torque)	−3	2	−3	4	7	5	−12	4	−17	4
MBT	−6	0	−6	0	−6	3	−12	2	−17	2
Ricketts	0	0	0	0	7	5	0	0	0	0
Roth	0	0	0	0	−11	7	−17	0	−22	0

TABLE 10.4 Molar Tube/Bracket Prescriptions

	FIRST MOLAR			SECOND MOLAR		
	Torque	Tip	Rotation	Torque	Tip	Rotation
Maxillary						
Alexander	−10	0	13	−10	0	10
Andrews	−9	5	10	−9	0	10
Damon (standard torque)	−18	0	12	−27	0	6
MBT	−14	0	10	−14	0	10
Ricketts	0	0	0	0	0	0
Roth	−14	0	14	−14	0	14
Mandibular						
Alexander	−10	0	0	0	0	5
Andrews	−25	2	0	−30	0	0
Damon (standard torque)	−28	2	2	−10	0	5
MBT	−20	0	0	−10	0	0
Ricketts	0	0	0	0	0	0
Roth	−30	1	4	−30	0	4

Self-ligating brackets	- 3 types: o Springy clip: Innovation, Speed o Spring retaining clip in the bracket walls: Smart Clip o Rigid clip: Damon → All ligation types perform well and remarkably similarly. - *Burrow, 2009* o Friction: If Angle = 0°: ▪ Self-ligating bk < conventional bk ▪ Passive clip < active clip o Binding: Self-ligating bk = conventional bk o → Binding is mainly responsible for the resistance to sliding, = no difference conventional & self-ligating bk. - *Marshal, 2010*: Evidence concerning self-ligating brackets: o Saving of little time in ligating. o No saving of tx time. o No better tx results.
Individual customized brackets e.g. Insigna from Ormco	- Brackets fabricated by CAD/CAM. - Slot of each bracket has the appropriate thickness, inclination and torque needed for ideal positioning of a certain tooth. - Archwires with an arch form established for an individual patient are supplied. → Ultimate straight wire system. (some adjustments of the final archwires are still required) - Indirect bonding needed. - Cave: The focus is largely on dental intra-arch relationship and so every patient gets the same ideal incisor inclination without modifications which are necessary to facilitate the correction of the malocclusion. - *Brown, 2015:* Tx time and number of arches ↓ for individual customized brackets compared to directly or indirectly bonded brackets. The decrease was however attributed more to indirect bonding than customized brackets.
Lingual appliances	- Custom made precious metal pads with an attached low-profile bracket on the pad. - Wire bending eliminated by using wire-bending robots to form the archwires. - *Grauer, 2011*: Accuracy Incognito: Outcomes are quite accurate representations of the template, except 2nd molars. - *Knosel, 2014 / Pauls2017:* Win: o 3D printing for bracket production. o Tx time ↓ compared to Incognito. o Same accuracy like Incognito to achieve the planed outcomes.
Appliance choice based on a patient's preferences	- Major age and some minor gender differences: - <u>9-11y:</u> o Shaped brackets with/without colored elastomeric ties o Mini-twin brackets with colored elastomeric ties - <u>12-14y:</u> o Clear aligner (not practical with erupting teeth) o Esthetic brackets o Mini brackets with colored elastomeric ties - <u>15-17:</u> o Clear aligner o Esthetic brackets with a clear wire - <u>Adults:</u> o Lingual appliances o Clear aligner o Esthetic brackets with a clear wire
Archform selection for an individual patient	- NiTi / B-TMA: Impossible to shape the wires: → No choice than to use preformed arches. - Dimensions and the shape of the dental arches are correlated with the dimension and shape of the face. - The patient's original arch form should be preserved → teeth are placed in a position of maximum stability → less post-tx changes.

 	- Define the arch form desired at the end of tx already at the beginning. - Mn arch form should be used as a basic guide, if the mx and mn arch forms are incompatible at the beginning of tx. This is not valid, if the mn arch form is distorted e.g. from lingually displaced incisors. *Bennet, 2014* Situations when it is allowed to change the mn intercanine-dimension: o RPE in the mx: 3-3 are displaced by the narrow maxilla. o Cl.II:2: 3-3 are displaced by the maxilla. o 3-3 displaced by habits. o 3-3 are erupted lingually in a crowded situation. - Natural dental arch form = **catenary curve**: (Angle also defined a catenary curve) • Length of the chain and the width between the supports determine the precise shape of the curve. • Fits very well for the incisor-canine-premolar segment if fitted at the posterior width of the first molars. • Fit distal to the 1st molars is not good, because the dental arch curves slightly lingually in the second and third molar region. → Modifications necessary by the orthodontist. • Shape of most arches provided by contemporary manufactures. - **Brader arch:** • Archform based on a trifocal ellipse. • Round in the premolar-region and constricted posteriorly. • The archform is maybe more compatible with expansion therapy.
Wire bending robots E.g. Win (lingual) Sure Smile (buccal)	- Scan of the positioned brackets → robot shapes the archwire from a digital setup to the desired archform and adjusts it at each bracket. - Precise positioning of the brackets is not necessary, but the characteristics of the brackets must be known. - Initial leveling with light round wires is typical. - Evidence: *Alford 2014, Larson 2013* o Shorter time in fixed appliance. Cave: Less severe malocclusions were treated compared to the control patients in the study and less detailed finishing. o Lower scores for torque and tip compared to conventional finishing. o Final tooth positions are remarkably close to what has been prescribed. o Trend towards a lack of full expression of arch form and torque on 2nd molars.
Clear polymer archwires	- Pro: o Better esthetics. o Physical properties equal or better than metal archwires. - Contra: o Problems with wire stability. o Discolorations. - 2 types in development (not in clinical use so far): • <u>Formable:</u> o Approach from polyphenylene polymer. o Properties similar to small dimension beta-Ti wires. o Formability similar to stainless steel wires. • <u>Non-formable:</u> o Polymer resin matrix reinforced with glass fibers. o Auxiliaries like rotating wedges or bracket repositioning can be used to treat simple cases without customized wires. o Series of wires necessary for more complex cases. - Further research needed
Coated archwires	- White wires are rated as highly as clear wires by adults. - Coating is still problematic (easily lost).

Temporary anchorage devices	
Bone screws	- May place bends in the archwire to create root separation in the area where the screw is placed. - Screw material = titanium. - The screw location should be in the attached gingiva, not in the mucosa.  Clinical stability is the sum of primary and secondary stability. Note that clinical stability declines to a minimum at about 2 weeks post insertion, then (if all goes well) stabilizes at a somewhat larger value than the initial primary stability at about 6 weeks. - **Primary stability** is determined by *mechanical retention* of the screw in the bone. Depends on: ○ Bone properties ○ Engineering design of the screw ○ Placement technique - **Secondary stability** is defined by the *biologic union* of the screw to the surrounding bone. Determined by: ○ Implant surface ○ Bone characteristics ○ Bone turnover ○ Mechanic system used. ○ It's important to limit micro-movements which lead to bone resorptions and formation of a fibrous capsule. - The tension created by the srew insertion accelerates bone remodeling and screws become fitter → Load the screws early.
Factors related to stability / success of bone screws	- <u>Pitch of the screw threads:</u> **thight** vs. loose. ○ The denser the bone, the closer the threads should be. ○ Most of the screw's resistance comes from contact with cortical bone, little from medullary bone: → Tight pitch of the threads near the head of the screw gives greater contact with the cortical bone, higher pull-out strength, better primary stability. - <u>Length</u>: Usually **6-8 mm**. ○ Stability is mainly determined by the contact area of the screw with cortical bone (which is thin). → Longer screws should not perform better, but the amount of soft tissues overlying the bone must be taken into considerations. ○ Long screws which penetrate the cortical bone on both sides provide better stability, but are not worth the greater invasiveness. - <u>Diameter</u>: Usually **1.3-2.0 mm**. ○ Clearance is necessary between the root and the screw. ○ Root proximity is not a major factor in long-term stability. ○ If the alveolar bone screw is however < 0.5 mm away from the periodontal ligament, success rate sign. ↓ ○ Penetration of the periodontal ligament does not lead to ankylosis (cave: dog study). In humans, the possibility of ankylosis as the screw socket heals cannot be ruled out. ○ Success drops if diameter <1.3 mm (breakage). ○ Larger diameter provides better primary stability when heavy force is applied.

	- Form of the tip: **Thread-forming** vs. **thread-cutting** (cutting flute on the tip)
	  ○ Thread-forming screw:
	  ▪ Compression of the bone around the threads as the screw advances.
	  ▪ Better bone-to-screw contact.
	  ▪ Better adapted for use with alveolar bone.
	  ○ Flute on thread cutting screw:
	  ▪ Improve penetration into denser bone.
	  ▪ Better performance in the mn ramus / buccal shelf, zygomatic buttress and palate.
	
	- Surface of the threated part of the screw: Machined or roughed
	  ○ Roughed surfaces (sand blasted and/or acid etched) increase the primary stability and allow immediate loading.
	  ○ No major influence on the clinical stability.
	
	- Shape of the screw: Conical, cylindrical or mixed
	  ○ Thickness at the head: conical screws < cylindrical screws.
	  → Microdamage of conical screws to cortical bone ↓

Factors related to ease of use of bone screws	- Need for a pilot hole:
	  ○ Self-drilling screws do not need a pilot hole.
	  ○ Exception: If penetration of the cortical plate is difficult to prevent high insertion torque and potential screw fracture.
	
	- Need for soft tissue punch:
	  ○ Rarely needed in the gingiva (unless a pilot hole is to be drilled).
	  ○ Frequently needed in unattached tissues (mucosa).
	
	- Insertion torque and insertion device:
	  ○ Moderate insertion torque provides enough primary stability without causing excessive bone compression and subsequent remodeling.
	  ○ Torque control instruments for placing decrease the chance of screw fracture or overstressing the bone.
	
	- Type of anchorage:
	  ○ Direct:
	  Force is applied directly to a tooth or a group of teeth from a bone screw.
	  ○ Indirect:
	  Bone screw anchors a tooth or a group of teeth to which force is applied. Goal = prevent movement of the anchored teeth.

Design Factors for Bone Screws

Related to Stability and Success

- Pitch of screw threads: tight, not loose
- Length of screw
  - Alveolar bone, approximately 6mm
  - Palatal or mandibular bone, approximately 4mm
  - Base of zygomatic bone, 6 to 8mm
- Diameter of screw
  - Minimum 1.3mm
  - Maximum 2.0mm
- Shape of screw: conical preferred
- Form of tip: thread-cutting preferred
- Bicortical versus monocortical: monocortical preferred
  - Minimal stability advantage for bicortical
  - Decreased ease of use

Related to Ease of Use

- Pilot hole: better if not necessary
- Soft tissue punch: better if not necessary
- Insertion torque: better if low
- Insertion device: better if simple
- Direct versus indirect anchorage: both acceptable

Linked screws for palatal anchorage	- Palatal bone: Highest density anterior and lateral to the midline. - Linking 2 screws increases the resistance to force → neither screw can rotate.
Miniplates	- Placed on the base of the zygomatic arch. - Small connector extending into the mouth. - Ideal location for connector = junction fixed gingival tissue & loose mucosa. - Ideal number of screws = 3. → 3 screws = more stability than 2 screws, but not less than 4 screws. - Failures are for common for young patients: Bone maturity for good retention of the screws is not reached before 11 y. - More invasive than miniscrews. - Failure rate: **7-8%.** - <u>Procedure:</u> 1. Flap 2. Contour the miniplate to the bone surface: Contact at the pint of emergence to prevent excessive moments against the proximal screw. 3. Suture - <u>Advantages compared to single miniscrews:</u> • Larger amount of force tolerated: hold by 3 screws, thicker cortical bone. • The direction of pull can be changed. The source of force can be moved quite far by extending wire hooks from the intraoral fixtures. • Placed about the roots of teeth: → No barrier to move the teeth mesially or distally like interdental screws.

TABLE 10.6 Bone Screws Versus Miniplates

Single Alveolar Screws	Palatal Screws Linked by Plate	Maxillary or Mandibular Miniplates
Advantages		
Less invasive, lower cost	Excellent stability and resistance	Excellent stability and resistance
Orthodontist can place and remove	Orthodontist can place and remove	Can be placed above and below roots to allow en masse movement
Multiple sites for placement	Useful for vertical and anteroposterior movements	Useful for vertical and anteroposterior movements
		Easy to activate unilaterally
		well tolerated during therapy
Disadvantages		
Limited anchorage amount, move one or two teeth but not more	Framework in palate can be difficult for patient to tolerate	Experienced surgeon needed, not for typical orthodontist
No way to alter force direction without risk of losing screw	Bilateral screws needed	Surgery to place and remove
Vertical movement limited	Moderately difficult placement	Cost of surgery and device
Major Indications for Use		
Repositioning or rotating single teeth	Indirect anchorage primarily, for retracting protrusive incisors	Direct anchorage primarily, for retraction and/or intrusion of incisors
Bringing impacted canine(s) into the arch while preserving arch form	Indirect anchorage for intrusion of posterior teeth	Direct anchorage for intrusion of posterior teeth
	Indirect anchorage to bring posterior teeth forward	Direct anchorage for skeletal Class III growth modification

Proffit Chapter 11:

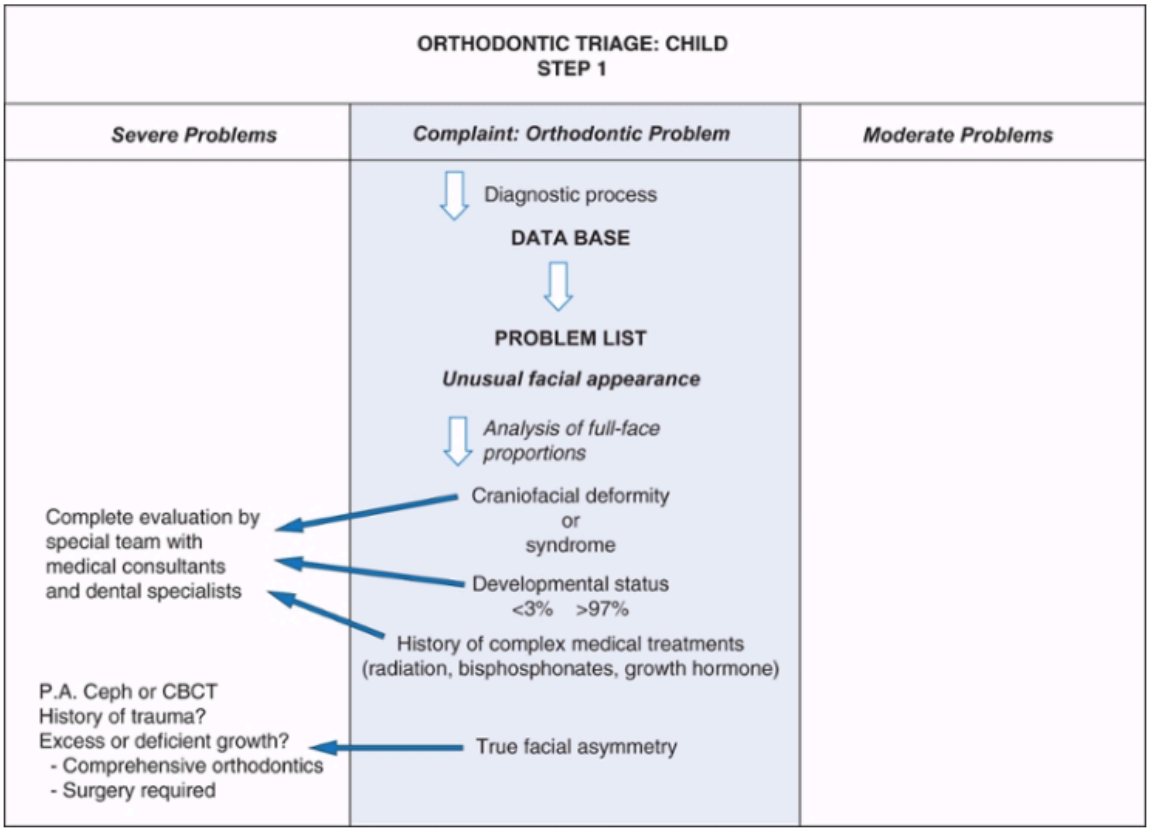
Moderate Nonskeletal Problems in Preadolescent Children:

Preventive and Interceptive Tx in Family Practice

Introduction: Tx in *preadolescent* children: What is different?	
Primary dentition	- Reasons against orthodontic tx: • Movement of primary incisors and canines is likely to lead to accelerated root resorption and premature loss of the primary teeth. • Movement of any primary tooth has little effect on where the permanent tooth will erupt. • Growth modification effects in young children are lost to a resumption of growth in the original pattern.
Mixed dentition:	- Focus on what "should be done". - Only obvious tx with effects that are known and proven is indicated. - Complex problems: High chance that a second stage of tx in the early permanent dentition is required. → Cave: Limit of time and cooperation from patients for orthodontic tx: • Patients can be burnt out by the time they are ready for comprehensive tx. • Chance of damaging the teeth / supporting structures increases with tx time. - Need of specific objectives, no need of comprehensive objectives. - Fewer tx options available. - Treat with a partial fixed appliance in a mixed dentition. - 2x4 / 2x6 arrangement: Long archwire spans → large moments are easily created, wires are springier and less strong → No use of superelastic wires with long unsupported spans. - Anchorage control more difficult and more critical. Implants are not possible: unerupted teeth, immature bone. - Unerupted teeth are at risk for resorption during tooth movement. E.g.: Movement of 2+2 → cave 3+3. - Make sure unerupted teeth are present. - Teeth without attachments tend to be displaced and squeezed out of the arch. - Sparingly use of interarch mechanics if no complete fixed appliance is present. Exception: crisscross elastics. - If early tx is carried out in only one dental arch, the final result is dictated by the untreated teeth / arch. → Difficult to obtain ideal occlusion & alignment. - Retention between the mixed dentition tx and eruption of permanent teeth is needed. - The final stage of transition is a particularly unstable time. o Wires through edentulous areas can interfere with the eruption of the permanent teeth. o Clasps on primary teeth are lost when the teeth are lost. o Higher hygiene risk and lower modifiability as teeth erupt with fixed retainers. o Overcorrection is maybe needed. (esp. for facemask or palatal expansion)
Summary prevalence malocclusions in the mixed dentition	- Posterior crossbite: **7.1%** - Anterior crossbite: **3.0%** - Anterior open bite: **< 4%** - Deep bite: **20%** - Ectopic eruption of mx canines: **1-2%** - Moderate anterior crowding 2-4mm: **25%** - Maxillary diastema: **25%** (Age 12-17: **7%**) - Transposition: **0.3%**

Orthodontic triage: Distinguishing moderate from complex treatment problems

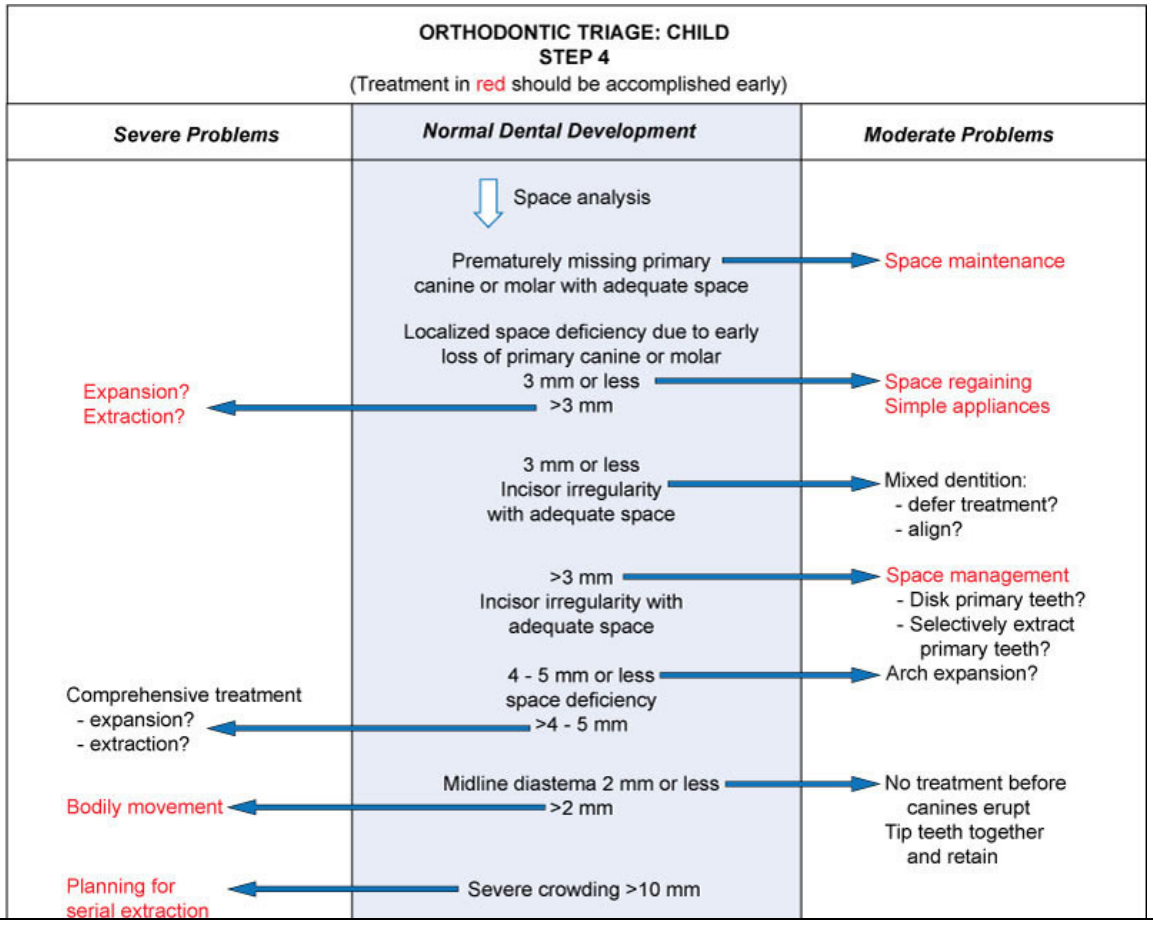
- Orthodontic problems are almost never an emergency.
- Adequate database + problemlist necessary for triage.
- Lateral ceph is not required → facial form analysis more appropriate in the generalist's office.



1. **Syndromes and developmental abnormalities**	- Easily to recognize by the physical appearance, medical / dental history, developmental status. - Complete evaluation by a special team with medical consultants and dental specialists. - Developmental status <3% or >97% requires special evaluation. - Significant skeletal asymmetries are always a severe problem. → Timing of the intervention depends on whether the cause of the asymmetry is deficient or excessive growth. - Growth disorders may demand that any orthodontic tx be carried out in conjunction with endocrine, nutritional or psychologic therapy. - Cave: Sign. skeletal asymmetry can also be caused only by a shift!
2. **Facial profile analysis**	- Early evaluation is indicated even if tx is deferred. - <u>Anterior-posterior problems:</u> • Class II tx can be deferred until near adolescence and be equally effective. ○ *Note*: Exception = Cl.II with lower lip interposition. • Class III tx for maxillary deficiencies should be addressed earlier. • Class III tx for protrusive mandibles: ○ Cl.III elastics during adolescence (less severe cases) or ○ Later orthognathic surgery - <u>Vertical problems</u> • Long face: ○ Can be delayed, growth persists until the late teens. ○ Condition can improve or become worse during the adolescent growth spurt. • Short face: ○ Can be delayed, managed well with comprehensive tx. ○ Exception: Early tx is indicated in case auf mx palatal gingiva damage.

	- <u>Asymmetry</u> • Early evaluation (a-p ceph, CBCT) is indicated even if tx is deferred. - <u>Excessive dental protrusion / retrusion:</u> • Urgency for tx depends on the esthetic impact & the potential for traumatic injury. • Incisor protrusion is often a compensation for crowding and an indication for premolar extractions.
3. **Dental development**	- Related problems often need tx as soon as they are discovered. - <u>Asymmetric dental development:</u> • In the absence of any pathology, often selective extraction of primary or permanent teeth needed. • Radiation therapy on the head / neck in childhood can cause root dilaceration. - <u>Missing permanent teeth</u> • Agenesis: most often 2+2, 5-5. • 21+12 = most likely to be lost in a trauma. • Maintenance of the primary tooth. → Anterior less an option due to enhanced esthetics. • Extract the overlaying primary tooth and allow the adjacent permanent teeth to drift. → Cave: Anterior edentulous ridges deteriorate quickly. • Extract the primary tooth following immediate orthodontic tx. • Replace the missing teeth prosthetically by transplantation or a later implant. *Note*: Timepoint for transplantation = 2/3 - 3/4 root formation. 80% success. • Ankylosed permanent teeth / PFE often require a combination of surgery (extraction or decoronation) and orthodontic tx. Tx options: o Ex + space closure / prosthetic replacement / transplantation o Luxation + traction o Surgical reposition o Segmentosteotomie / Distraction • *Oeschger et al.:* Influence of the craniofacial morphology. The location and the severity of the hypodontia define the severity of the impact. Mn plane angle ↓, ramus height, anterior & posterior face height, soft tissue convexity, measurements of upper and lower incisors. - <u>Supernumerary teeth:</u> • 90% in the anterior mx part. • Multiple supernumerary teeth can be an indicator for a syndrome or a congenital abnormality (e.g. cleidocranial dysplasia). • Early removal is indicated. • Single supernumerary teeth with *normal shape* often *erupt spontaneously* causing crowding problems. • Tubercle-shaped and *inverted* supernumerary teeth normally *do not erupt* spontaneously.
4. **Space problems**	- Protrusion accompanying a crowding is an indication that the natural limit of anterior displacement is already reached. - Correct handling of space deficiencies: Moderate crowding 2-4 mm = **25%** • <u>3 mm loss of space:</u> Space can be regained • <u>≤ 4 mm:</u> Labial reposition of incisors or space management during the transition phase. • <u>≥ 5 mm:</u> Mx anchorage or robust mechanics needed if non-ex tx. • <u>≥ 10 mm:</u> Spend attention, that permanent teeth are not impacted or deflected in their eruption path. - Diastema: **25%** • <2 mm will close spontaneously. • >2 mm, spontaneous closure unlikely, adjacent teeth can be inhibited to erupt properly

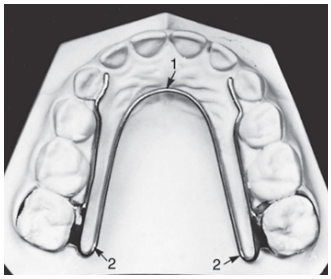
5. **Other occlusal discrepancies**	- Severity of CB, OB and open bite should be classified according to the facial form. - <u>Anterior CBs:</u> - Usually reflect a jaw discrepancy but can result only from lingual tipping of the incisors → tx fix or removable. - <u>Lateral crossbite:</u> **7%** • CB with a lateral shift form the initial dental contact position should be treated. • Tx of CBs without a shift should be delayed until the late mixed dentition: ○ If treated in adolescence, heavier forces and complex appliances will be probably required. ○ Early tx is maybe indicated if space in the arch is borderline. - <u>Excessive OJ:</u> **25%** Often reflects a skeletal problem. → Tx with removable appliances at any age. - <u>Anterior open bite:</u> **<4%** Good chance for spontaneous correction. - <u>Deep bite:</u> **20%** • Often caused or made worse by short anterior face height. • Seldom treated in the mixed dentition. - <u>Traumatically displaced erupted incisors:</u> • Often create an occlusal interference. • Risk of ankylosis. • Spontaneous re-eruption warranted if the apex is open and the root development incomplete. • Adults: ○ Intrusion < 4 mm: Short period of observations if re-eruption occurs. ○ Intrusion > 4 mm or no re-eruption after a smaller intrusion: Immediate orthodontic or surgical tx necessary.



Management of occlusal relationship problems: Posterior crossbite

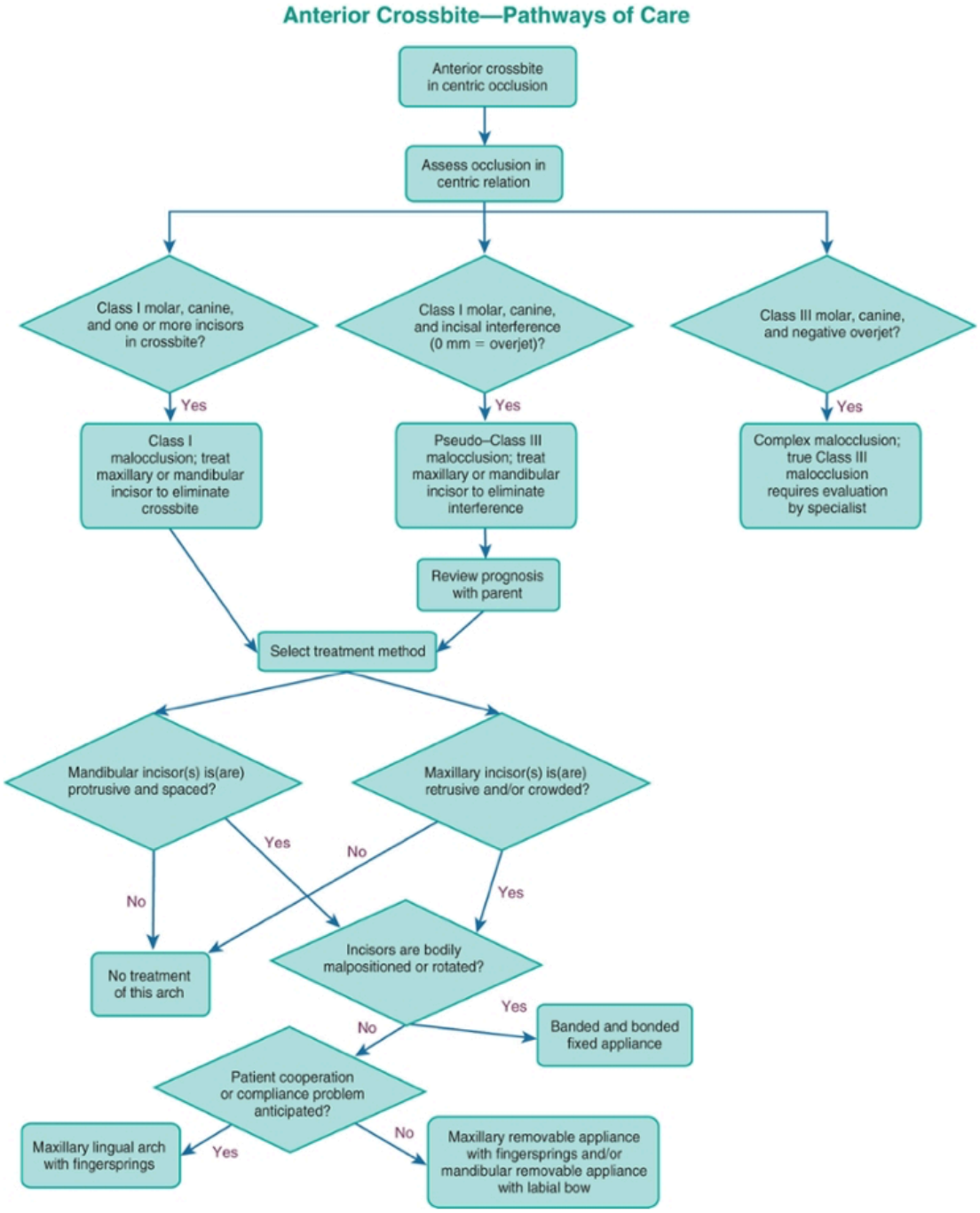
- **7.1%** of US children age 8-11y.
- Reasons:
    - Narrowing of the mx arch (prolonged sucking)
    - Lingual tipping of the mx teeth
    - Shift
- Shift / severe constrictions which reduce sign. the space within the arch → indication for early correction. Otherwise tx can be deferred.
- Differentiate if the mn asymmetry is the result of a shift of the lower jaw due to dental interferences or a true maxillary / mandibular asymmetry.
- Differentiate if the CB is related to skeletal maxillary retrusion or mandibular protrusion = relative mx deficit.
- **1 mm increase in the inter-premolar width → increase of arch perimeter values by 0.7 mm.**
- Total relapse after tx is unlikely in the absence of a skeletal problem.
- Heavy force and rapid expansion are not indicated in the primary or early mixed dentition.
  → Risk of distortion of the nose!

1. Equilibrium to eliminate a mandibular shift	- Occlusal interference for shifts is mostly caused by the primary canines or less frequently by the primary molars. - Position the mandible in CR → no CB. - Tx = reduction of the primary canines.

2.	**Expansion of a constricted maxillary arch**	- Expand to prevent a shift in CB if diagnosed. Exception if 6+6 are expected to erupt in less than 6 m→ wait to include them in the expansion device. - If the maxillary constriction is severe (mx teeth sit inside the mn teeth) and no shift exists → less reason to provide early tx, if it is not accompanied by severe crowding. - <u>Tx appliances:</u> • **Split plate**: relies on compliance, longer tx time, more expensive. → Not recommended. • **W- arch**: o Proper force level when opened 4-6 mm wider than the passive width. o Often teeth and maxilla move more on one side than on the other.  The W-arch appliance is ideal for bilateral maxillary expansion. (A) The appliance is fabricated from 36-mil wire and soldered to the bands. The lingual wire should contact the teeth involved in the crossbite and should not extend than 1 to 2 mm distal to the banded molars to eliminate soft tissue irritation. Activation at point 1 produces posterior expansion and activation at point 2 produces anterior expansion. The lingual wire should remain 1 to 1.5 mm away from the marginal gingiva and the palatal tissue. • **Quadhelix:** o More flexible & greater range of action than the W-arch. o 38 mil steel wire soldered to molar bands. o Bulky helices anterior help to remain stopping a finger in case of a sucking habit • **General rules for lingual arches:** o Lingual wire contacts the teeth involved in the CB 1-1.5 mm away from the marginal gingiva and the palatal tissue. o Activation for posterior or anterior expansion is possible. o Some opening of the midpalatal suture can be expected, not only dental expansion in a child with a primary or mixed dentition. o Skeletal change = ~50% of the total change o Effect: 2 mm expansion per month (1 mm per side) o CB should be overcorrected: Lingual cups of the maxillary teeth should occlude on the lingual inclines of the buccal cups of the mn molars. o IO adjustment is possible but may lead to unexpected changes. → Better appliance removal and recementation at each tx visit. o 3 m retention → correction seems to be stable in long term. o Imprint on the tongue possible: → disappears after removal of the appliance, but can last for up to 1 y.
3.	**Unilateral repositioning of teeth**	- <u>Tx if only the mx teeth need correction:</u> • Use different arm lengths of a W-arch or QH. Cave: Some bilateral expansion must be expected. • Mandibular lingual arch to stabilize the lower teeth + crisscross elastics to correct the mx teeth (more unilateral effect). Cave: Needs compliance. - <u>Tx if the mx and mn teeth need correction:</u> • Crisscross elastics. Cave: Extrusion possible. - Crossbites treated with elastics should be overcorrected and the attachments left in place after active tx. → Removal is possible when the occlusion is stable after a couple of weeks.

Management of occlusal relationship problems: Anterior crossbite

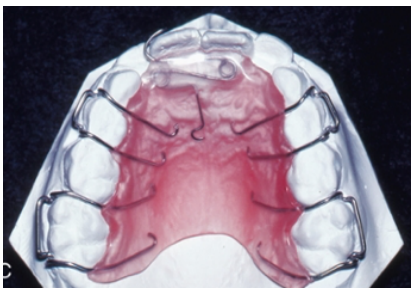
- Rarely found in children with no skel. cl.III jaw relationship.
- **3%** in the mixed dentition (mixed racial groups).
- In most patients due to lingually displaced mx central or lateral incisors:
  - Lingual position of developing tooth buds.
  - Teeth deflected to a lingual position by supernumerary anterior teeth / overretained primary incisors.
  - Lack of space for permanent incisors (most often).
- If discovered before complete eruption (no overbite), the adjacent primary teeth can be extracted to provide the necessary space.



1. Tx of nonskeletal anterior crossbite	- Develops typically with the eruption of the permanent incisors. - Origin of crossbite for isolated teeth: o Permanent incisor germs develop lingual of the primary teeth. o Eruption path of permanent incisors is deflected by space deficit / supernumerary teeth / trauma.

- Reasons to correct lingually positioned mx incisors / labial positioned mn incisors:
    - Limitation of lateral jaw movement.
    - Risk for sign. incisal abrasion.
    - Risk for gingival recession (esp. labial positioned mn incisors)

  Early correction is indicated.
  → But not in the primary dentition for most patients: rare event, incisors exfoliate before correction.
- Provide adequate space for spontaneous tooth movement:
    - Reducing the width of some teeth.
    - Extraction of adjacent primary teeth.
    - Opening space orthodontically.
- Most corrections are possible with tipping.
  Cave: If bodily movement is required, questionable stability is achieved with tipping.
- **Removable appliances with fingersprings or screws for facial movement of maxillary incisors:**
    - Labial bow is usually contraindicated, because it can interfere with facial movement of the incisors.
    - Reducing OB during CB correction is not necessary to prevent incisor interferences to achieve a correction with children, except if they are clenching / grinding or the OB is exceptionally severe.
      → Start with a removable appliance without bite plate and ad cement occlusal 6-6 if no correction is achieved after 2 m.
      Cave: Risk for elongation of posterior teeth, if the bite is opened.
    - Nearly fulltime wear necessary.
      Cave: Irregular wear time can jeopardize the result.
    - Perform a slight overcorrection.
    - May use a 22 mil double helix.
    - 2 months retention or until the OB is adequate to retain the incisors.

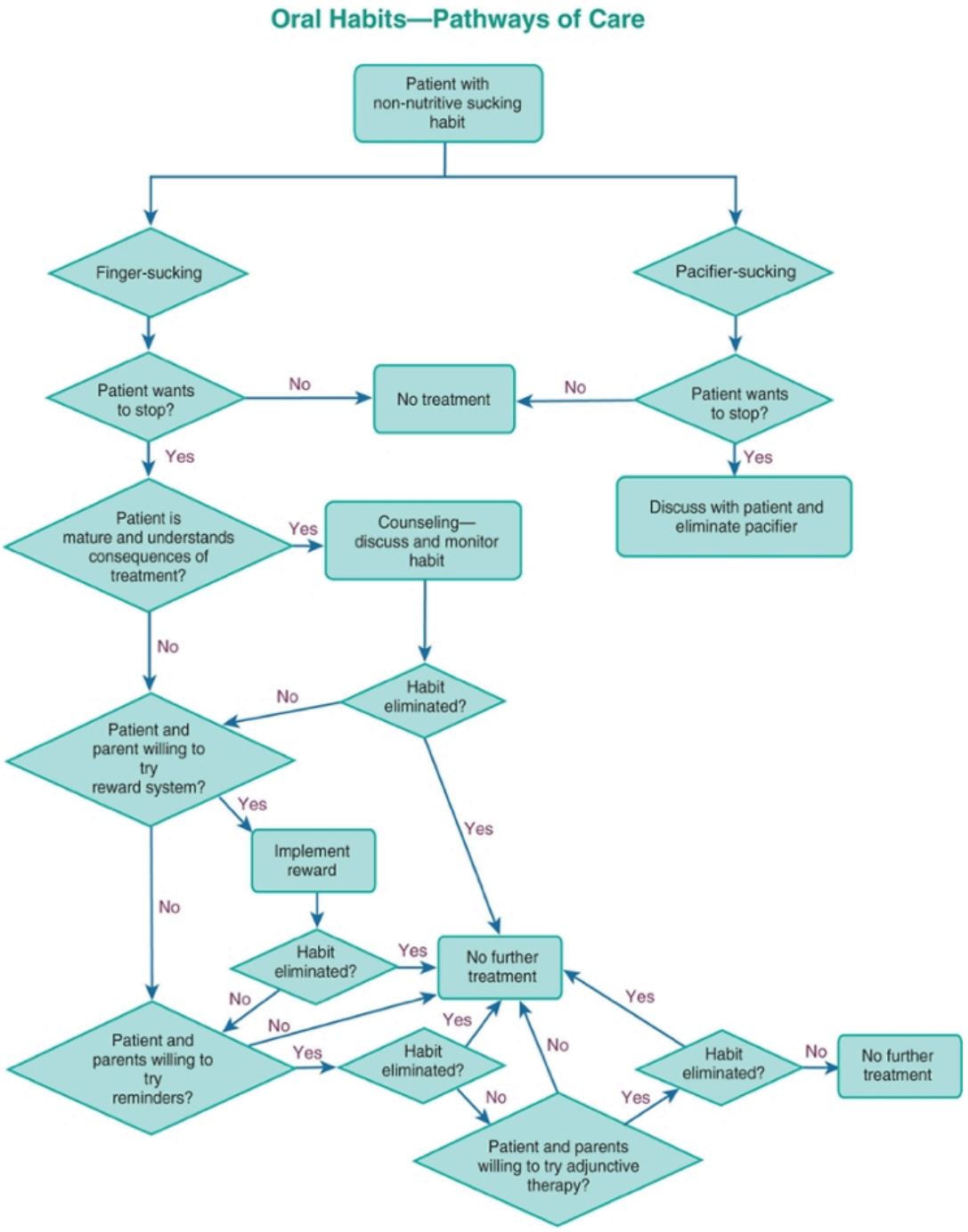


- **Maxillary lingual arch with fingersprings / whip springs**
    - Soldered on the opposite side of the arch from the tooth to be corrected to increase their length, ideal 15 mm.
      (gekreuzte Arme anterior)
    - A guide wire between the incisors can help to keep the springs from moving incisal.

- **2x4 fixed appliance**:
    - Best choice if crowding exists and need for rotations / bodily movement / more permanent teeth involved in CB.
    - Place brackets 2+2 with increased mesial root tip to prevent resorption by 3+3

- **Mandibular removable appliance with labial bow**

Management of occlusal relationship problems: Anterior open bite	
- **< 4%** in the mixed dentition: - Many of the transitional and habit related open bites resolve with time or cessation of sucking habit. - Open bites that persist until adolescence, except those related to habits, almost always have a significant skeletal component = complex open bites.	
Sucking habits:	- Effects depend on the frequency: o Mx incisors tip facially, mn incisors tip lingually. o Eruption of some incisors is impeded while elongation of the posterior teeth is allowed. o OJ increases. o OB decreases. o Mx intercanine and intermolar width is narrowed → posterior CB. Tongue is not placed in the palate → pressure from the check let the mx arch collapse) - Longer breastfeeding → fewer non-nutritive sucking habits. But: No difference in the long run in the prevalence of malocclusions between breastfed and non-breastfed children. - Pacifier shapes that are designed to produce a more physiologic sucking pattern have not been proven to be beneficial when compared to other pacifiers or to finger-sucking. - Some increased prevalence for a posterior CB for children with pacifier use compared to thumb-sucking. - Most of the sucking adaptions resolve spontaneously, except a posterior CB. - Tx is not indicated for children who don't want to quit sucking.
Nondental intervention:	- **Straightforward discussion** between the dentist and the child: Explain the problem. - **Reminder therapy**: Adhesive bandage with waterproof tape on the finger / anterior portion of the Quadhelix appliance. - **Reward system** for every day without sucking, big reward for total elimination. - **Elastic bandage** loosely wrapped around the elbow that prevents the arm from flexing
Appliance therapy:	- **Removable reminder:** Contraindicated if the nondental interventions were not successful. - **Maxillary lingual arch 38-40 mil with an anterior crib device** which interferes with the finger position during sucking for 6 m. - **Appliance to laterally expand** a constricted mx arch and retract flared and spaced incisors is maybe necessary.



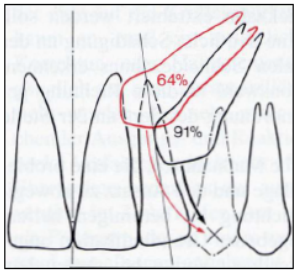
Management of occlusal relationship problems: Deep bite

- **20%** patients in the mixed dentition:
- Possible causes:
    - Reduced lower face height = skeletal problem. (not enough growth of the ramus)
    - Lack of eruption of the posterior teeth.
    - Overeruption of the anterior teeth.
- Addressed during comprehensive tx, unless there is tissue damage.

- Interim measure:
  Removable appliance with an anterior bite plane to encourage eruption of the posterior teeth and to protect the anterior tissue.

Management of eruption problems	
Over-retained primary teeth	- Extract if ¾ of the root of the permanent tooth is built. - Risk associated with over-retained primary teeth: o Gingival inflammation. o Hyperplasia → pain, bleeding. o Deflection of the eruption of the permanent tooth. - If a part of the permanent tooth crown is visible and the primary tooth moves 1 mm: → Encourage the child to wiggle → extraction if no exfoliation within a few days. - Roots of primary molars who hinder exfolitation: o Maxilla: buccal or lingual root. o Mandibula: mesial or distal root. - Removal of the retained primary tooth will allow some spontaneous alignment of moderately displaced facial or lingual positioned teeth, because of the equilibrium of soft tissue pressure.
Ectopic eruption of lateral incisors	- Ectopic = permanent tooth erupts on a different eruption path. → Emergence in the mouth at a different location than normally or sometimes totally blocked out. - Often associated with resorption of a primary tooth other than the one it is supposed to replace or resorption of an adjacent permanent tooth. - Some resorption of III+/- III is common when 2+/-2 erupt and indicates just a transitional crowding. - Loss of a primary canine indicates a significant lack of space for all permanent teeth: → Consider arch lengthening / expansion or later premolar extractions. - <u>Early loss of 1 mx primary canine:</u> o Immediate tx is almost required. - <u>Early loss of 1 mn primary canine:</u> o *Christenson, 2018 (data from the Iowa and Burlington growth study):* Prevalence of a clinical sign. midline shift is statistically not significant or greater than what was seen in patients with normal eruption: 1.3 mm and 1.0 mm rsp. o → Extraction of the contralateral canine to prevent a midline shift and stabilization with a lingual arch with a spur to prevent lingual tipping of the incisors is not necessary although thought so for a long time. - <u>Early loss of 2 mn primary canines:</u> Consider a passive lingual arch to prevent lingual tipping of the incisors and maintain adequate space if indicated.
Ectopic eruption of maxillary first molars	- <u>Resorption < 1-1.5 mm:</u> • Self-correction in $^{2}/_{3}$ of the cases. (**jumped teeth**) • Tx if eruption blockage lasts > 6 m or resorption continues. (**hold teeth**) - <u>Tx options to move the first molar away from the primary molar:</u> • **20/22 mil brass wire:** o Lopped and tightened around the contactpoint. o Tightened every 2nd week. o The patient must feel some discomfort to be sure that it is active enough. • **Steel spring clips separator:** Activated every 2nd w. • **Elastomeric separators:** o Large → force is needed to place it. o Potential to be displaced in an apical direction and cause periodontal irritation. • **Fixed appliance:** o Band on the primary molar with a soldered spring bonded to the permanent molar. o Band and loop spring fabricated intraorally. o 2 bonded brackets and a loop spring. - <u>If extraction of the primary molar is necessary:</u> The permanent molar must be guided during eruption, hold and repositioned distally after fully eruption.

<table>
<tr><td></td><td>    </td></tr>
<tr><td>Ectopic eruption of maxillary canines</td><td>- 1-2% of patients.
- Consequences:
• Impaction of the canine.
• Resorption of the permanent incisors 21+12.
Resorption is sign. more likely to occur, when no space is available for the canine.
- Genetic basis for the phenomenon probably.
- Sometimes related to small or missing maxillary lateral incisors / missing second premolars.
- CBCT is superior for the diagnosis of the location and the amount of resorption on adjacent teeth. Nevertheless, an OPG is recommended first to gain an overview and diagnose eventually other anomalies.

- <u>Mesial position of III+III with no root resorption 2+2:</u>
• Extract the primary canine: Ericson & Kurol, 1988
→ 91% normalization of the eruption path, if less than half of the root 2+2 is overlapped by the canine.
→ 64% normal eruption or improvement of the canine’s position, if more than half of the root 2+2 is overlapped by the canine.
 
• Good prognosis of spontaneous eruption, if the angle between the central incisor and the canine > 20°.

- <u>Criteria for successful eruption of ectopic canines:</u>
• Small dislocation vector.
• Prepubertal skeletal maturation
• Open apex

- <u>Therapy:</u>
• Ex primary canine → 60% spontaneous eruption (vs. 20% of controls)
• Ex primary canine +
▪ HG or
▪ RPE or
▪ TPE or
▪ RPE + HG = 80% spontaneous eruption.

- <u>If resorption on 21+12 is occurring:</u>
• Surgically exposure of the canine and alignment into position with orthodontic force and a bonded attachment.
• Looping a wire around the cervical part of the crown is no longer recommended:
More extensive bone removal, risk for ankylosis ↑, potentially reduced gingival attachment.
• Resorption produced by the canine will stop, but some resorption and blunting of the roots may continue.</td></tr>
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Supernumerary teeth	- Mostly in the anterior part of the maxilla. - Supernumerary teeth erupt before or with the normal teeth, if they are not inverted. Inverted teeth do not erupt spontaneously. - Early extraction is indicated before problems arise: o Disruption of the eruption path of the normal teeth. o Crowding → arch distortion. o Spacing. o Displacement of other teeth. o Resorptions. → The earlier the extraction, the more likely that the normal teeth will erupt without further intervention. - Retain the tooth which is best in size, color, morphology and position related to the other teeth → CBCT may helpful. If all characteristics are equal, retain the tooth nearest to the ultimate final position. - Multiple supernumerary teeth can be an indicator for a syndrome or a congenital abnormality (e.g. cleidocranial dysplasia).
Delayed incisor eruption	- Often related to a retained primary tooth, a supernumerary tooth or some type of pathology. - Consider the morphology (usability) of the unerupted tooth and the likelihood to bring it into the arch (enough space must be available). - <u>Surgically uncovering:</u> • Superficial location: o Soft tissue excision. • Tooth more deeply positioned: o Reposition of the adjacent tissue apically to expose the crown. Cave: Risk of an uneven gingival margin. (will be overcome with further eruption of the incisors) o Surgical exposure and placement of a bonded attachment followed by fixed tx.
Ankylosed primary teeth	- Usually exfoliate when the permanent successor erupts without creating long-term problems. - Possible causes for retained primary teeth: • Delay of the eruption of the permanent tooth. • Deflection of the successor tooth from the normal eruption path. - <u>Tx if the permanent tooth is present:</u> • Maintain the primary tooth until an interference with eruption or drift of other teeth occur → then extract the primary tooth and place a lingual arch or a fixed appliance if needed to secure the space. • Adjacent tipped teeth most be repositioned. • Vertical bone discrepancies are corrected with the eruption of the permanent tooth. - <u>Tx if no permanent successor exists:</u> • Extract or decoronate (without root filling, but removal of the vital pulp tissue) the ankylosed tooth before a large vertical occlusal discrepancy develops. → It is possible that new bone will form coronal to the buried root structure and allow a later implant with good bony support. • Move teeth partially into the edentulous space to create new bone and then reposition them prior to implant or prosthetic replacement. → Space maintenance is contraindicated. • The longer the ankylosed primary tooth is left in place, the greater the chance of a long-term vertical bone defect + problems with reduced attachment and exposed cementum. (although extraction will also result in some loss of alveolar bone)

Management of space problems

Space analysis: Quantification for space problems

- Consider the space analysis in the context of the profile.
- Avoid expansion with limited OB.
  (facial tipping of the teeth moves them usually also vertical)
- Comparison between the amount of space available and the space required.
  Cave assumptions:
  - Anterior-posterior position of the incisors is correct.
  - The space available will not change because of growth and dental compensatory tipping.
    (true for most children if there is no jaw discrepancy exists)
  - All the teeth are present and reasonably normal in size.

- <u>Measure the arch perimeter:</u>
  - Divide the dental arch into segments that can be measured as straight-line approximations of the arch.
    Stöckli 1994: Space slightly underestimated.
  - Contouring a piece of wire → straightening it out for measurement.
    Stöckli 1994: Space slightly overestimated

- <u>Space required:</u>
  Measure the m-d width of each erupted tooth + estimate the size of unerupted permanent teeth.
  - Measurement of the teeth on x-rays:
    Cave: Distortion, radiation burden, compensation necessary for the enlargement. → Measure an object that can be seen on the x-ray and on the cast and the make a proportional calculation.
    OPG: Vertical distances can be measured and corrected by multiplying with the enlargement factor, but not horizontal distances.
  - Estimation from proportionality tables:
    Good correlation if applied to the population group from which they were developed.
    Exception: If obvious anomalies in tooth size or form are seen in the x-ray.

    Tanaka & Johnston 1974:
    Size prediction of the unerupted canines & premolars according the size of the lower incisors.
    Cave:
  - Caucasian females: mx + mn space overestimated.
  - African-American males: mn space underestimated.

  Proffit:

One half of the mesiodistal width of the four lower incisors	+10.5mm = estimated width of mandibular canine and premolars in one quadrant +11.0mm = estimated width of maxillary canine and premolars in one quadrant

Bernerskript:

$$\text{OK } \Sigma \varnothing 3\,4\,5 = \frac{\Sigma \varnothing \overline{2\,1|1\,2}}{2} + \boxed{10,5}^{*} \quad \begin{matrix} \♂ + \boxed{10,8}^{**} \\ \♀ + \boxed{10,2}^{**} \end{matrix}$$

$$\text{UK } \Sigma \varnothing 3\,4\,5 = \frac{\Sigma \varnothing \overline{2\,1|1\,2}}{2} + \boxed{10,0}^{*} \quad \begin{matrix} \♂ + \boxed{10,3}^{**} \\ \♀ + \boxed{9,4}^{**} \end{matrix}$$

* durchschnittliche Summanden,
** geschlechtsspezifische Summanden aufgrund Untersuchung an Zürcher Kindern (Müller, H. J.: Med. Dissertation, Zürich 1976)