Chapter 4

Orthodontics

Contents

Relevant pages in other chapters Surgical management of CLP, ➔ Clefts and craniofacial anomalies, p. 484; abnormalities of eruption, ➔ Abnormalities of tooth eruption and exfoliation, p. 64; supernumerary teeth, ➔ Hyperdontia, p. 66; orthognathic surgery, ➔ p. 486.

Further reading A. McNair & D. Morris (eds) 2010 *Managing the Developing Occlusion*, BOS. M. T. Cobourne *et al.* 2009 *Handbook of Orthodontics*, Mosby Elsevier. D. S. Gill 2008 *Orthodontics at a Glance*, Blackwell. L. Mitchell 2013 *An Introduction to Orthodontics* (4e), OUP. D. S. Gill *et al*. 2011 *Orthodontics: Principles and Practice*, Wiley-Blackwell. See also Cochrane Library http://www.thecochranelibrary.com

It has been said that orthodontists forget to ask the patient to open wide, thus missing any dental pathology, whilst generalists forget to ask the patient to close together, thus missing any malocclusion! The aim of this chapter is to help ensure that this is not true. A problem-orientated approach has been used (rather than by classification) for simplicity.

What is orthodontics?

Orthodontics has been defined as that branch of dentistry concerned with growth of the face, development of the dentition, and prevention and correction of occlusal anomalies. Ortho (from Greek) = straight. Malocclusion is not a disease – it is variation from ideal occlusion.

Prevalence of malocclusion Crowding ~60%; Class II/1 ~15–20%; Class II/2 ~10%; Class III ~3% (Fig. 4.1).

Why do orthodontics? Research shows that individual motivation has more effect upon the presence of plaque than alignment of the teeth, therefore, the main indications for orthodontic Rx are aesthetics and function. Functional reasons for Rx include deep traumatic overbite, ↑ overjet especially if the lips are incompetent (↑ risk of trauma), and labial crowding of a lower incisor (as this reduces periodontal support labially). While it is accepted that severe malocclusion may affect self-esteem and psychological well-being, the impact of more minor anomalies and, indeed, perceived need, are influenced by social and cultural factors. The Index of Orthodontic Treatment Need (IOTN) has been developed to try to standardize and quantify this difficult issue (➔ The Index of Orthodontic Treatment Need, p. 126). In adults Rx may be indicated to facilitate restorative management.

It is important to evaluate the risks and benefits of treatment for an individual patient. Even with good OH, a small loss of periodontal attachment is common and with poor OH this will be ↑. Decalcification (decay) will occur if there are frequent sugar intakes between meals and around 1–2mm of root resorption is associated with fixed appliance Rx and in at-risk patients (shortened/blunt root shape) this may be ↑. Therefore, the potential benefits must be sufficient to counter-balance these risks.

Who should do orthodontics? All dentists should be concerned with growth and development. Unless anomalies are detected early and any necessary steps taken at the appropriate time, then provision of the best possible outcome for that patient is less likely. Most orthodontic Rx in Europe is now carried out by trained specialist orthodontic practitioners. In the UK the hospital consultant service acts as a source of advice and a referral point for more complex and multidisciplinary problems.

When should we do orthodontics? Most orthodontic Rx is not started until the early 2° dentition, when the canines and premolars have erupted. At this stage the response to orthodontic forces is more rapid, appliances are better tolerated, and, most importantly, growth can be utilized to help effect sagittal or vertical change. However, there is some evidence that protraction facemask therapy for Class III malocclusions achieves more skeletal change around age 8–9 than in older children.

In adults, lack of growth, ↑ risk of periodontal disease, worn, damaged, and missing teeth, and slower tooth movement will limit the type of malocclusion that can be tackled by orthodontics alone.

What to refer and when

Deciduous dentition

- Cleft lip and/or palate (if patient not under the care of a cleft team).
- Other craniofacial anomalies (if patient not under the care of a multidisciplinary team).

Early mixed dentition

- Delayed eruption of the permanent incisors.
- Impaction or failure of eruption of the 6s.
- 6s of poor long-term prognosis.
- Severe Class III skeletal problems suitable for orthopedic treatment.
- Anterior crossbites (Xbites) which compromise periodontal support.
- Ectopic maxillary canines.
- Patients with medical problems where monitoring of the occlusion would be beneficial.
- Pathology, e.g. cysts.

Late mixed dentition

- Growth modification of skeletal Class II malocclusions.
- Hypodontia.
- Most routine problems.

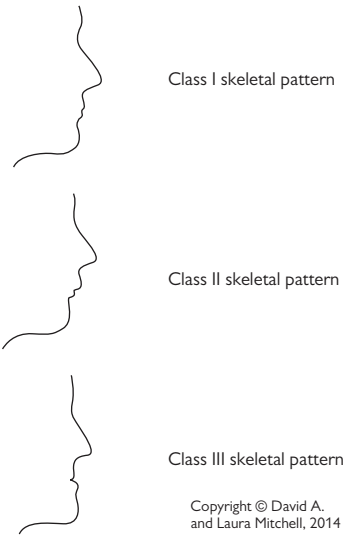


Fig. 4.1 Malocclusion.

Definitions

Ideal occlusion Anatomically perfect arrangement of the teeth. Rare.

Normal occlusion Acceptable variation from ideal occlusion.

Competent lips Lips meet with minimal or no muscle activity.

Incompetent lips Evident muscle activity is required for lips to meet.

Frankfort plane Line joining porion (superior aspect of external auditory meatus) with orbitale (lowermost point of bony orbit).

Class I The lower incisor edges occlude with, or lie immediately below, the cingulum of upper incisors (Fig. 4.2).

Class II The lower incisor edges lie posterior to the cingulum of the upper incisors. *Division* 1 the upper central incisors are upright or proclined and the overjet is ↑ (Fig. 4.3). *Division 2* the upper central incisors are retroclined and the overjet is usually ↓ but may be ↑ (Fig. 4.4).

Class III The lower incisor edges lie anterior to the cingulum of the upper incisors and the overjet is ↓ or reversed (Fig. 4.5).

Bimaxillary proclination Both upper and lower incisors are proclined.

Overjet Distance between the upper and lower incisors in the horizontal plane.

Overbite Overlap of the incisors in the vertical plane.

Complete overbite The lower incisors contact the upper incisors or the palatal mucosa.

Incomplete overbite The lower incisors do not contact the upper incisors or the palatal mucosa.

Anterior open bite There is no vertical overlap of the incisors when the buccal segment teeth are in occlusion.

Crossbite A deviation from the normal bucco-lingual relationship. May be anterior/posterior &/or unilateral/bilateral.

Buccal crossbite Buccal cusps of lower premolars or molars occlude buccally to the buccal cusps of the upper premolars or molars.

Lingual crossbite Buccal cusps of lower molars occlude lingually to the lingual cusps of the upper molars.

Dento-alveolar compensation The inclination of the teeth compensates for the underlying skeletal pattern, so that the occlusal relationship between the arches is less severe.

Leeway space The difference in width between C, D, E, and 3, 4, 5. Greater in lower than upper arch.

Mandibular deviation Path of closure starts from a postured position of the mandible.

Mandibular displacement When closing from the rest position, the mandible displaces (either laterally or anteriorly) to avoid a premature contact.

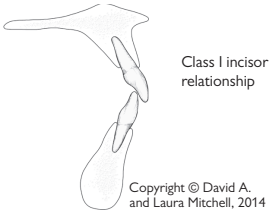


Fig. 4.2 Class I incisor relationship.

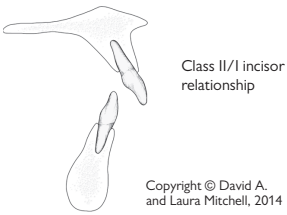


Fig. 4.3 Class II/1 incisor relationship.

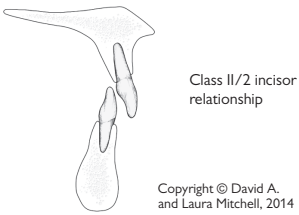


Fig. 4.4 Class II/2 incisor relationship.

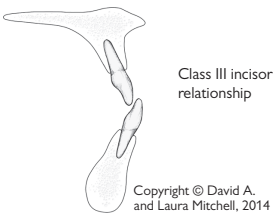


Fig. 4.5 Class III incisor relationship.

Orthodontic assessment

Brief screening procedure

The purpose of this is to ensure early detection and Rx of any abnormality, prepare the patient for any later Rx, and influence the management of any teeth of poor prognosis.

At every visit Once the 2° incisors have erupted and until 2° dentition is established (if in doubt refer).

- Keep the eruption sequence in mind (➔ Failure of/delayed eruption, p. 64).
- Failure of a tooth to appear >6 months after the contralateral tooth has erupted should ring alarm bells.
- Ask child to close together and look for Xbites, reverse or ↑ o/j.
- Consider the long-term prognosis of the 6s (➔ Extraction of poor quality first permanent molars, p. 138).

From age 9yrs onwards and until they erupt, palpate for 3 in the buccal sulcus. A definite hollow &/or asymmetry warrants further investigation.

Detailed orthodontic examination

Should be carried out in a logical sequence so that nothing is missed.

- Who wants Rx (patient or parent) and what for?
- Is patient willing to wear braces?
- Enquire about any previous extractions and orthodontic Rx.
- Check medical history.
- Assess growth status.

EO examination (with Frankfort plane horizontal)

- Assess skeletal pattern:
  - Anteroposterior (max = mand—Class I; max > mand—Class II; max < mand—Class III). See Fig. 4.1.
  - Vertically (Frankfort–Mandibular planes angle ~28°. Lower face height is the distance from the base of the nose to the point of the chin, and in a normally proportioned face is equal to the middle facial third–eyebrow line to base of nose).
  - Transversely (? asymmetry).
- Soft tissues: can patient achieve lip competence with or without muscle activity? Check the position of the lower lip relative to the inc and how the patient achieves an oral seal (? lip to lip; lip to tongue; or by the lower lip being drawn up behind the incisors). Note also the length of the upper lip, the amount of inc seen, gingival display on smiling and lip tonicity.
- Check rest position of mandible and for any displacement on closure.
- Habits? Does patient suck a thumb/finger, bite fingernails, or brux?

IO examination

- Record OH, gingival condition, and teeth present. Any teeth of poor prognosis?
- LLS: inclination to mandibular base, crowding/spacing, displaced teeth, angulation of lower canines
- ULS: inclination to maxillary base, crowding/spacing, rotations, displaced teeth, presence and angulation of 3|3.

- Measure o/j (mm), o/b (↑ or ↓, complete or incomplete) (Fig. 4.6). Check centre lines coincident and correct within face.
- Buccal segments: crowding/spacing, displaced teeth.
- Check molar and canine relationship. Any Xbites?
- Crowding: mild <4mm; moderate 4–8mm; severe >8mm.

Diagnostic records

- To facilitate diagnosis and treatment planning.
- Measuring the progress and outcome of treatment.
- Medico-legal.
- Audit and research.

X-rays Usually a DPT is taken and, if not clearly visible on the DPT, an intraoral of the inc. A lateral skull view is indicated if the patient has a skeletal discrepancy or AP movement of the incisors is anticipated.

- Look for unerupted, missing, displaced, or $ teeth, or other pathology. Check root morphology looking for blunt or pipette-shaped roots.
- Cephalometric analysis ➔ Cephalometrics, p. 128.

Study models Study models should be trimmed so that they occlude correctly on a flat surface. Digital study models becoming more popular as easier to store.

Photographs Good quality extra- & intra-oral colour photos.

Problem list

This information is then collated into a problem list subdivided into:

- *Pathological*—e.g. caries, perio disease, impacted teeth.
- *Developmental*—patient's concerns; skeletal and dental problems in AP, vertical, and transverse; alignment of upper and lower arches including crowding and/or spacing.

The aims of Rx can then be derived from the problem list (➔ Problem list, p. 132).

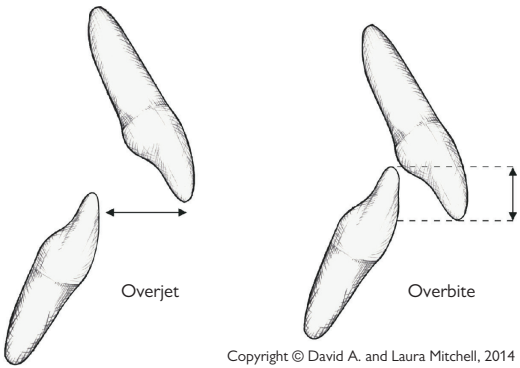


Fig 4.6 Overjet and overbite.

The Index of Orthodontic Treatment Need

The IOTN (Box 4.1) was developed to quantify and standardize an individual patient's need for orthodontic Rx, so that the potential benefits can be weighed against the possible disadvantages.[1] The Index consists of two components:

The dental health component was developed from an index used by the Swedish Dental Health Board (which was used to determine the amount of financial help that would be given by the State towards Rx costs). The Dental Health Component of IOTN (reproduced by kind permission of University of Manchester) has five categories of Rx need, ranging from little need to very great need. A patient's grade is determined by recording the single worst feature of their malocclusion. MOCDO is helpful when assessing dental health component as it provides a hierarchy of severity—Missing teeth; Overjet; Crossbite; Displacement; Overbite.

The aesthetic component is based on a series of 10 photographs of the labial aspect of different Class I or Class II malocclusions, which are ranked according to their attractiveness. A patient's score is determined by the photograph, which is deemed to have an equivalent degree of aesthetic impairment.

Box 4.1 The Index of Orthodontic Treatment Need

Grade 1 (None)

1 Extremely minor malocclusions including displacements less than 1mm.

Grade 2 (Little)

2a Increased overjet 3.6–6mm with competent lips.
2b Reverse overjet 0.1–1mm.
2c Anterior or posterior crossbite with up to 1mm discrepancy between retruded contact position and intercuspal position.
2d Displacement of teeth 1.1–2mm.
2e Anterior or posterior openbite 1.1–2mm.
2f Increased overbite 3.5mm or more, without gingival contact.
2g Pre-normal or post-normal occlusions with no other anomalies. Includes up to half a unit discrepancy.

Grade 3 (Moderate)

3a Increased overjet 3.6–6mm with incompetent lips.
3b Reverse overjet 1.1–3.5mm.
3c Anterior or posterior crossbites with 1.1–2mm discrepancy.
3d Displacement of teeth 2.1–4mm.
3e Lateral or anterior openbite 2.1–4mm.
3f Increased and complete overbite without gingival trauma.

1 W. C. Shaw 1991 *BDJ* **170** 107.

Grade 4 (Great)

4a Increased overjet 6.1–9mm.
4b Reversed overjet greater than 3.5mm with no masticatory or speech difficulties.
4c Anterior or posterior crossbites with greater than 2mm discrepancy between retruded contact position and intercuspal position.
4d Severe displacement of teeth, greater than 4mm.
4e Extreme lateral or anterior openbites, greater than 4mm.
4f Increased and complete overbite with gingival or palatal trauma.
4h Less extensive hypodontia requiring pre-restorative orthodontic space closure to obviate the need for a prosthesis.
4l Posterior lingual crossbite with no functional occlusal contact in one or both buccal segments.
4m Reverse overjet 1.1–3.5mm with recorded masticatory and speech difficulties.
4t Partially erupted teeth, tipped and impacted against adjacent teeth.
4x Supplemental teeth.

Grade 5 (Very great)

5a Increased overjet greater than 9mm.
5h Extensive hypodontia with restorative implications (more than one tooth missing in any quadrant) requiring pre-restorative orthodontics.
5i Impeded eruption of teeth (with the exception of third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth, and any pathological cause.
5m Reverse overjet greater than 3.5mm with reported masticatory and speech difficulties.
5p Defects of cleft lip and palate.
5s Submerged deciduous teeth.

Reproduced from Brook, P., Shaw, W., The development of an index of orthodontic treatment priority. *Euro J Ortho* **11** (1989) 309–20, with permission from Oxford University Press.

Cephalometrics

Cephalometric analysis is the interpretation of lateral skull radiographs (Fig. 4.7). They are taken in a cephalostat to standardize position and magnification (usually around 7–8%) so that they are reproducible. It is not obligatory for orthodontic Δ and where the incisor position is not to be changed significantly, the X-ray exposure may not be justified for the information gained. However, where AP movement is required, a lateral skull radiograph will back-up the clinical assessment of skeletal pattern, and help to determine the degree of difficulty. Serial lateral skulls aid assessment of growth.

Tracing/digitizing

Nowadays most lateral skull X-rays are digital and can be digitized directly. If a landmark is hard to see, block off the rest of the film so that only that area is illuminated. By convention, the most prominent image should be traced, i.e. the most anterior in the face so that the difficulty of Rx is not underestimated.

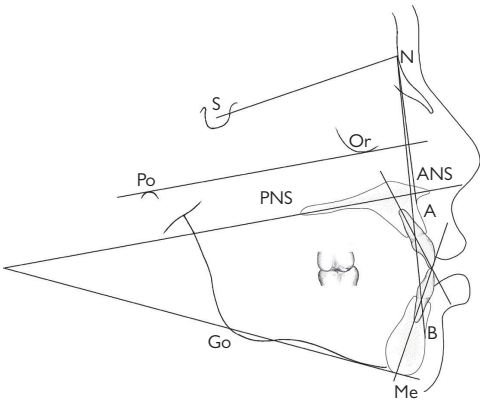
There are many commercial programs of varying complexity and cost to facilitate cephalometric analysis and treatment planning.

Pitfalls

- Consider the cephalometric values for a particular patient in conjunction with their clinical assessment, as variation from the normal in a measurement may be compensated for elsewhere in the face or cranial base.
- Angle ANB varies with the relative prominence of nasion and the lower face. If SNA significantly ↑ or ↓ this could be due to the position of nasion, in which case an additional analysis should be used, e.g. Wits analysis.
- For landmarks which are bilateral (unless superimposed exactly) the midpoint between the two should be taken to correspond with other reference points which are in the midline.
- Tracing errors; with careful technique these should be of the order of ± 0.5° and 0.5mm. Errors are compounded when comparing tracings, therefore changes of only 1° or 2° should be interpreted with caution.
- If the values you obtain are the norms for a giraffe and the patient looks humanoid repeat your digitization!

Lower facial height (LFH) is the distance from anterior nasal spine to menton as a percentage of the total face height (from nasion to menton).

Soft tissue analysis Particularly useful in orthognathic patients. Naso-labial angle is angle between nose and upper lip.



S	= Sella: mid-point of sella turcica.
N	= Nasion: most anterior point on fronto-nasal suture.
Or	= Orbitale: most inferior anterior point on margin of orbit (take average of two images).
Po	= Porion: uppermost outermost point on bony external auditory meatus.
ANS	= Anterior nasal spine.
PNS	= Posterior nasal spine.
Go	= Gonion: most posterior inferior point on angle of mandible.
Me	= Menton: lowermost point on the mandibular symphysis.
A	= A point: position of deepest concavity on anterior profile of maxilla.
B	= B point: position of deepest concavity on anterior profile of mandibular symphysis.
Frankfort plane	= Po–Or.
Maxillary plane	= PNS–ANS.
Mandibular plane	= Go–Me.

Fig. 4.7 Most commonly used cephalometric points.

More cephalometrics

Analysis and interpretation

The analysis of lateral skull tracings is carried out by comparing a number of angular measurements and proportions with average values for the population as a whole. Normal values for Caucasians (UK), standard deviations in parentheses (Table 4.1).

Table 4.1 Analysis of lateral skull tracings

SNA	= 81° (±3)
SNB	= 79°(±3)
ANB	= 3°(±2)
$\underline{1}$-Max	= 109°(±6)
$\underline{\bar{1}}$-Mand	= 93°(±6) or 120 minus MMPA
MMPA	= 27°(±4)
Facial proportion	= 55% (±2)
Inter-incisal angle	= 133°(±10)

When interpreting a tracing bear in mind:

- 68% of values lie within 1 standard deviation of the mean.
- 95% of values lie within 2 standard deviations of the mean.
- >99% of values lie within 3 standard deviations of the mean.

It is important to remember that the ANB difference is not an infallible assessment of skeletal pattern as it assumes (incorrectly in some cases) that there is no discrepancy in the cranial base and that A and B are indicative of basal bone position. When a cephalometric tracing seems at odds with your clinical impression it is worth doing another analysis which avoids reliance on the cranial base, such as a Wits analysis.

Before deciding on a Rx plan it is helpful to consider what factors have contributed to a particular malocclusion, e.g. in a patient with a Class II/1 incisor relationship on a Class I skeletal pattern, the prognosis for Rx is much better if the ↑ o/j is due to proclination of the upper rather than retroclination of the lower incisors. The relative contribution of the maxilla and mandible to the skeletal pattern may indicate possible lines of Rx; e.g. if an ↑ o/j is due to a retrusive mandible, a better aesthetic result may be achieved by use of a functional appliance.

As a rough guide can assume that there is ~2.5° of angular movement for every millimetre of linear movement of the incisor edge.

Cone beam X-rays are increasingly available. 3-D analyses are being developed but the main value of this technique is the additional spatial dimension for assessing asymmetry, tooth position and pathology etc. For a good discussion of the pros and cons see reference.[2]

2 A. Abdelkarim 2012 J World Fed Orthod **1** e3.

Wits analysis

Used to assess anteroposterior skeletal pattern (Fig. 4.8).

Method

- Construct the functional occlusal plane (FOP) by drawing a line through the cusp tips of the molars and premolars or deciduous molars.
- Drop perpendiculars to the FOP from A point (to give AO) and B point (to give BO).
- Measure the distance from AO to BO.

In Class I AP relationship

Males: BO is 1mm (± 1.9mm) ahead of AO.
Females: BO = AO (± 1.77mm).

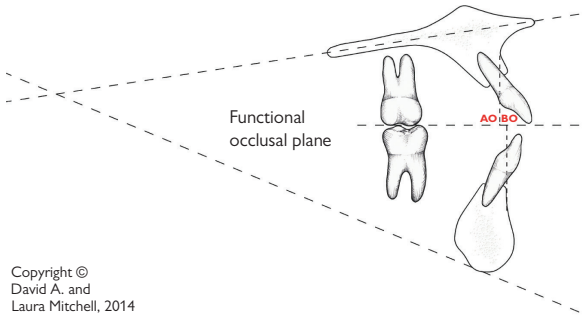


Fig. 4.8 Wits analysis.

Treatment planning

Problem list

The problem list is a logical summary of the main features of a malocclusion i.e. the diagnosis. It is usually subdivided into pathological and developmental features (➔ Orthodontic assessment, p. 124).

Aims of Rx

The next step is to work through these and decide which problems will be accepted and which corrected—the latter are the Aims of Rx. Then possible solutions and their relative risks and benefits can be considered. These should be discussed with the patient (along with the option of no treatment) before informed consent is obtained for the definitive treatment plan.

Basic treatment planning principles

The lower arch lies in a zone of relative stability between the lips, cheeks, and tongue, therefore, in most cases it is advisable to maintain its current position. This gives a starting point around which to plan Rx. The first step is to decide if the lower arch is sufficiently crowded to warrant extractions. If the crowding is moderate to severe and likely to ↑, then extractions are probably indicated (➔ Extractions, p. 136). In some cases movement of the LLS is indicated but these are the province of the specialist, e.g. Class III where retroclination of the LLS is required for camouflage; Class 11/2 cases where it may be advisable to accept a little proclination to help ↓ o/b and improve aesthetics.

If in doubt, refer for advice.

The upper arch Next the position of the upper arch can be planned to achieve a Class I incisor relationship. This usually requires positioning, in the mind's eye, the $\underline{3}$ into a Class I relationship with $\overline{3}$ (in corrected position if LLS crowded). This will give an indication of the space required and the amount and type of movement necessary. In the upper arch, space for retraction of $\underline{3}$ can be gained by: (i) extractions, (ii) expansion (only indicated if a Xbite exists), (iii) distal movement of the upper buccal segments (➔ Distal movement of the upper buccal segments, p. 140), (iv) a combination of these. Should extractions be indicated in both arches, mechanics are often easier if the same tooth is extracted in the upper as in the lower. However, in Class II cases it may be advantageous to extract further forward in the upper arch and vice versa in Class III.

Buccal segments It is not always necessary to plan to a Class I buccal segment relationship. If only upper arch extractions are required to gain space to ↓ an overjet, then the final molar relationship will be Class II. Likewise if only lower teeth are extracted the molar relationship will be Class III at the end of treatment.

Treatment mechanics The next step is to plan what tooth movements need to be carried out, including which appliances are to be used and in what sequence. These decisions should be made based on available evidence of efficiency, predictability, minimal risks, and minimal patient cooperation.

Anchorage To every force there is an equal and opposite reaction. In orthodontic treatment the resistance to unwanted tooth movement is called anchorage and also needs to be considered when planning Rx. *Retention* of the final result should be included in the Rx plan and the need for compliance with wearing retention appliances explained to the patient. Many orthodontists now plan for long-term retention.

Consent

In some cases more than one Rx plan can be offered to the patient, with a hierarchy of complexity and finished result. The risks and benefits of each option (including no treatment) should be carefully explained to the patient/parent so they can make an informed choice. If a compromise plan is chosen by the patient this should be recorded in the consent process. It is advisable to get written consent, including specific details of the Rx and associated risks.

► *Refer for advice* if the malocclusion under consideration contains one of the following features:

- Marked skeletal discrepancy, AP (II or III), or vertically.
- If the o/j is increased and the upper incisors are upright.
- If the o/j is reversed and there is no o/b to hold the corrected incisor relationship.
- Severe Class II/2 malocclusions.
- Class II/1 incisor relationship, with molars a full unit Class II and a crowded lower arch.

Rx planning is the most important, and most difficult, part of orthodontics.

Further reading

S. J. Littlewood *et al*. 2006. Retention procedures for stabilizing tooth position after treatment with orthodontic braces. *Cochrane Database Syst Rev* **1** CD002283.

Notebox:
Summary points for treatment planning
(you write here)

Management of the developing dentition

See also delayed eruption, Failure of/delayed eruption, p. 64.

The way in which mixed dentition problems are approached will often affect the ease or difficulty of subsequent Rx.

Normal development of dentition The 1° incisors are usually upright and spaced. If there is no spacing warn the parents that the 2° incisors will probably be crowded. Overbite reduces throughout the 1° dentition until the incisors are edge to edge. All 2° incisors develop lingual to their predecessors, erupt into a wider arc, and are more proclined. It is normal for 1|1 to erupt with a median diastema which reduces as 2|2 erupt. Later, pressure from the developing canines on the roots of 2|2 results in their being tilted distally and spaced. This has been called the 'ugly duckling stage', but it is better to describe it as normal development to parents. As the 3 erupts the 2 upright and the spaces usually close.

The majority of Es erupt so that their distal edges are flush. The transition to the normal stepped (Class I) molar relationship usually occurs during the 2° dentition as a result of greater mandibular growth &/or the leeway space.

Development of dental arches In the average (!) child, the size of the dental arch is more or less established once the deciduous dentition has erupted, except for an increase in inter-canine width (2–3mm up to age 9yrs) which results in a modification of arch shape.

Retained deciduous teeth If deflecting eruption of 2° tooth, extract.

Infraoccluded deciduous molars Prevalence 8–14%. Provided there is a successor, an infraoccluded 1° molar will probably be exfoliated at the same time as the contralateral tooth.[3] Extraction is only indicated if there is no successor or the infraoccluded molar is likely to disappear below the gingival margin.

Impacted upper first permanent molars Prevalence 2–6%. Indicative of crowding. Spontaneous disimpaction rare after 8yrs. Can try dislodging 6 by tightening a piece of brass wire round the contact point with E over several visits. Otherwise just observe, extracting E if unavoidable and dealing with resultant space loss in 2° dentition.

3 J. Kurol 1985 *Am J Orthod* **87** 46.

Habits Effects produced depend upon duration of habit and intensity. It is best not to make a great fuss of a finger-sucking habit. If parents concerned, reassure them (in presence of child) not to worry, as only little girls/boys suck their fingers. Appliances to break the habit may help, but most children will stop when they are ready. However, this is no reason to delay the start of Rx for other aspects of the malocclusion.

Effects of premature loss of deciduous teeth

Unfortunately, when a child attends with toothache, in the rush to relieve pain it is all too easy to extract the offending tooth without consideration of the consequences. The major effect of early deciduous tooth loss is localization of crowding, in crowded mouths. The extent to which this occurs depends upon the patient's age, degree of crowding, and the site. In a crowded mouth the adjacent teeth will move round into the extraction space, therefore, unilateral loss of a C (and to a lesser degree a D) will result in a centre-line shift. This is also seen when a C is prematurely exfoliated by an erupting 2. As correction of a centre-line discrepancy often involves fixed appliances, prevention is better than cure, so loss of Cs should always be balanced. If Es are lost the 6 will migrate forward. This is particularly marked if it occurs before eruption of the permanent tooth, so if extraction of an E is unavoidable try to defer until after the 6s are in occlusion and do not balance or compensate.

The effect of early loss of 1° teeth on the eruption of the permanent successor is variable.

Timely loss of Cs is indicated for:

- $\underline{2}$ erupting palatally due to crowding. Extraction of $\underline{C}|\underline{C}$ as the $\underline{2}$ erupting may allow the tooth to escape labially and prevent a Xbite.
- Extraction of lower Cs when a lower incisor is being crowded labially will help to ↓ loss of periodontal support.

Balancing extraction Extraction of the same (or adjacent) tooth on the opposite side of the arch to preserve symmetry.

Compensating extraction Extraction of the same tooth in the opposing arch.

Further reading

O. Chawal 2012 *Faculty Dent J* **3** 208.

Extractions

In orthodontics, teeth are extracted to relieve crowding, level and align, and to provide space to compensate for a skeletal discrepancy.

▶ Before planning the extraction of any permanent teeth a thorough orthodontic and radiographic examination should be carried out.

▶ In a Class I or II, it is advisable to extract at least as far forward in the upper arch as the lower; vice versa in a Class III.

Lower incisors Rarely tooth of choice as it is difficult to arrange 6 ULS teeth around 5 LLS teeth. Indications: ↓ prognosis or perio support, Class I buccal segments and LLS crowding, mild Class III with well-aligned buccal segments.

Upper incisors If traumatized or dilacerated, there may be no alternative (➔ Management of missing incisors, p. 112). Peg-shaped $\underline{2}$ may be extracted if contra-lateral $\underline{2}$ absent.

Lower canines Usually only extracted if severely displaced.

Upper canines See ➔ Buccally displaced maxillary canines, p. 141.

First premolars are a popular choice in moderate to severe crowding because of their position in the arch. They also give best chance of spontaneous improvement especially if extracted just as the 3s are appearing, but if appliance therapy is planned, defer until the canines have erupted.

Second premolars Preferred in cases with mild crowding, as their extraction alters the anchorage balance, favouring space closure by forward movement of the molars. FAs are required, especially in the lower arch. If 5s hypoplastic or missing there may be no choice. Early loss of an E will often lead to forward movement of the 6 and lack of space for 5s. In the upper arch this results in $\underline{5}$ being displaced palatally and provided $\underline{4}$ is in a satisfactory position, extraction of $\underline{5}$ on eruption is advisable. In the lower arch 5s are usually crowded lingually. Extraction of lower 4 is easier and will give lower 5 space to upright spontaneously.

First permanent molars See ➔ Extraction of poor quality first permanent molars, p. 138.

Second permanent molars Extraction of $\overline{7}$ will not alleviate incisor crowding but may relieve mild lower premolar crowding and avoid difficult extraction of impacted $\overline{8}$.

To increase likelihood of $\overline{8}$ erupting successfully to replace $\overline{7}$, need: posterior crowding and $\overline{8}$ formed to bifurcation and at an angle of between 15° and 30° to long axis $\overline{6}$. Even so, may still require appliance therapy to align $\overline{8}$ on eruption.

In the upper arch extraction of $\underline{7}$ often limited to facilitating distal movement of the upper buccal segments.

Third permanent molars Early extraction of lower 8s is no longer advocated to prevent LLS crowding (as now thought to be due to late facial growth and soft tissue change).

Space can also be provided in selected cases by:

- Expansion (only in upper arch with a Xbite, otherwise not stable).
- Distal movement of the upper buccal segments (➔ Distal movement of the upper buccal segments, p. 140).
- Reducing the width of the teeth interproximally (usually limited to LLS in selected cases).

Extraction of poor quality first permanent molars

First permanent molars are never the first choice for extraction, as even if removed at the optimal time a good spontaneous alignment of the remaining teeth is unlikely. However, if there is hypoplasia or a large restoration is required in a molar tooth for a child, the long-term prognosis should be considered. A well-timed extraction may be better for the child (and your BP) than heroic attempts to restore hopeless molars. Equally well, placing a dressing and maintaining a poor-quality 6 until the 7 has erupted and the extraction can be incorporated into an orthodontic plan, may keep you on the specialist orthodontists' Christmas card list. Points to note:

- Check the remaining teeth are present and in a good position. If not, avoid extraction of $\overline{6}$ in affected quadrant.
- Timing of loss of a $\overline{6}$ is critical. There is a greater tendency for mesial drift in the maxilla, therefore, the timing of loss of $\underline{6}$ is less important.
- In the lower arch good spontaneous alignment is more likely following extraction $\overline{6}$ if: (i) $\overline{7}|\overline{7}$ development has reached bifurcation, (ii) angulation between crypt $\overline{7}$ and $\overline{6}$ is <30°, (iii) $\overline{7}|\overline{7}$ crypts overlap $\overline{6}|\overline{6}$ roots.
- If the $\overline{6}$ is extracted after eruption of the $\overline{7}$ little space closure will occur and the $\overline{7}$ will tilt and roll lingually
- Assess the prognosis for remaining 6s. If they are all restored then extraction of all four is probably indicated. If only one poor $\underline{6}$, do not extract corresponding lower tooth. If $\overline{6}$ of poor prognosis it is advisable to extract opposing $\underline{6}$ as otherwise this tooth will over-erupt and prevent $\overline{7}$ moving forward. Balancing with extraction of a corresponding sound $\overline{6}$ is inadvisable; better to deal with other side of arch on its merit.
- In Class I with anterior crowding and Class II malocclusions, $\underline{6}|\underline{6}$ should, if possible, be preserved until $\underline{7}|\underline{7}$ have erupted, and can be held back by an appliance and the extraction space utilized for relief of crowding and/or o/j reduction.
- In Class III, if $\underline{6}|\underline{6}$ of poor prognosis try to preserve until incisor relationship corrected (to provide retention for appliance). In cases with poor quality $\overline{6}|\overline{6}$, extract at optimal time to aid space closure.
- If the dentition is uncrowded, avoid extraction of 6s as space closure will be difficult.
- Extraction of 6s will relieve buccal segment crowding, but will have little effect on labial segment crowding. Impaction of 8s less likely but not impossible.

► In a child with poor quality 6s, remember that the premolars may well be in a similar condition 6yrs on unless the caries rate is stabilized.

Spacing

Uncommon in UK; crowding is the norm.

Generalized spacing

Is due either to hypodontia or small teeth &/or large jaws. Note that hypodontia is associated with small teeth (➲ Hypodontia (oligodontia), p. 66). Rx of spacing is problematic; a purely orthodontic approach is liable to relapse and requires prolonged retention. In milder cases it may be wiser to build up the teeth if small or accept the spacing. In more severe cases a combined restorative/orthodontic approach to localize space for the provision of prostheses or implants may be required.

Median diastema

Prevalence 6yr-olds = 98%, 11yr-olds = 49%, 12–18yr-olds = 7%.

Aetiology Small teeth in large jaws; absent or peg-shaped 2|2; midline $; proclination of ULS; physiological (caused by pressure of developing teeth on upper incisor roots which reduces as 3 erupts), or due to a fraenum.

The upper incisive fraenum is attached to the incisive papilla at birth. As 1|1 erupt the fraenum recedes, but this is less likely if the arch is spaced. A fraenum contributes to a diastema in a small number of cases and is associated with the following features:

- Blanching of incisive papilla when fraenum put under tension.
- Radiographically there is a V-shaped notch in the interdental bone between 1|1 indicating the attachment of the fraenum.
- Anterior teeth may be crowded.

Management Take a periapical X-ray to exclude presence of a $.

- Before 3 erupted: if diastema <3mm—review after eruption of canines as will probably ↓ unaided. If >3mm—may need to approximate incisors to provide space for canines to erupt, but care is required not to resorb roots of 2|2 against crowns of 3|3. Requires FA and prolonged retention.
- After 3 erupted: orthodontic closure will require prolonged retention as has high tendency to relapse. If fraenum an aetiological factor consider doing a fraenectomy. There is no evidence to indicate whether this should be done before or during FA Rx. Long-term retention still required. Alternatively, measure width of 1 and 2, and if they are narrower than average (1 = 8.5mm, 2 = 6.5mm) consider composite additions or veneers to close space. If teeth of normal width and no other orthodontic Rx required, could try and talk patient into accepting their diastema (currently very fashionable!).

Distal movement of the upper buccal segments

This is usually thought of as an alternative to extraction, but in practice often results in the crowding being shifted distally, requiring the loss of 7 or 8. It is only applicable to the upper arch. Indications:

- Either Class I with mild upper-arch crowding, or Class II/1 with well-aligned lower arch and molars <1 unit Class II.
- High anchorage case where extraction of 1 tooth per quadrant does not provide sufficient space to align upper arch.

Can be achieved either using a temporary anchorage device (➔ Temporary Anchorage Devices (TAD), p. 156) or more usually by headgear to molar bands on 6|6. As 6|6 move distally, will need some expansion to keep the roots in cancellous bone. The chances of success are greater in a growing child. Can expect 1/2 unit change in 3–4 months with good cooperation. If need unilateral distal movement, extraction of 7 on that side can be considered (provided 8 present and in good position). To facilitate distal movement a direction of pull parallel to the occlusal plane is advisable.

Headgear safety

Cases have been reported where damage to the eye as a result of headgear has resulted in loss of vision. For this reason headgear should only be used by those who have received training and to avoid injury to the face, it should only be used in conjunction with 2 safety mechanisms which prevent displacement &/or recoil of the facebow. If eye injury should occur immediate referral to an ophthalmologist is required.

Buccally displaced maxillary canines

▶ Width 3 > width 4 > width C.

3 is usually the last tooth to erupt anterior to 6. If the upper arch is crowded, 3 may be squeezed buccal to its normal position, in which case space needs to be created for its alignment. Usually 4 is the tooth of choice for extraction and, if so, this should be carried out just as 3 is about to erupt. If space is critical an appliance should be fitted first.

Where 2 and 4 are in contact, extraction of 4 alone will not provide sufficient space to accommodate 3 so consider extracting 3. Less commonly, 3 may develop well forward over the root of 2. In this case orthodontic Rx to align 3 will be prolonged. If the arch is crowded it may be simpler to extract 3 and align remaining teeth. If 3 has been extracted need to rotate 4 slightly mesio-palatally with FA to hide palatal cusp.

Transposition almost exclusively involves a canine tooth. In the maxilla 3 is usually transposed with 4 and in the mandible the lateral incisor is more commonly involved. Rx options include alignment of teeth in transposed position, extraction of the most displaced tooth, or correction if transposition of root apices is not complete.

Palatally displaced maxillary canines

▶ Early detection is essential.

Width 3 > width 4 > width C.

Prevalence

Up to 2%. Occurs bilaterally in 17–25% of cases. F > M.

Aetiology

In normal development, the maxillary canine develops palatal to C and then migrates labially to erupt down the distal aspect of 2 root. The aetiology of palatal displacement is not fully understood, but some suggest a lack of guidance is the reason behind the association with missing or short-rooted 2[4] (~6% of palatal 3 associated with small 2). Others argue that it is an inherited polygenic trait and that the link with missing or short-rooted 2 is part of association with other dental anomalies including microdontia and hypodontia.[5] Others have noted that palatal displacement of 3 is evident radiographically as early as age five.

Assessment

Clinically by palpation and from inclination of 2; and by X-rays. A DPT and an intra-oral view or two intra-oral views with tube shift can be used to assess the position of the canine by parallax (➔ Parallax technique, p. 17 remember your 'pal' goes with you!). Consider also position and prognosis of adjacent teeth (including C), the malocclusion, and available space.

Management

Early detection is key, therefore when examining any child >9yrs, palpate for unerupted 3. If there is a definite hollow &/or asymmetry between sides, further investigation is warranted.

Interceptive extraction of C has long been advocated to facilitate an improvement of a displaced 3 but there is currently no robust evidence to support this approach.[6] Nevertheless most orthodontists continue provided:

- The 3 is not too far displaced.
- The pros and cons have been discussed with the patient and informed consent obtained.
- The patient is willing to commit to exposure and alignment if the 3 does not erupt unaided.
- Recent evidence has suggested the chances of success are ↑ if space is created.

4 A. Becker *et al*. 1981 *Angle Orthod* **51** 24.

5 S. Peck *et al*. 1994 *Angle Orthod* **64** 249.

6 N. Parkin & P. Benson 2011 *Faculty Dent J* **2** 24.

If the canine is only very slightly palatally displaced or impacted between 2 and 4, provision of space should result in eruption. The majority of palatally displaced canines, however, do not erupt spontaneously, so hopeful watching and waiting may only result in an older patient who is less willing to undergo the prolonged Rx required to align the displaced tooth.

Rx alternatives available:

- Maintain C and keep unerupted canine under radiographic review. Provided no evidence of cystic change or resorption, removal of 3 can be left until GA required, e.g. for extraction of 8s. Patient must understand that C will eventually be lost, necessitating a prosthesis.
- No Rx, if 2 and 4 are in contact and appearance is satisfactory, or if patient refuses other options. Again, 3 will require removal in due course.
- Exposure and orthodontic alignment only feasible if: (i) canine in favourable position for orthodontic alignment; (ii) sufficient space available for 3, or can be created; (iii) patient willing to undergo surgery and prolonged orthodontic Rx (usually 2+yrs). Sequence is to arrange exposure, and allow tooth to erupt for 3 months, and then commence orthodontic traction to move tooth towards arch. FAs are required.
- Autotransplantation is not an instant solution, as space is needed to accommodate 3, which may involve appliances &/or extractions. Prognosis is ↑ by avoiding damage to PDL and if root formation is not complete. If apex not open should root fill <10 days. Immature apex may revascularize.

Resorption

Unerupted and impacted canines can cause resorption of incisor roots. For this to occur a 'head-on' collision between the two seems to be required. If detected on X-ray, a specialist opinion should be sought, quickly. Extraction of the canine may be necessary to limit resorption, but if extensive, removal of the affected incisor may be preferable, thus allowing the canine to erupt.

Further reading

Cochrane Library (http://www.thecochranelibrary.com).
Faculty of Dental Surgery clinical guidelines (http://www.rcseng.ac.uk).

Increased overjet

The 'normal' range for o/j is 2-4mm. The risk of trauma to the inc ↑ as the overjet ↑ especially if lips are grossly incompetent.

Aetiology

Skeletal pattern ↑ o/j can occur in association with Class I, II, or even III skeletal patterns. If Class II (~75%), often due to a normally sized mandible being positioned posteriorly on the cranial base. Be wary of patients with vertical proportions at either extreme of the range, as they are difficult to treat.

Soft tissues The effects of the soft tissues are usually determined by the skeletal pattern, as the greater the discrepancy the less likely it is that the patient will have competent lips. Where the lips are incompetent, the way an anterior oral seal is achieved will influence incisor position; e.g. if the lower lip is drawn up behind the upper incisors this may have contributed to the ↑ o/j, but if the incisors can be retracted within control of the lower lip at the end of Rx the prognosis for stability is ↑. The soft tissues can also help to compensate for the skeletal pattern by proclining the lower &/or retroclining the upper incisors.

Dental Crowding may contribute to an ↑ o/j. Digit-sucking can cause proclination of the upper and retroclination of the lower incisors. The effects are related to frequency, intensity and duration. Steps should be taken to stop the habit before active o/j ↓ is started.

► In the majority of cases skeletal pattern will determine difficulty of Rx and the soft tissues will influence stability of the end result.

Management of increased overjet

(See also ➔ Functional appliances—rationale and mode of action, p. 162.)

Class I or mild Class II skeletal pattern The majority of patients in this category are managed using FA to retract the upper incisors. Extractions are often required to relieve crowding and provide space for o/j ↓. Anchorage requirements should be assessed and if required re-inforced (➔ Reinforcing anchorage, p. 154).

If the skeletal pattern is more Class II then a functional appliance can be used for growth modification prior to FA.

Moderate to severe Class II skeletal pattern Approaches available:

- Modification of growth—either by restraint of maxillary growth with headgear, or by encouraging mandibular growth with a functional appliance.
- Orthodontic camouflage—by extractions in upper arch and bodily movement of inc with FAs.
- Surgical correction.

Because mandibular growth predominates during teens, a greater proportion of Class II than Class III skeletal problems is amenable to orthodontic correction. Research would suggest that the amount of growth modification that can be achieved is limited, but every little helps and in practice the majority of growing children in this category are treated by a combination of growth modification and camouflage. This usually takes the form of an initial phase of functional appliance therapy in the early permanent dentition, followed by FA ± extractions.

Adults whose skeletal pattern is not too severe may be treated by orthodontic camouflage, but in cases with a more severe skeletal problem &/or an ↑ o/b a surgical correction may be the only option.

Retention should be planned and presented to patient as part of overall treatment package.

Beware:
- Obtuse naso-labial angle as o/j ↓ will further reduce lip support.
- Grossly incompetent lips as stability is compromised.
- Significantly ↑ or ↓ vertical proportions.

Further reading

J. E. Harrison *et al*. 2007 Orthodontic treatment for prominent upper front teeth in children. *Cochrane Database Syst Rev* **3** CD003452.

Increased overbite

Normal o/b is between 1/3 and 1/2 overlap of the lower incisors. It is usual to record o/b in terms of whether it is ↑, ↓, or normal, rather than to try to measure it with a ruler. ↑ o/b is associated with Class II/2 incisor relationship, where typically 1|1 are retroclined and 2|2 are proclined, reflecting their relationship to the lower lip. But the o/b can also be ↑ in Class III and II/1 malocclusions. ↑ o/b *per se* is not an indication for Rx, unless it is traumatic and this is relatively rare, but o/b reduction may be necessary before correction of other anomalies. In Class III cases an ↑ o/b is advantageous as this will help to retain the corrected incisor position.

Aetiology

The lower incisors usually erupt until they contact the upper incisors, the palatal mucosa or are prevented by the tongue or a habit. An ↑ o/b occurs because the incisors are able to erupt past each other due to a combination of some or all of the following interrelated factors: ↓ LFH; high lower lip line; retroclined incisors; ↑ inter-incisal angle.

Normal inter-incisal angle is 135°. Highest acceptable angle is 145°. Above this value the tendency for the lower incisors to erupt may be inadequately resisted.

In some Class II/2 cases, the LLS teeth are trapped by the ↑ o/b behind the ULS. Freeing them by, e.g. provision of a URA with a biteplane may allow the lower incisors to spontaneously procline to a new stable position. This is one of the few situations where proclination (within reason!) of the LLS is stable.

Approaches to reducing overbite

- *Extrusion/eruption of molars*. Passive eruption of lower molars occurs when an URA incorporating a biteplane is worn. Active extrusion of molars in either arch is possible using FA. However, unless the patient grows vertically to accommodate this ↑ dimension, the molars will re-intrude under the forces of occlusion once appliances are withdrawn. This approach is of limited value in adults.
- *Intrusion of incisors*. This is difficult, requires FA, and in most cases the major effect is extrusion of the buccal segments. More successful in growing patients.
- *Proclination of lower incisors*. Movement of the lower incisor from their position of stability within the soft tissue envelope is unstable in most cases. Active proclination should only be attempted by the experienced orthodontist, who will be better able to judge those cases where this is indicated.
- *Surgery*. Indicated in severe cases especially if associated with A–P skeletal discrepancy, and in adults.

Management of increased overbite

Class II/2

It is often prudent to avoid extractions when the lower arch is mildly crowded in a Class II/2, to avoid moving the lower incisors lingually during space closure as this will ↓ o/b. Cases with sufficient crowding to warrant premolar extractions in the lower arch and moderately to severely ↑ overbite are best treated with FA to close space by forward movement of the buccal segments and to correct the incisor relationship.

Where o/b ↓ is required, the inter-incisal angle will need to be reduced in order to achieve a stable result. Usually this necessitates FA. However, in growing patients with a skeletal II pattern an alternative approach is to procline ULS to convert to a Class II/1 and use a functional appliance to reduce the resultant overjet. Proclination can be done either with URA first, or with sectional FA on ULS, or by incorporating a spring in the functional appliance.

Class II/1

o/b ↓ is required before o/j ↓. If a functional appliance is indicated for A–P correction then some o/b reduction can often be achieved during this phase by trimming the appliance to allow eruption of the lower molars. If headgear is being used then it may be helpful to commence o/b ↓ with an URA with a FABP, clipped over the bands on the upper molars. Rx of most II/1 will need FA either as the sole Rx or following a functional appliance or headgear. Including lower second molars in the FA will aid intrusion of the LLS (by ↑ vertical anchorage), but inevitably some extrusion of the molars will occur.

Class III

(See ➔ Reverse overjet, p. 150.)

Avoid reducing o/b as it will aid retention of the corrected incisor position.

Stability of overbite reduction

Stability of o/b ↓ is enhanced by:

- Reducing the inter-incisal angle and creating an occlusal stop to prevent the lower incisors over-erupting.
- Favourable growth as this compensates for molar extrusion.
- Eliminating or reducing the aetiological factors but ↓ LFH and high lower lip line can only be altered if growth is favourable.

Further reading

W. J. B. Houston 1989 Incisor edge-centroid relationships and overbite depth. *Eur J Orthod* **11** 139.

D. T. Millett *et al*. 2006 Orthodontic treatment for deep bite and retroclined upper front teeth in children. *Cochrane Database Syst Rev* **4** CD005972.

Anterior open bite (AOB)

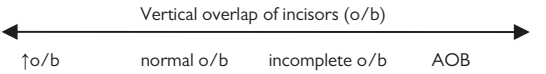


Fig. 4.9 Anterior open bite diagram.
AOB can occur in Class I, II, and III malocclusions.

Aetiology

Either *skeletal*—vertical > horizontal growth (↑ LFH &/or ↑ MMPA), or *environmental*—habits, tongue thrust, iatrogenic. Or a combination of these. If the distance between maxilla and mandible is sufficiently increased such that even if incisors erupt to their full potential they do not meet, an AOB will result (Fig. 4.9). This is often associated with incompetent lips and a lip-to-tongue anterior oral seal, which may exacerbate the AOB. Tongue thrusts are usually adaptive and can maintain an AOB due to a habit even after the habit has stopped.

Localized failure of maxillary dento-alveolar development resulting in an open bite is seen in CLP.

Treatment

Is generally difficult, except where due mainly to a habit, therefore it is wise to refer patient to a specialist for advice.

Skeletal In milder cases can align arches and accept, or try to restrain vertical development of the maxilla &/or upper molars with headgear &/or a functional appliance with posterior bite blocks. TADs can be used to facilitate molar intrusion in the management of AOB. Most operators leave the TADs *in situ* during initial months of retention to continue intrusive forces and offset relapse. Extrusion of the incisors is unstable. For more severe cases the only alternative is surgery.

Habits Better to await natural cessation of habit. Once habit stops o/b should re-establish within 3yrs, unless perpetuated by soft tissues or because it is skeletal in origin.

Tongue thrust None.

Hints for cases with ↑ vertical dimensions and ↓ o/b or AOB.

- Avoid extruding molars, e.g. cervical pull headgear to 6|6, URA with a biteplane.
- Avoid upper arch expansion as this will tip down the palatal cusps of buccal segment teeth, reducing o/b.
- Extraction of molars will not 'close down bite'.
- Space closure is said to occur more readily in patients with ↑ vertical skeletal proportions.

Further reading

D. A. Lentini-Oliveira *et al*. 2007 Orthodontic and orthopaedic treatment for anterior open bite in children. *Cochrane Database Syst Rev* **2** CD005515.

Notebox:
Summary points for topics so far
(you write here)

Reverse overjet

This will include only those cases with >2 teeth in linguo-occlusion, i.e. Class III cases. For management of one or two teeth in Xbite, see ➔ Crossbites p. 152.

Aetiology

Skeletal Reverse overjet is usually associated with an underlying Class III skeletal pattern. This is most commonly due to either a large mandible &/or a retrusive maxilla &/or a forward position of glenoid fossa. Class III malocclusions occur in association with the whole range of vertical patterns. Xbites are a common feature, due to the more forward position of the mandible relative to the maxilla.

Soft tissues A patient's efforts to achieve an anterior oral seal often result in dento-alveolar compensation, i.e. retroclination of the lower and proclination of the upper incisors therefore the incisor relationship is often less severe than underlying skeletal pattern.

Growth Is often unfavourable in Class III malocclusions.

Dental crowding This is usually greater in the upper than the lower arch.

Assessment

(See ➔ Orthodontic assessment, p. 124.)

Consider also the following:

- Patient's opinion about their facial appearance (be tactful!).
- Severity of skeletal discrepancy.
- Amount and anticipated pattern of facial growth.
- Amount of dento-alveolar compensation as if this marked will limit further decompensation for orthodontic camouflage.
- Amount of overbite. Need a positive o/b to retain corrected incisor position at the end of treatment. Remember that proclination of ULS will ↓ o/b and retroclination of LLS will ↑ o/b.
- Can patient achieve an edge-to-edge contact of the incisors? If so this ↑ prognosis for correction of incisor relationship.

Treatment approaches

▶ Class III malocclusions tend to become worse with growth.

Accept in mild cases particularly with ↓ o/b. Some patients with more severe skeletal Class III opt for alignment accepting incisor relationship rather than proceed with surgery.

Early orthopaedic treatment there is some evidence to show that in <10yrs can use protraction face-mask or bone-anchored screws or miniplates in the maxilla to enhance forward growth of the maxilla. But this approach still needs to be evaluated in the longer term.

Camouflage this involves proclining the ULS &/or retroclining the lower incisors with FA (Fig. 4.10 and Fig. 4.11).

Surgery for more severe cases, particularly with ↑ vertical skeletal proportions &/or asymmetry. It is difficult to produce hard and fast rules, but 2 predictors from a cephalometric analysis which have been suggested are:

- ANB value below –4°
- Lower incisor angle to the mandibular plane of <80°.

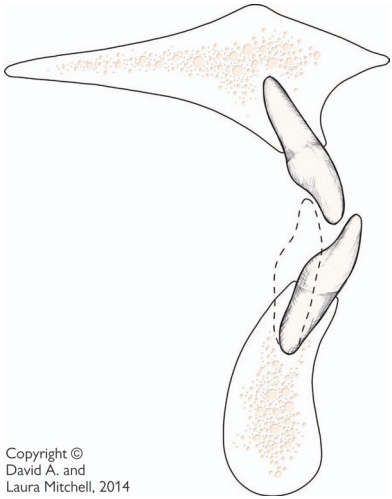


Fig. 4.10 Correction of a Class III incisor relationship by retroclination of the lower incisors increases overbite.

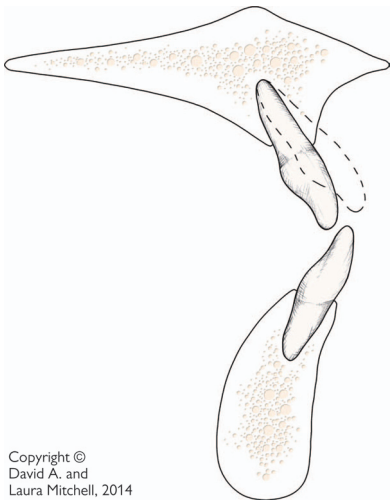


Fig. 4.11 Correction of a Class III incisor relationship by proclination of the upper incisors alone reduces overbite.

Crossbites

By convention the lower teeth should be described relative to the upper (➔ Definitions, p. 122). Xbites can be anterior or posterior (unilateral/bilateral), with displacement, or with no displacement.

Aetiology

Xbites can be skeletal &/or dental in origin. For posterior Xbites, the skeletal component is usually the major factor. AP discrepancies obviously play a part in anterior Xbites, but can also result in posterior Xbites in Class II (lingual Xbite) and Class III (buccal Xbite) skeletal patterns.

Displacement may occur when a premature or deflecting cuspal contact is encountered on closure and the mandible is postured either anteriorly or laterally to achieve better interdigitation. This new path of closure becomes learned and the patient closes straight into maximum interdigitation. To help detect displacement on closure, try to get the patient to close on a hinge axis by asking them to curl their tongue back to touch the back of the palate and then close together slowly, whilst guiding the mandible back via the chin. In addition, look for other clues like a centre-line shift (of lower in direction of displacement) in association with a posterior unilateral Xbite.

Anterior crossbites

For Class III see ➔ Reverse overjet, p. 150.

Anterior Xbites can be treated interceptively in mixed dentition if associated with a displacement, provided sufficient o/b exists to retain the result. If not, probably best to defer until the 2° dentition and use FA. Upper lateral incisors that are displaced bodily will require buccal root torque for correction.

Posterior crossbites[7]

Unilateral Generally, the greater the number of teeth involved the greater the skeletal contribution to the aetiology. If only affects one or two teeth in each arch, movement of opposing teeth in opposite directions can be achieved by cross-elastics attached to attachments on the affected teeth. Unilateral Xbite from the canine region distally is usually associated with a displacement, as true skeletal asymmetry is rare. If the arches are of a similar width when the patient closes the cusps will meet so the patient displaces laterally to achieve a better interdigitation. In these cases Rx should be directed towards expanding the upper arch so that it fits around the lower, provided the upper teeth are not already buccally tilted.

Bilateral buccal crossbite This suggests a greater underlying transverse skeletal discrepancy. Is less commonly associated with displacement.

Correction of a bilateral Xbite should be approached with caution, because partial relapse may result in the teeth occluding cusp to cusp and development of a unilateral Xbite with displacement.

7 J. Harrison & D. Ashby 2001 *Cochrane Database Syst Rev* **1** CD000979.

Bilateral lingual crossbite (or scissor bite) occurs due to either a narrow mandible or a wide maxilla. In milder cases only 4|4 may be involved, and if these teeth are extracted to relieve crowding or for retraction of 3|3, so much the better. Where the whole buccal segments are involved, Rx will probably involve expansion of the lower &/or contraction of the upper, therefore refer to a specialist.

Rapid maxillary expansion

Involves a screw appliance comprising bands attached to 64|46 and connected to a midline screw. The object is to expand the maxilla by opening the midline suture and is therefore more successful in younger patients. Large forces are required to accomplish this—the screw is turned 0.2mm twice a day for about 2 weeks. Over-expansion is necessary as the teeth relapse about 50% under soft-tissue pressure. Not to be attempted by the inexperienced!

Quad helix appliance

This is a very efficient fixed, slow expansion appliance. It is made of 1mm SS attached to bands on 6|6 and is W-shaped. Activated by expanding 1/2 tooth width per side before placement (Fig. 4.12).

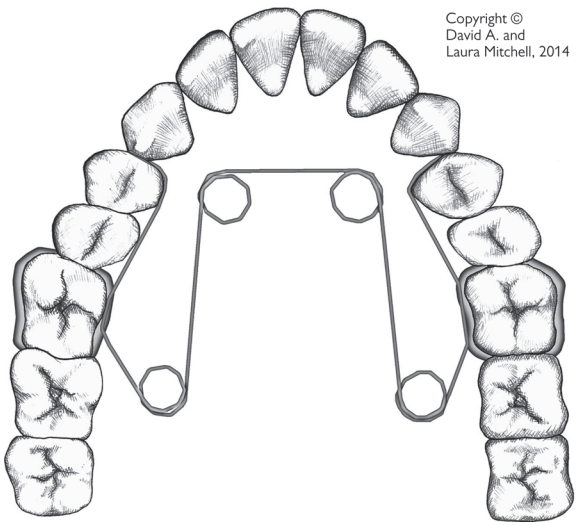


Fig. 4.12 Quad helix appliance.

Crossbites

By convention the lower teeth should be described relative to the upper (➔ Definitions, p. 122). Xbites can be anterior or posterior (unilateral/bilateral), with displacement, or with no displacement.

Aetiology

Xbites can be skeletal &/or dental in origin. For posterior Xbites, the skeletal component is usually the major factor. AP discrepancies obviously play a part in anterior Xbites, but can also result in posterior Xbites in Class II (lingual Xbite) and Class III (buccal Xbite) skeletal patterns.

Displacement may occur when a premature or deflecting cuspal contact is encountered on closure and the mandible is postured either anteriorly or laterally to achieve better interdigitation. This new path of closure becomes learned and the patient closes straight into maximum interdigitation. To help detect displacement on closure, try to get the patient to close on a hinge axis by asking them to curl their tongue back to touch the back of the palate and then close together slowly, whilst guiding the mandible back via the chin. In addition, look for other clues like a centre-line shift (of lower in direction of displacement) in association with a posterior unilateral Xbite.

Anterior crossbites

For Class III see ➔ Reverse overjet, p. 150.

Anterior Xbites can be treated interceptively in mixed dentition if associated with a displacement, provided sufficient o/b exists to retain the result.

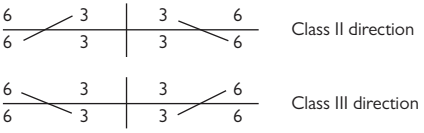


Fig 4.13 Reinforcing anchorage.

If not, probably best to defer until the 2° dentition and use FA. Upper lateral incisors that are displaced bodily will require buccal root torque for correction.

Posterior crossbites[7]

Unilateral Generally, the greater the number of teeth involved the greater the skeletal contribution to the aetiology. If only affects one or two teeth in each arch, movement of opposing teeth in opposite directions can be achieved by cross-elastics attached to attachments on the affected teeth. Unilateral Xbite from the canine region distally is usually associated with a displacement, as true skeletal asymmetry is rare. If the arches are of a similar width when the patient closes the cusps will meet so the patient displaces laterally to achieve a better interdigitation. In these cases Rx should be directed towards expanding the upper arch so that it fits around the lower, provided the upper teeth are not already buccally tilted.

Bilateral buccal crossbite This suggests a greater underlying transverse skeletal discrepancy. Is less commonly associated with displacement.

Anchorage loss

May occur because of:

- Failure to appreciate fully anchorage requirements at Rx planning stage (generally if 75–100% of space generated from extractions is required for planned tooth movement, anchorage requirements are high).
- Active force exceeding available anchorage (often due to over-activation or too many teeth being moved at a time).
- Poor patient compliance.

Notebox:
Summary points for anchorage
(you write here)

Temporary anchorage devices (TAD)

Implants have been adopted in orthodontics to provide skeletal anchorage, to ↓ need for patient compliance. This has ↑ the envelope in terms of the severity of malocclusions that can be treated by orthodontics alone. Currently the term TAD is in vogue, but mini-implants, microscrews, bone anchorage devices (BAD) are also used (Table 4.2). Success rates of 80–90% have been reported.[8]

Table 4.2 Types of implant

Osseointegrated	No osseointegration
Designed to maximize surface contact for integration	Designed for ease of placement and removal
Short body length and large diameter	Screw or plate
Surface coating	No surface coating
More difficult to place. ↑ morbidity at removal due to osseointegration	Plate design more difficult to place and remove than screw
Usually used in edentulous, retromolar, palatal areas	Can be placed in dento-alveolar bone between tooth roots
Useful when wish to replace a missing tooth after orthodontic treatment	

A screw design with no osseointegration is now the most widely used in orthodontics, because it is easy to place and remove. Typically 1–2mm wide and 6–15mm in length with a neck that protrudes through the mucosa and a head designed for attaching an orthodontic force system (e.g. elastic or coil spring).

There are 2 sub-divisions:

- Self-tapping—site is pre-drilled with specially designed handpiece prior to insertion of screw.
- Self-drilling—implant is screwed directly into bone. Better results as causes less thermal damage to bone.

8 S. Kuroda *et al*. 2007 *Am J Orthod Dentofac Orthoped* **131** 9.

Site selection

- Treatment mechanics—including direction of desired force.
- Anatomy—tooth roots, other structures.
- Depth of available bone including thickness of cortical plate.
- Bone quality.
- Access for placement.
- Gingival health and quality—Good OH. Attached gingiva better.

Need good X-rays.

Local anaesthesia is used by most operators. A stent can be used to guide placement. Screws can be inserted with a hand (screw) driver or using an engine driver i.e. a speed reduction (<30rpm) contra-angle handpiece.

Loading

Most operators load the screws immediately. The osseointegrated type requires a latent period for integration. Need to avoid excess force levels (<250g).

Explantation

Fancy term for removal. For osseointegrated types need to raise a flap and cut out implant. Screw designs can usually be removed without LA by unscrewing.

Problems

Success is a screw that is functional for the duration the orthodontic force is required. A screw that is slightly mobile may still be functional. If a screw contacts a root then this usually results in the screw becoming loose &/or some patient discomfort.

- Screw becomes loose—remove and replace in another site.
- Breakage—about 3–4%.
- Root damage—evidence suggests that if root is perforated then get healing by cementum.
- Mucosal discomfort—check OH.

Further reading

R. R. J. Cousley 2012 Changing the face of orthodontics with mini-implants. *Faculty Dent J* **3** 34.

NICE 2007 IPG238. *Mini/Micro Implantation for Orthodontic Anchorage: Guidance* (http://www.nice.org.uk).

R. M. Skeggs *et al.* 2007 Reinforcement of anchorage during orthodontic brace treatment with implants or other surgical methods. *Cochrane Database Syst Rev* **3** CD005098.

Removable appliances

Removable appliances are single-arch appliances that can be taken out of the mouth by the patient. They are only capable of tilting movements of individual teeth, but can be used for moving blocks of teeth. In addition they can be used to allow differential eruption of teeth via biteplanes or buccal capping. Now used more as an adjunct to comprehensive FA treatment and for retention after FA.

Indications

Active

- Movement of blocks of teeth, e.g. correction of a buccal Xbite by expansion of upper arch (Fig. 4.14).
- As an interceptive Rx in the mixed dentition, e.g. correction of an upper incisor in Xbite.
- Overbite reduction.
- In conjunction with other appliance, e.g. to facilitate distal movement of upper molar(s) with headgear.
- Elimination of occlusal interferences by addition of biteplane or buccal capping. Useful for movement of a tooth over the bite during fixed appliance Rx.

Passive

- Space maintainer, e.g. following loss of an upper central incisor due to trauma.
- Retaining appliance, e.g. following fixed appliance Rx.
- Habit deterrent.

Practical points

Active components

- Springs (made in SS wire) are the most commonly used active component because they are versatile and cheap to construct.
- Screws are useful when the teeth to be moved need to be clasped for retention(see Fig. 4.14).

Retention

Is the means by which the appliance is retained in the mouth. The best retention posteriorly is provided by the Adams crib (Fig. 4.15), which is made in SS wire in either 0.7mm (for permanent molars) or 0.6mm (for premolars and primary molars). Anterior retention can be gained by a labial bow or a clasp—these components are usually constructed in 0.7mm wire.

Baseplate

Holds other elements together and may also itself be active. Heat-cure acrylic is more robust than self-cure.

- A flat anterior biteplane will allow the lower molars to erupt and will if worn well result in o/b ↓.
- Buccal capping frees the occlusion on the tooth being moved and allows further relative eruption of the incisors (therefore is C/I if o/b is already ↑).

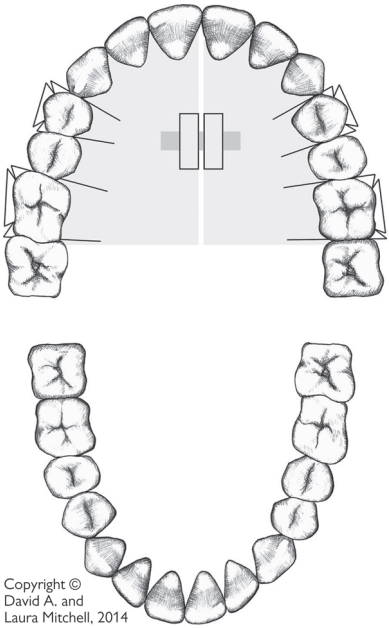


Fig. 4.14 Upper removable appliance to expand upper arch with midline screw. Cribs 6|6 0.7mm SS; 4|4 0.6mm SS; buccal capping or FABP.

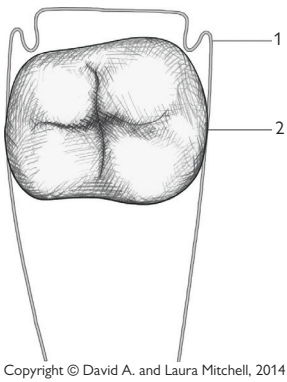


Fig. 4.15 Adjustment of Adams crib.
1 Arrowhead moves horizontally towards tooth.
2 Arrowhead moves towards tooth and also vertically towards gingival crevice.

Fixed appliances

▶ FA should only be used in cooperative patients with good OH, to minimize damage to the teeth and their supporting tissues.

As the name implies, FA are attached to the teeth. They vary in complexity, from a sectional involving a few teeth to full fixed appliances in both arches. FA give precise 3-D control of tooth movement. They can be used to tilt, rotate, intrude, extrude, and move teeth bodily. Not surprisingly, FA have a greater propensity for things to go wrong, therefore they should only be used by those with the necessary skills and training.

Principles

- Rx planning (➔ Treatment planning, p. 132). Need particular attention to anchorage requirements, especially if apical movement is planned.
- As FA are able to achieve bodily movement, it is possible (within limits) to move teeth to compensate for a skeletal discrepancy.
- FA can be used in conjunction with other appliances &/or headgear.
- For initial alignment, flexible archwires are used, but to minimize unwanted movements, progressively more rigid archwires are necessary.
- Archwires should be based on the pre-Rx lower arch-form for stability.
- Mesio-distal movement is achieved either by: (i) sliding the teeth along the archwire with elastic force (sliding mechanics), or (ii) moving the teeth with the archwire.

Intermaxillary traction (➔ Inter-maxillary, p. 154) is often used to aid AP correction and increase anchorage.

Components of fixed appliances

Bands Usually used on molar teeth. Indicated for other teeth if bonds fail or lingual attachment is required for de-rotation. If tooth contacts are tight these will need to be separated prior to band placement using an elastic doughnut stretched around the contact point for 1–7 days. Use of GI cements helps to ↓ decalcification.

Bonds are attached to enamel with (acid-etch) composite. There are two commonly used types: (i) metal (poor aesthetics); (ii) ceramic (prone to # and can cause enamel wear). There is a wide variety of designs (see ➔ Types of fixed appliance, p. 161).

Archwires Flexible nickel titanium archwires are used in the initial stages of Rx and more rigid stainless steel wires used in the later stages for the planned tooth movements. Tungsten molybdenum, and cobalt chromium alloys are also popular.

Auxillaries Elastic rings or wire ligatures are used to tie the archwire to the brackets. Forces can be applied to the teeth by auxiliary springs or elastics.

Types of fixed appliance

Almost infinite variety, but most well-known are:

Standard edgewise Historical. Brackets are rectangular and wide mesiodistally for rotational control. The intended final 3-D position of each tooth had to be built into rectangular stainless steel archwires by bends placed in all three planes of space.

Pre-adjusted systems These 'pre-programmed' brackets are designed with the average values for the intended final 3-D position built into the archwire slot. Thus the amount of archwire bending required is reduced. As each tooth has its own individual bracket with a built-in prescription for that tooth, these systems are more expensive, but that is offset by savings in operator time. A number of different prescriptions are available.

Self-ligating systems have a clip mechanism incorporated into the bracket to hold the archwire in place (rather than elastic or wire tie) which is said to ↓ friction, making tooth movement quicker, though more recent work challenges this claim. Examples include Damon®, SmartClip™, Innovation®.

Tip edge is based on the Begg philosophy which used round wires which fitted loosely into a vertical slot in the bracket, thus allowing the teeth to tip freely. Auxiliaries were required to achieve apical and rotational movements. Tip-Edge brackets also have pre-adjusted values incorporated to give the 'finish' produced by using a straight wire appliance.

Lingual appliances Popular with patients, but not widely available as access for placement and adjustment more challenging! Expensive.

Clear plastic aligners. These are vacuum-formed thermoplastic appliances which look like a thin mouthguard. Although strictly not a FA they are included here as they are popular with patients as a more aesthetic alternative to FA. Study models are scanned digitally and then the computer program designs a sequence of models with increment changes in tooth position. A series of clear plastic aligners are then made which move teeth to desired final result. The rate of tooth movement is 0.25 to 0.33mm/aligner. Best suited to mild malocclusions treated without extractions.

More details can be found in specialist texts (naturally the reference is my own book!).[9]

► FA should only be used by the clinicians trained in their use and management of the problems that can arise.

9 L. Mitchell 2013 *An Introduction to Orthodontics*, OUP.

Functional appliances—rationale and mode of action

Definition Functional appliances utilize, eliminate, or guide the forces of muscle function, tooth eruption, and growth to correct a malocclusion.

Philosophy Functional appliances are so-called because it was thought that by eliminating abnormal muscle function, normal growth and development would follow. Nowadays, the importance of both genetic and environmental factors in the aetiology of malocclusion is acknowledged, but functional appliances are still successfully used in the Rx of Class II malocclusions by a combination of skeletal and dental effects. Functional appliances (or just 'functionals') can also be used in the management of AOB and Class III, but those approaches are beyond the scope of this text.

Mode of action In the average child the face grows forward relative to the cranial base and mandibular growth predominates. Functional appliances help to harness this change to correct Class II malocclusions by a restraining effect on the maxilla and maxillary teeth and a forward pressure on the mandible and mandibular teeth. A similar effect is produced with Class II elastics (➔ Reinforcing anchorage, p. 154). Functional appliances are ineffective for individual tooth movement.

Indications To achieve some AP correction for a Class II malocclusion prior to FA ± extractions. Ideally: Class II/1 with mandibular retrusion, average or reduced LFH, or upright or retroclined LLS. A useful test is to examine the profile with patient postured forward to a Class I incisor relationship, and if not improved consider another appliance. Can also use for Class II/2 but need to procline ULS, e.g. with sectional FA.

Changes produced by functional appliances

Skeletal

- Research would suggest that changes seen are 25% skeletal and 75% dental.
- Optimizing of mandibular growth. The evidence would suggest that in the short term an extra 1–2mm mandibular growth results, however, long term that overall gain is small.
- Restraint of forward maxillary growth.
- Forward movement of the glenoid fossa.
- ↑ LFH.

Dental

- Palatal tipping of the upper incisors.
- Labial tipping of the lower incisors (not a consistent finding).
- Inhibition of forward movement of the maxillary molars.
- Mesial and vertical eruption of the mandibular molars.

Keys to success with functional appliances

- Cooperative and keen patient. Remember co-operation is finite.
- Favourable growth; therefore should coincide Rx with pubertal growth spurt.
- Confident operator, so that child believes appliance will work and will persevere with wearing it.

Further reading

J. E. Harrison *et al.* 2007 Orthodontic treatment for prominent upper front teeth in children. *Cochrane Database Syst Rev* **3** CD003452.
K. D. O'Brien *et al.* 2003 Effectiveness of treatment for Class II malocclusion with the herbst or twin-block appliances: a RCCT *Am J Orthod Dentofac Orthop* **124** 128.
K. D. O'Brien *et al.* 2009 Early treatment for Class II divisions 1 malocclusion with the Twin-Block appliance: a multi-center randomized controlled trial. *Am J Orthod Dentofac Orthop* **135** 573.

Notebox:
Summary points for functional appliances
(you write here)

Types of functional appliance and practical tips

Choice of appliance

Some of the more popular types:

Twin block Is the most commonly used design in the UK. Comprises separate upper and lower removable appliances which by means of sloping buccal blocks help to posture the mandible forward. Because they are individual upper and lower appliances and are retained by clasping the teeth they are well tolerated by patients and can be worn for meals. In addition, a screw can be incorporated in the upper twin block if expansion is required, as well as springs (e.g. to procline ULS or align 2). Need a wax bite recorded with the mandible postured forwards 7–10mm so that blocks are >5mm height (see Fig. 4.16 and Fig. 4.17).

Medium opening activator (MOA) Useful in case with ↓ LFH as design allows eruption of lower molars. It is a one-piece functional therefore a preliminary phase of upper arch expansion prior to fitting the MOA is required in most patients to co-ordinate arch widths. Must be made in heat-cure acrylic as extensions to lower arch prone to fracture. Worn full-time except eating.

Herbst Is a fixed functional appliance. Comprises metal cast splints cemented onto the buccal segment teeth which are connected by metal arms in a piston arrangement which hold the mandible forward. Achieves rapid AP correction. Expensive to make.

Practical tips

- Advise patient to wear appliance full-time. Only Herbst and twin-block appliance can be worn for eating. See every 2 months.
- Problems with appliances that fall out in bed at night are often cured by ↑ wear during the day.
- Expect at least 1mm o/j reduction per month (more with Herbst).
- If no progress or progress stalls this may be due to poor wear (most likely), lack of growth, problems with fit or design of appliance.
- Functional appliances are successful in around 80% of growing patients.

End-point of functional appliance treatment

In most patients it is wise to slightly over-correct AP to an edge-to-edge incisor relationship. Most operators then get the patient to wear nights only for 3 months before making transition to fixed appliances ± extractions. The buccal blocks of a twin block can be reduced to encourage molar eruption during this phase.

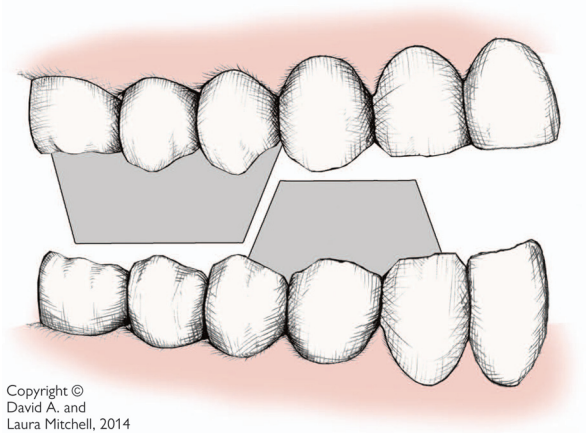


Fig. 4.16 Demonstrating how the inclined bite blocks of the twin-block appliance hold the mandible forward in a postured position.

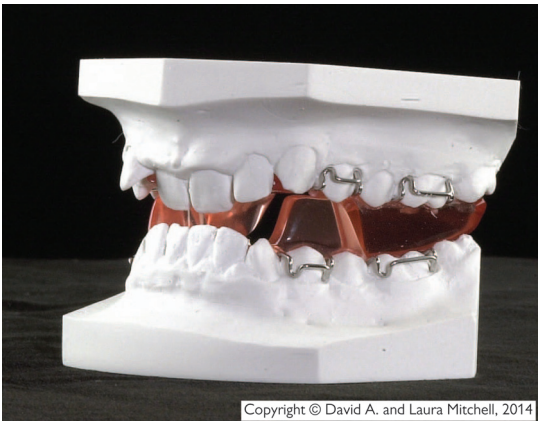


Fig. 4.17 Twin-block appliance. A spring positioned behind the ULS or a sectional fixed appliance can be used to procline $\underline{1|1}$.

Orthodontics and orthognathic surgery

Orthognathic surgery is the correction of skeletal discrepancies that, due to their severity, lie outside the scope of orthodontics alone. Usually deferred until active growth has slowed to adult levels.

Diagnosis and Rx planning

This is best done jointly by orthodontist and maxillofacial surgeon and ideally with psychology input. Require the following information:

Patient's perception of problem Are they concerned with appearance of jaws or teeth, speech, or problems with eating? Are their expectations realistic?

Clinical examination Assessment of the balance and proportions of full face and profile.[10]

Study models Needed to assess co-ordination of arches.

Radiographs require DPT and lateral skull, plus PA skull for asymmetries. A number of computer programs of varying complexity and cost are available to aid in Δ and planning. With increasing availability of CBCT 3-D programs are being developed. However, these should not supersede clinical assessment.

Photographs Required as pre-Rx record and can also be manipulated with lateral skull for visual computer predictions.

It is important to correlate desired facial changes with patient's occlusion. Pre-surgical orthodontics will be required to decompensate teeth so that a full surgical correction is possible.

It is important (in order to obtain informed consent) that patients are fully informed of the risks of surgery, particularly mandibular procedures, in addition to the orthodontic risks. The British Orthodontic Society has produced an excellent DVD which provides a well-balanced overview for prospective patients.

Sequence of Rx

Pre-surgical orthodontics Aim of this phase is to align and coordinate the arches so that the teeth will not interfere when the jaws are placed in their correct position. This usually involves decompensation, i.e. removal of any dento-alveolar compensation for the skeletal discrepancy so that the teeth are at their correct axial inclinations and a full surgical correction can be achieved. If a segmental procedure is planned space will be needed interdentally for surgical cuts. It is inefficient to carry out movements that can be accomplished more readily at surgery (e.g. expansion of upper arch if Le Fort 1 planned), or following surgery (e.g. levelling of lower arch in Class II/2). In addition, the FA provides a means of fixation at surgery.

10 N. P. Hunt 1984 *Br J Orthod* **11** 126.

Surgery (➔ Orthognathic surgery, p. 486.) Full records should be taken for final planning. For bimaxillary procedure need study models mounted on semi- or fully adjustable articulator.

Post-surgical orthodontics Lighter round wires and inter-maxillary traction are used to detail occlusion.

Retention This is the same as after conventional FA Rx.

Relapse This can be surgical or orthodontic or both. Relapse more likely in Rx of deficiencies as soft tissues are under greater tension post-operatively. Research[11] has shown the hierarchy of stability in Table 4.3.

Table 4.3 Hierarchy of stability

Very stable	Max. up Mand. forward Chin—any direction
Stable	Max. forward Max. asymmetry
Stable with rigid fixation	Max. up & mand. forward Max. forward and mand. back Mand. asymmetry
Least stable	Mand. back Max. down Widening of max.

Distraction osteogenesis

A proportion of severe cases (particularly congenital craniofacial deformity) require movements beyond the scope of conventional orthognathic surgery—principally due to soft tissue restriction. Distraction osteogenesis is useful in the management of these cases as it involves slow distraction across the osteotomized bones, which stretches the surrounding soft tissues. The surgical cuts for an osteotomy are made in the usual way, but then after allowing a few days for initial callus formation, traction is applied across the bone cuts via a distractor. The healing callus is put under tension and bone is laid down in the direction of force. A period of consolidation is required after the desired surgical movements are achieved.

Further reading

S. Cunningham *et al.* 1998 Psychological assessment of patients requiring orthognathic surgery and the relevance of body dysmorphic disorder. *Br J Orthod* **25** 293.

11 W. R Proffit *et al.* 2007 *Head Face Med* **3** 21.

Cleft lip and palate

Prevalence CLP varies with racial group and geographically. Occurs in 1:700 Caucasian births, but prevalence ↑. M > F. If unilateral L > R. Family history in 40% of cases.

Isolated cleft palate occurs in 1:2000 births. F > M. Family history in 20%.

Aetiology Multifactorial with both genetic and environmental factors (including maternal smoking, alcohol, and phenytoin intake) involved. Can occur in isolation or as part of a syndrome.

Classification Many exist, but best approach is to describe cleft: primary &/or secondary palate; complete or incomplete; unilateral or bilateral. Submucous cleft of the palate is often missed until poor speech noticed, as overlying mucosa is intact.

Problems

Embryological anomalies Tissue deficit, displacement of segments, abnormal muscle attachments.

Post-surgical distortions Unrepaired clefts show normal growth. In repaired clefts maxillary growth is ↓ antero-posteriorly, transversely, and vertically. Mandibular growth also ↓.

Hearing and speech are impaired.

Other congenital anomalies occur in up to 20% of cases with CLP and are more likely in association with isolated clefts of palate than lip.

Dental anomalies In CLP ↑ prevalence of hypodontia and $ teeth (especially in region of cleft). Teeth adjacent to cleft are often displaced. Also ↑ incidence of hypoplasia and delayed eruption.

Management (of unilateral complete CLP)

Team usually includes cleft surgeon, ENT surgeon, health visitors, orthodontist, speech therapist, clinical psychologist, and central coordinator. Centralization of care and audit of outcome gives better results.

Pre-natally/birth Parents need explanation, reassurance, and help with feeding. Pre-surgical orthopaedics is now out of vogue as benefits not proven.

Lip closure Usually between 3–6 months of age. Delaire or Millard &/or modifications are the most popular. Some surgeons do Vomer flap at same time. Bilateral lips are closed either in one or two operations.

Palatal closure Usually between 9–12 months. Delaire or Von Langenbeck ± modifications are the most popular. Deferring repair until patient is older ↓ growth disturbance, but speech development is adversely affected.

Primary dentition Speech and hearing assessments. Establishment of good dental care.

Mixed dentition In most cases any orthodontic Rx is better deferred until just prior to 2° bone grafting at 8–10yrs.

Alveolar bone graft If an alveolar cleft is present then this should be grafted when the canine root is 1/2 to 2/3 formed (around age 8 1/2 to 10 1/2 yrs) with cancellous bone. Advantages:

- Provides bone for 3 to erupt through.
- Allows tooth movement into cleft site therefore may avoid prosthesis.
- ↑ bony support for alar base.
- Aids closure of oro-nasal fistulae.
- Also helps to stabilize mobile premaxillary segment in bilateral cases.

To aid surgical access and improve outcome usually need to expand collapsed arches and align the upper incisors prior to grafting. FA are usually used and care is required not to move roots of adjacent teeth into cleft. Bone usually harvested from the iliac crest.

Permanent dentition Because of the restraining effects of 1° surgery upon facial growth, cleft patients often have a Class III malocclusion. If this is not significant (and/or patient doesn't want orthognathic surgery) then definitive Rx for alignment and space closure with FA can be carried out. Ideally, if 2 missing, Rx should aim to bring 3 forward to replace it, thus avoiding a prosthesis.

Late teens If orthognathic surgery is indicated (➔ Orthognathic surgery, p. 486) then this should be deferred until active growth has slowed to adult levels. Pre-surgical orthodontic alignment with FA will be required. If nasal revision surgery is planned then this should be carried out after bony surgery.

A proportion of cleft patients will have a skeletal discrepancy that is too severe for conventional surgical movements. In addition advancement of the maxilla may, by bringing forward the soft palate, adversely affect speech. In these cases distraction osteogenesis (➔ Distraction osteogenesis, p. 167) can be considered.

See also ➔ Clefts and craniofacial anomalies, p. 484.

Notebox:
Summary points for orthodontics
(you write here)