

1

Principles of Treatment Planning

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CHAPTER OUTLINE

Introduction, 3
 Patient Concerns, 4
 Patient Motivation and Compliance, 4
 Handling Patient Expectations, 4
 Medical History, 6
 General Dental Health, 6
 Previous Orthodontic Treatment, 7
 Treatment Timing: When Should Treatment be Undertaken?, 7
 Teasing and Bullying, 7
 Dental Health Problems and Habits, 8
 Relevance of Growth and Growth Estimation, 8
 Problem List, 9
 Treatment Aims, 11
 Aesthetic-Centred versus Occlusion-Centred Planning, 11
 Static and Functional Occlusion, Stability and Health, 13
 Presenting the Treatment Options, 14
 No Treatment, 15
 Treatment with Limited Objectives, 15
 Orthodontics Alone, 15
 Orthodontics in Association with Multidisciplinary Care, 15
 How do we decide whether or not to Extract Teeth?, 15
 Space Analysis and Space Planning, 17
 Informed Consent, 21
 What Should be Included in a Treatment Plan, 23
 Treatment Mechanics, 23
 References, 26

Introduction

Comprehensive clinical diagnosis of the craniofacial complex and the analysis of diagnostic records have been described elsewhere (presented in detail in *Facial Aesthetics: Concepts and Clinical Diagnosis* and chapters 5 and 6 of *Orthognathic Surgery: Principles, Planning and Practice*).^{1,2} The reader is directed to these sources for the required systematic clinical evaluation leading to clinical diagnosis, which is beyond the scope of this chapter. The purpose of this chapter is to describe

the principles of treatment planning for orthodontic patients, specifically in relation to preadjusted edgewise appliances.

There are numerous skills that a clinician embarking on fixed appliance orthodontic treatment must acquire, including diagnosis, treatment planning, technical expertise in the use of a variety of removable, functional and fixed appliances, and an understanding of multidisciplinary care. Of these skills, competence in logical treatment planning is often the most difficult and the slowest to acquire as it requires judgement as well as skill.

A methodical approach to the collection and analysis of information from the patient interview and clinical evaluation is the precondition to successful treatment planning. The treatment planning process follows a logical sequence, from clinical diagnosis through to the synthesis of the definitive treatment plan and the proposed sequencing of mechanics required to accomplish the plan (Figure 1.1).

Patient Concerns

The most important question to have answered from the patient interview is to elicit the patient's actual concern(s). This becomes fraught with potential misunderstandings due to either the clinician misinterpreting the patient's terminology, or patients misusing clinical terminology, both carrying the risk of not addressing the patient's actual concerns. For example, a patient may complain of 'the space between my teeth' and present with a maxillary dental midline diastema of 3 mm and a 10 mm anterior open bite. Without accurate questioning, it would be easy enough for the clinician to misinterpret the patient's concern to mean their open bite, even though the patient's only concern may be their diastema. Therefore, an initial open question, such as 'What are your concerns?' may be followed by specific closed questions such as 'Which space are you referring to?'

Younger patients may use contemporary colloquialisms, such as describing a significant Class II division 1 incisor relationship as having 'goofy teeth', whether due to prominent or proclined maxillary incisors or normally positioned maxillary incisors on a Class II skeletal pattern with mandibular retrognathia. Alternatively, the term 'wonky' may be used by patients to describe dental crowding, rotations, crossbites or even spacing. The patient's exact meaning should be deciphered. Adult patients may use more descriptive terminology but with a different perception of the word from its clinical meaning, for example patients often use the term 'overbite' when they mean incisor overjet.

With children, it is also important to ascertain whether the patient's concerns match those of their parents. This is also true of adult patients presenting with their partners or family members. Where concerns differ, this should be explored and discussed further, and will be particularly relevant when obtaining consent.

The referring dentist's concerns are also part of the equation. It is important to ascertain whether the impetus for the referral was from the patient, or whether the dentist felt that treatment was required; the patient-driven referral may mean a greater degree of motivation and cooperation with proposed treatment, whereas the dentist-instigated

referral may be an issue in terms of patient motivation for treatment that potentially they did not desire.

Patient Motivation and Compliance

The patient's motivation for treatment is invariably correlated with their potential compliance with proposed treatment. Asking a patient to rate their level of distress regarding their presenting malocclusion on a scale from 0 (no concern) to 10 (extreme concern) may be a useful starting point. It is important to ascertain whether their concern is primarily aesthetic, functional, or both. It is also important to ascertain whether a patient demonstrates **external (extrinsic) motivation**, when the motivation is from the urging of others or based on unrealistic expectations of the impact of the treatment result on their external life and circumstances (e.g. the desire to obtain a promotion or find a partner), or **internal (intrinsic) motivation**, i.e. the desire for an improved dentofacial appearance or occlusal function, or both, because of the patient's own desire for treatment. Externally motivated patients are less likely to be happy with the results of treatment, regardless of the quality of the result.

The dental health and aesthetic components of the Index of Orthodontic Treatment Need (IOTN) may be useful for patient and parent counselling, particularly when they present with excessive concerns regarding minor aesthetic or occlusal discrepancies.³

If a patient persistently focuses on a minor or potentially imperceptible 'deformity' and their level of dissatisfaction and concomitant anxiety exceeds what would be considered justifiable, both socially and clinically, the patient may have a **body image disorder**, such as body dysmorphic disorder (BDD).⁴ In such circumstances, the patient should be informed in a polite and straightforward manner that they may benefit from a consultation with an appropriately trained clinical psychologist or liaison psychiatrist.

Handling Patient Expectations

Socially well-adjusted patients with relatively stable lives and realistic expectations are likely to benefit from treatment. This relates to the attitudes of adult patients and to those of young patients *and* their parents. Patients, or parents, with unrealistic expectations, in terms of both the potential aesthetic treatment results and the potential effects of treatment on their life (e.g. the assumption that they will get a promotion if their teeth are aligned, or that their child will win a talent show) will inevitably be unhappy with the results of treatment.

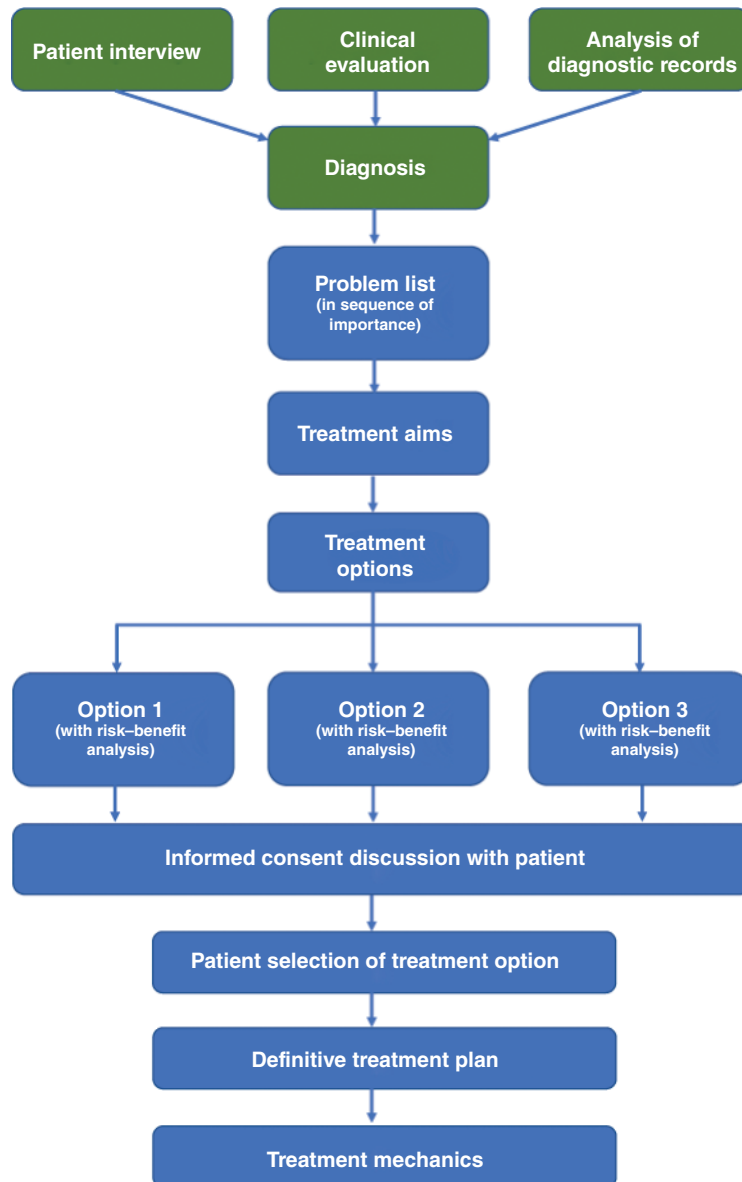


Figure 1.1 Algorithm for devising a definitive treatment plan. The adage ‘If you don’t know what’s wrong, you can’t fix it’ is rather apt in this context. If the ‘knowing what is wrong’ applies to clinical diagnosis, the strategy of ‘how to fix it’ is the purpose of treatment planning. Clinical diagnosis involves the collection of factual information based on the patient interview, a methodical, accurate and thorough clinical evaluation of dentofacial aesthetics and dental-occlusal function, and the analysis of the diagnostic records (shown in green). Unlike diagnosis, which is essentially a fact-finding procedure, treatment planning requires judgement, as not every plan will be ideal for every patient. Even a set of identical twins may choose different treatment options for the same problem, and each may well be right depending on their reasoning. Once the clinical diagnosis has been reached, the first formal step in the treatment planning process following this is the development of a **problem list**. In reality, at this stage there may be two problem lists. The first is simply an ordered list of the presenting problems that are a concern for the patient, in order of what is most important for the patient to what is least important. The second is a logically sequenced list based on factors identified by the diagnosing clinician as needing to be dealt with in the treatment plan. Ideally the two lists should tally; when discrepancies exist, it is important to discuss the reasons why until a consensus is reached. Having established the ordered problem list, the next stage is to identify the **treatment aims** (what the patient and clinician would like to achieve). When the aims of treatment have been determined, the next step is to decide on the available **treatment options** that may be presented to the patient for their consideration, together with a jargon-free discussion of the risk/cost/harm versus benefit analysis of each option. This forms the **informed consent discussion** with the patient, following which they should be given time to contemplate the information provided so that they can select their preferred option, which becomes the **definitive treatment plan**. The final stage of treatment planning involves the formation of a step-by-step (i.e. visit-by-visit) list of the **treatment mechanics**, i.e. what will be done at each visit (bearing in mind that some changes are inevitable), and with what mechanics these movements will be achieved, including the archwire placed and the required mechanics to provide the desired tooth movements.

Clinicians should never over-promise a result, or down-play the length of treatment or its potential complications (e.g. root resorption, decalcification, pulp devitalisation, fenestration or dehiscence of alveolar cortical plates, alveolar bone loss, ankylosis), or social costs, i.e. the inconveniences and sacrifices required of the patient in undergoing treatment. Patients must understand their role in treatment progress. Lack of patient cooperation, whether in maintaining oral hygiene, keeping appointments or wearing elastics as instructed, is likely to lead to unsuccessful treatment.

Medical History

A thorough medical history is mandatory. Standardised self-administered questionnaires may be helpful in encouraging more truthful responses to sensitive questions. Patients may complete such a questionnaire prior to their consultation, but the responses should be double-checked by the clinician.

The majority of patients presenting for orthodontic treatment are fit and healthy. However, certain medical conditions may affect the provision and outcome of orthodontic treatment. When previously diagnosed, a history of allergies or allergic reactions must always be ascertained prior to instigating treatment. Patients with type IV delayed hypersensitivity reactions to nickel may require nickel-free brackets and archwires. For patients with type I immediate natural rubber latex allergies, latex gloves or elastics must be avoided. Many manufacturers now avoid latex in such products for all patients.

Patients at risk of developing infective endocarditis no longer require antibiotic prophylaxis.⁵ However, an excellent level of pretreatment oral hygiene, and its maintenance throughout treatment, is even more important in such patients, to reduce the potential for bacteraemia. It may also be better to use bonded molar tubes rather than bands, to aid in the maintenance of optimal oral hygiene.

Removable appliances, particularly those made of acrylic, are contraindicated in patients with poorly controlled grand mal epilepsy, to avoid their potential fracture during a seizure and subsequent aerodigestive injury, swallowing or inhalation. Headgear is also contraindicated in these patients due to the risk of eye or facial injury.

Adult orthodontics is now far more common and adults may present with more complicated medical histories or on multiple medications. The use of bisphosphonates for osteoporosis has become commonplace, and as well as the potential obviation of dental extractions, such medications may affect orthodontic tooth movement through suppression of osteoclastic activity.

Another category that may have added difficulties for clinicians is **special needs orthodontics**. Some patients may have practical physical problems making access more demanding, for example patients with spinal abnormalities, such as scoliosis, may find it difficult to lie flat in a dental chair for an extended period of time, and patients with cerebral palsy may lack the manual dexterity required for maintenance of oral hygiene or placement of orthodontic elastics. However, such potential difficulties are not valid reasons to withhold treatment that would otherwise be beneficial for a patient. Nowhere is this more true than in the management of patients with Down syndrome or those on the autistic spectrum. The most important quality for a clinician undertaking special needs orthodontics is patience. Each patient should be given time to get used to the clinical team and the clinical environment. Parents and carers are also invaluable, and a team approach is required. When trust develops, special needs patients, even those who initially may not even sit in the dental chair, can be excellent and compliant patients. There is very little to compare with the satisfaction of achieving a good orthodontic result and thereby improving the quality of life for special needs patients.

The treatment of special needs patients may require some common-sense modifications of the average appointment, the most obvious being to book longer appointments in order not to rush a patient getting used to the team and the environment. It is also useful for the clinical staff to wear clear masks (Figure 1.2), which negates some of the problems with communication during appointments for patients on the autistic spectrum and those with learning difficulties, and makes it easier for patients with hearing loss as they can still lip read and see facial expressions.

General Dental Health

A high standard of oral and dental health is a prerequisite for fixed appliance orthodontic treatment. Poor oral hygiene increases the risk of gingivitis and periodontal problems, and a high frequency of sugar in the diet can lead to enamel decalcification around the fixed appliance brackets. Consumption of acidic drinks, particularly those with high sugar levels, will have erosive effects on the enamel.

Insufficient improvement in oral hygiene prior to treatment after appropriate oral health education in an otherwise competent patient is usually a reliable indicator of poor compliance with orthodontic treatment.

A patient's past dental history may be relevant to future behaviour.⁶ Patients who regularly attend their dentist and



Figure 1.2 Clear masks negate some of the problems with communication during appointments for patients on the autistic spectrum and those with learning difficulties, and makes it easier for patients with hearing loss as they can still lip-read and see facial expressions.

act on advice regarding oral hygiene and diet are more likely to comply with orthodontic treatment. Casual attenders to their dentist may have poor compliance with subsequent orthodontic treatment. However, a high dental caries rate and a heavily restored dentition, even in good attenders, is a cause for concern. Patients who ignore their dentist's advice, such as reducing the frequency of sugar intake, are also likely to ignore their orthodontist's instructions during treatment.

Patients with high levels of anxiety about dental treatment may find complex prolonged orthodontic treatment difficult. It may be better to delay complex orthodontic treatment until overall dental anxiety has been reduced using techniques such as systematic desensitisation. This will make future orthodontic treatment easier for the patient and the clinician.

A history of previous dental trauma should always be taken, even if such trauma occurred years previously. Evidence of previous trauma is not always evident on clinical examination, but such teeth may be at greater risk of pulpal necrosis or root resorption with fixed appliance orthodontic treatment. Pretreatment radiographs should always be checked for signs of caries, alveolar bone loss, and short, blunt or thin root morphology which may be a risk factor for root resorption.

Previous Orthodontic Treatment

A history of previous orthodontic treatment may be a useful guide to potential patient cooperation with treatment. Failure to complete previous treatment with another clinician, particularly in teenage patients when the referral is instigated by the parents, is likely to result in continued lack of cooperation from the patient. Alternatively, adult patients often attend, having failed to cooperate with orthodontic treatment in their teenage years. These patients may well be motivated and cooperate with treatment. However, a full discussion of what is realistically achievable is required, for example if the teenage failed treatment was with functional appliances. Adults may also seek treatment for relapse following poor retainer wear, where previous orthodontic treatment was successful. The implications of prolonged retainer wear must be explored at length, as a second course of treatment is again likely to be unstable without long-term retention.

Another potential complication of previous treatment includes previous dental extractions, when the extraction space has been closed or otherwise lost, and where space is now required to correct the presenting malocclusion. In such situations, further dental extractions may not be possible, and alternative methods of space creation may be required (see later sections on teeth extraction and space analysis). A second course of fixed appliance orthodontic treatment may also increase the risk of root resorption.

Treatment Timing: When Should Treatment be Undertaken?

Teasing and Bullying

The psychosocial importance of dentofacial appearance cannot be underestimated.⁷ Difficulties can arise for patients if they desire treatment when they are not yet at the right age to obtain treatment. Desire for orthodontic treatment may arise in early adolescence, often as a result of negative comments, teasing or bullying in the school environment.

The bully attempts to harm or intimidate their victim, often repeatedly, and physical appearance is one of the main targets for teasing and bullying. Unfortunately, bullying has not reduced, despite purported social progress. If anything, the now commonplace use of social media for schoolchildren (and adults) has given rise to a new and potentially more pervasive source of bullying with mass online teasing and victimisation. Prolonged exposure to bullying may lead to anxiety, depression, low self-esteem and even suicidality, particularly in more vulnerable adolescents.⁸

A cross-sectional study of adolescents aged 10–14 years attending UK hospital orthodontic departments for potential orthodontic treatment found the prevalence of bullying to be nearly 13%.⁹ Being bullied was significantly associated with a Class II division 1 incisor relationship, increased overjet, and a high need for orthodontic treatment assessed using the Aesthetic Component of the IOTN. Bullied participants also reported lower levels of social competence, physical appearance-related self-esteem and general self-esteem, and higher levels of oral symptoms, functional limitations, emotional and social impact from their oral condition, resulting in a negative impact on overall oral health-related quality of life (OHRQoL). A follow-up study to measure the self-reported frequency and severity of bullying in these patients, after they had commenced interceptive orthodontic treatment, found that undergoing orthodontic treatment may in itself have a positive effect on adolescents experiencing bullying related to their malocclusion and their OHRQoL.¹⁰

Another study assessed 920 children from randomly selected schools and in the school environment, investigating the experience of bullying in a representative sample of Jordanian schoolchildren.¹¹ The prevalence of bullying was found to be 47%, with the percentage subjected to name-calling nearly 41%. A significantly greater proportion of victims of bullying reported playing truant from school and disliking school compared with those who were not bullied. Teeth were the number one feature targeted for bullying, followed by strength and weight. The three most commonly reported dentofacial features targeted by bullies were spacing between the teeth or missing teeth, shape or colour of the teeth, and prominent maxillary incisors.

When viewed from the broad context of overall psychosocial and emotional development, visually obvious dentofacial traits, such as prominent maxillary incisors, and the negative response of others to them, may be viewed as **handicapping malocclusions**,¹² as the malocclusion may markedly restrict the individual's ability to function socially, as well as physically (the term 'handicapping' should not be used in the presence of patients, for obvious reasons). Therefore, these can significantly affect psychosocial and emotional development, and social interaction, particularly of more vulnerable children. The relevance of the stage of dental development to issues related to handicapping malocclusions is an important consideration. Some patients may benefit from early interceptive treatment, for example to retrocline maxillary incisors or align impacted maxillary incisors, and where such treatment is deemed appropriate, and in the patient's best interest, it should be carried out. However, occasionally active treatment cannot be undertaken despite the patient's

concerns, such as a severe Class III malocclusion in a growing patient. In such circumstances, the clinician may act somewhat akin to a counsellor. Explaining to a patient that future treatment is available may in itself help the patient to cope, and sometimes upper arch alignment may be undertaken earlier, if deemed appropriate and helpful for the patient.

Dental Health Problems and Habits

As already described, orthodontic treatment with fixed appliances should not be undertaken until oral health has been achieved and oral hygiene is optimal. The only potential caveat is the treatment of special needs patients and those with learning difficulties if achieving optimal oral hygiene may not be possible, but the patient would benefit from some form of orthodontic treatment, albeit with limited objectives. In such situations, the clinician should work closely with parents/carers and ideally an experienced dental hygienist, in order to carry out treatment in the best interests of the patient. Concerted pretreatment efforts and continuous attempts during treatment should be made to improve oral hygiene and treatment duration kept as short as reasonably achievable.

Digit sucking habits should ideally have stopped by the primary dentition stage at least, and is often followed by spontaneous reduction in the severity of a resulting malocclusion. A digit sucking habit that has continued into the permanent dentition stage must cease prior to fixed appliance treatment. These habits can be difficult to give up as they provide comfort, particularly at night. As such, if all else fails, a fixed thumb guard may be fitted for approximately six months prior to instigating fixed appliance treatment (see Chapter 11, Figures 11.7 and 11.8). Nail biting habits can potentiate orthodontically induced root resorption and should also cease prior to active treatment.

Relevance of Growth and Growth Estimation

Prior to fixed appliance treatment, some patients may benefit from functional and dentofacial orthopaedic appliances, which are growth-dependent and ideally should be timed to coincide with the maximal pubertal growth spurt (Figure 1.3). For most patients, simple questions about potentially recent rapid growth in height, an increase in size of clothes and shoes, and standing height compared to siblings and parents provide an idea of their likely position on the growth curve. Alternatively, this may be achieved by plotting standing height measurements on a gender-specific **growth chart**, or by using the **cervical vertebral maturation (CVM) method**, which involves examining the patient's lateral cephalometric radiograph



Figure 1.3 (a–d) Pretreatment photographs and lateral cephalometric radiograph of a patient with a Class II division 1 incisor relationship on a moderate Class II skeletal pattern, with proclined maxillary incisors, Class II canine and buccal segment relationships, and a 14-mm incisor overjet. (e–g) After 12 months of functional appliance treatment (12 months full-time wear and 3 months part-time nights-only wear), demonstrating an improved sagittal dental arch relationship towards Class I incisor and buccal segment relationships.

for a change in the morphology of the second and third cervical vertebrae, specifically for the caudal surfaces to progress from a flat to concave morphology.¹³ In addition, the rapid adolescent growth may well facilitate tooth movement with fixed appliances.

Problem List

The problem list is simply a logically ordered list of the presenting problems that are a concern for the patient and those identified by the diagnosing clinician as needing to be dealt with in the treatment plan and corrected. The information required to generate a problem list is derived from three sources (Table 1.1):

- the patient interview/consultation
- clinical evaluation of the patient

- analysis of diagnostic records (e.g. radiographs, scans, clinical photographs, and dental study models, including space analysis and space planning).

Where possible, the problems should be noted quantitatively, such as a reduced upper lip height of 15 mm (average 20 mm for age and sex of the patient), or exact degree of crowding. Alternatively, some problems may be classified as mild, moderate or severe. The benefit of this very basic classification is to allow the clinician to begin to form an idea of whether treatment can be undertaken with orthodontics alone (e.g. a mild Class II skeletal pattern), whether other forms of treatment may be required (e.g. a moderate Class II skeletal pattern requiring dentofacial orthopaedic appliances or orthodontic camouflage treatment), or whether complex multidisciplinary treatment is required (e.g. a severe Class II skeletal pattern). The clinical

Table 1.1 Information required to generate a problem list for a standard orthodontic patient contemplating fixed appliance orthodontic treatment^(a).

Diagnostic information source	Information required to generate a problem list
Patient interview	• Presenting complaint(s), in order of priority for the patient. Does it match the order of priority for the clinician? • Patient's perception: does it tie in with the clinician's evaluation? • Motivation: internal or external? High or low? • Expectations: realistic or unrealistic? • Cooperation and potential compliance • Medical history • Dental history (e.g. regular or casual attendee to dentist) • Family history (e.g. siblings having orthodontic treatment; are family supportive?) • Social history (e.g. smoking, history of truancy from school)
Pathology evaluation (clinical and radiographic)	• Is there any pathology (e.g. dental caries, gingivitis, periodontal disease, alveolar bone loss)? • Is there any pain, noises or limitation of movement related to the temporomandibular joints (TMJs)? • Previous trauma to the teeth (history or signs)
Clinical evaluation	
Soft tissue evaluation	• Nasolabial angle, specifically lower component (i.e. upper lip inclination in profile view) (Figure 1.4). If the upper lip is inclined backwards as part of an obtuse nasolabial angle, avoid maxillary incisor retraction. Alternatively, a proclined upper lip may be due to proclined maxillary incisors (Figure 1.5) • Is the lower anterior face height (LAFH) reduced, average or increased in proportion to the facial proportions. If increased, may need to avoid posterior dental extrusive movements • Upper lip height: is it short, average or increased? • Maxillary incisor exposure in relation to upper lip at rest (Figure 1.6a). If there is reduced incisor exposure, avoid maxillary incisor intrusion. Also assess incisor and gingival exposure on smiling (Figure 1.6b) • Maxillary dental midline in relation to the mid-philtrum of the upper lip and facial midline: is it coincident, and are the incisors correctly angulated mesiodistally?
Skeletal evaluation	• Is the maxilla and associated dentoalveolus sagittally prominent, average or retrusive? • Is the mandible and associated dentoalveolus sagittally prominent, average or retrusive? • Is the maxillary-mandibular planes angle increased, average or reduced? • Is the maxillary occlusal plane level in frontal view, or is there a transverse cant (Figure 1.7)? If there is a cant, can it be corrected orthodontically, can it be accepted, or is surgery potentially required?
Dental evaluation	• What is the inclination of the labial crown face of the maxillary incisors in profile smiling view? A tangent to the labial face should be approximately parallel to the true vertical, with the patient in natural head position (Figure 1.8).^{1, 14} If the crown face is proclined or retroclined, it is likely to require correction • Is the mandibular dental midline coincident with the maxillary dental midline and facial midline (Figure 1.9)? • Are the incisors correctly angulated mesiodistally (Figure 1.10)? • Are the dental arch forms symmetrical? • What is the overall shape of the dental arch forms? • What is the incisor overjet? • What is the incisor overbite? • Is there an anterior open bite (AOB)? If so, is it predominantly skeletal, soft tissue or habit-related in aetiology? • What is the degree of crowding, spacing or rotations? • Are there missing teeth, extra teeth (supernumerary or supplemental), crossbites, premature contacts with displacements, impacted or ectopic teeth? • Are there any overerupted or infraoccluded teeth? • Is the gingival morphology thin or thick biotype (Figure 1.11)? • Is there any gingival recession (Figure 1.12)?
Analysis of diagnostic records	
Panoramic radiograph	• Overall dental assessment and comparison of left-right symmetry
Cephalometric analysis	• Particularly if skeletal deviations from the average are evident, or if significant change in incisor positions is planned. Mandatory if orthognathic surgery is contemplated

Table 1.1 (Continued)

Diagnostic information source	Information required to generate a problem list
Study models	• Evaluation of dental arch symmetry • Space analysis and space planning (see below)
Other	• Serial height measurements • Cone beam computed tomography (CBCT), e.g. evaluating positions of difficult impacted teeth, or significant facial asymmetry potentially requiring surgical correction • Maxillary occlusal radiograph: to assess root morphology and for localisation of impacted canines using the parallax method

(a) More complex treatment, such as orthognathic surgery, requires more than the basic information provided in this table. For further information, see chapters 5 and 6 of *Orthognathic Surgery: Principles, Planning and Practice*.²

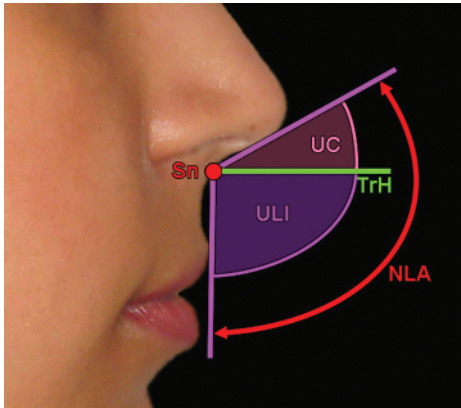


Figure 1.4 The nasolabial angle (NLA) may be divided into an upper component (UC) and a lower component, which is effectively the upper lip inclination (ULI), by a true horizontal line (TrH) passing through subnasale (Sn, defined as the deepest midline point where the base of the nasal columella meets the upper lip), with the patient in natural head position. Source: modified from Naini FB. *Facial Aesthetics: Concepts and Clinical Diagnosis*. Oxford: Wiley Blackwell, 2011, used with permission.

diagnosis is based on a synthesis of the salient information collected from the above, which leads to the formation of the patient-specific problem list.

Treatment Aims

If the problem list has been accurately compiled to identify the problems requiring correction, the aims of treatment usually follow seamlessly from the list. In this context, because the clinical diagnosis described above leads to the formation of a problem list, treatment planning therefore becomes a problem-solving exercise. The aims of treatment should consider:

- addressing the patient's concerns
- improving or at least not deteriorating facial and smile aesthetics
- establishing and maintaining a functional and stable dental occlusion

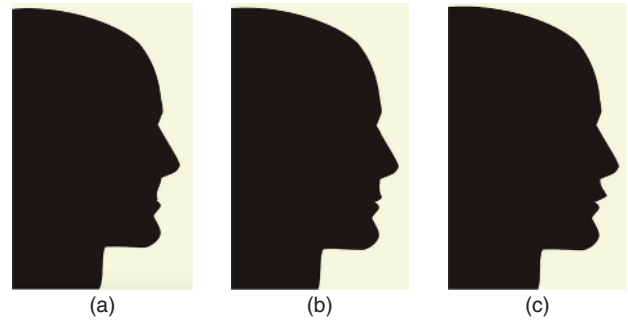


Figure 1.5 (a) Retroclined upper lip, which is usually a sign of lack of support for the upper lip, from a retruded maxilla/maxillary dentoalveolus or retruded/retroclined maxillary incisors. (b) Normal upper lip inclination. (c) Proclined upper lip, which may be due to proclined maxillary incisors.

- prioritising and determining the sequence of the planned stages of treatment.

It is important that the aims of treatment are logically ordered. For example, growth-related treatment requiring functional appliances takes precedence over incisor alignment in a patient near their pubertal growth spurt, or implementing treatment to arrest the trauma associated with a deep incisor overbite would need to be at the top of a list of aims.

If there is inconsistency between the order of priorities of the patient/parents and the clinician, as occasionally happens, a frank discussion is required to explain why a certain part of the treatment may need to be the initial focus (e.g. if it is growth related and time is running out). It is important that the patient/parents agree with the proposed steps in the planned treatment.

Aesthetic-Centred versus Occlusion-Centred Planning

In the early stages of orthodontic fixed appliance development at the beginning of the twentieth century, orthodontic treatment aimed to improve the dental occlusion; this was based on the conviction that well-aligned teeth in a Class I occlusion, with all the teeth present, would automatically



Figure 1.6 (a) Maxillary incisor exposure in relation to the upper lip in repose tends to be most attractive at approximately 2–5 mm, usually more in women than men. (b) On smiling, most of the maxillary incisor crowns and possibly 1–2 mm of the labial gingivae are evident.



Figure 1.7 A maxillary occlusal plane cant, which is down on the patient's right side. In patients with level eye positions, the maxillary occlusal plane is usually approximately parallel to the interpupillary line.

lead to an 'ideal' facial aesthetic result. As is so often the case, untested beliefs were promoted as irrefutable facts for a few decades. However, evaluation of case results over time demonstrated this view to be inaccurate, with many cases resulting in extreme dentoalveolar protrusion or prone to significant relapse. Towards the middle of the twentieth century, outlooks shifted towards treating to arbitrary cephalometric *hard tissue* standards, particularly in relation to the sagittal position of the mandibular incisors, predominantly because cephalometric analysis was poorly understood and thereby often misapplied in clinical practice.¹⁵ Opinions and outlooks continued to wax and wane for a number of decades. Parallel to, but separate

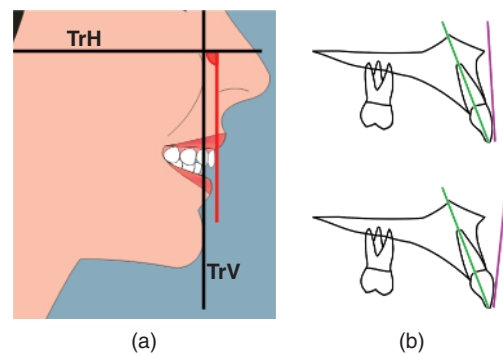


Figure 1.8 (a) The inclination of the labial crown face of the maxillary incisors should be evaluated in profile smiling view. A tangent to the labial face should be approximately parallel to the true vertical, with the patient in natural head position. (b) The inclination of a tangent to the labial crown face of the maxillary incisor (purple line) is more important than the inclination of the entire tooth (green line), as it is the incisor crown that is aesthetically visible. These two parameters are not directly related. Source: (a, b) Naini et al. The maxillary incisor labial face tangent: clinical evaluation of maxillary incisor inclination in profile smiling view and idealized aesthetics. *Maxillofac. Plast. Reconstr. Surg.* 2019; 41: 31–38.



Figure 1.9 Mandibular dental midline is significantly to the right of the maxillary dental midline. Mandibular right canine was ectopic and unerupted. The mesiodistal angulation of the incisors is normal. There is a right-sided posterior crossbite. With unilateral posterior crossbites the clinician must always check for a lateral mandibular displacement.



Figure 1.10 (a) Mandibular incisor mesiodistal angulation is significantly angulated to the patient's left. (b) This is even more evident on slight opening of the mouth.



Figure 1.11 Patients with a thin gingival biotype often present with a 'washboard' appearance of the anterior tooth roots, particularly in the mandibular incisor and canine region.



Figure 1.12 Gingival recession evident in the central incisor region and buccal segments.

from, the development of orthodontics was the development of orthognathic surgery; contrary to orthodontic planning, many of the early pioneering surgeons were promoting the importance of the facial soft tissue aesthetic result as the most important consideration.¹⁶

Within modern orthodontics, an **aesthetic-centred** approach to treatment planning, with emphasis on the

most aesthetic relationship of the maxillary incisor position within the face, in repose and in animation, has now superseded earlier **occlusion-centred** approaches, based around the lower incisor position and static occlusal goals.¹⁷ This is particularly important if **orthodontic camouflage** treatment is being planned; this refers to the treatment of a malocclusion where the skeletal discrepancy is not corrected, but the teeth are repositioned through their supporting alveolar bone in order to improve the dental occlusion. Undertaken incorrectly, orthodontic camouflage treatment may worsen facial appearance; for example, in a Class II malocclusion predominantly due to mandibular retrognathia, with the maxillary incisor sagittal position essentially normal, any retraction of the maxillary incisors to reduce the incisor overjet to a Class I incisor relationship (an occlusion-centred approach) may have significant detrimental facial aesthetic effects, such as reducing support for the upper lip and creating an obtuse nasolabial angle. In such patients, an aesthetic-centred approach would suggest that consideration is given to aligning the teeth and either maintaining or only partially correcting the incisor overjet.

Static and Functional Occlusion, Stability and Health

The other aims of orthodontic treatment are to obtain a well-interdigitated and well-functioning dental occlusion, a relatively stable result (or at least avoiding unstable movements) and an improvement in the patient's health-related quality of life.

The Six Keys to Occlusion described the morphological characteristics of an 'ideal' **static occlusion**: correct molar relationship, correct crown angulation (mesiodistal 'tip'), correct crown inclination (buccolingual or labiolingual inclination), no rotations, no interdental spaces, and a flat or very mild curve of Spee.¹⁸ A seventh key was later added, that of correct relative tooth sizes. Achievement of a well-interdigitated dental occlusion is an aim of orthodontic treatment with fixed appliances (Figure 1.13).



Figure 1.13 A relatively well-interdigitated dental occlusion.

In addition, improved **functional occlusion** is also an aim of treatment, referring to the dynamic relationship of the maxillary and mandibular teeth during dentally guided mandibular movements (e.g. lateral and protrusive movements), away from and towards maximum intercuspation, without occlusal interferences and providing protection and health of the periodontium and ideally well-functioning temporomandibular joints.

The most stable dental–occlusal outcome is an important aim of treatment. Depending on the original malocclusion and the dental movements undertaken, some may be inherently predicted as being unstable, for example closing a large maxillary midline diastema or correcting severe dental rotations. However, the biological variability and response to treatment between different patients means that it is not possible to predict accurately the degree of stability of standard orthodontic treatment with fixed appliances. Therefore, long-term wear, albeit often night-time wear of removable retainers, is deemed mandatory for patients desiring to maintain their treatment result.¹⁹ Patients at greater risk of relapse may require bonded retainers in addition to removable retainers.

The definition of health provided by the World Health Organization (WHO), which has not been amended since 1948, is that ‘health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’. A primary focus of modern healthcare is on the effects of treatment on a patient’s quality of life, with OHRQoL defined as a multidimensional construct that includes a subjective evaluation of the individual’s oral health, functional well-being, social and emotional well-being (which incorporate positive health states such as happiness and confidence), expectations and satisfaction with care, and sense of self.²⁰ It is an integral part of general health and well-being. Oral health can affect anyone’s life,²¹ but the importance of children’s oral health to their overall health and well-being has been highlighted, together with the profound impact that oral health can have on children’s quality of life.^{22, 23} Orthodontic treatment deals

with physical well-being by focusing on dental–occlusal function, and with mental and social well-being by focusing on improving dentofacial aesthetics. Evidence for the improvement in quality of life from orthodontic treatment and orthognathic surgery is increasing.²⁴

Presenting the Treatment Options

Having established the aims of treatment, the next step is to decide on the available treatment options, which may deal with only some, most or all of the treatment aims. Depending on the complexity of the case, this will often result in a number of treatment options of ascending complexity that may be presented to the patient for their consideration. The treatment plans should be unambiguous and not unnecessarily ambitious for the orthodontist, particularly when addressing the patient’s concerns does not require such treatment. If a specific treatment option is more appropriate for a patient, then that should be discussed, as should the reasons for the degree of appropriateness (e.g. considering factors such as the patient’s motivation, ability to comply with the treatment, or medical history). Treatment planning should be undertaken in collaboration with the patient and where appropriate the interaction of parents/carers, in order to do what is best for that individual patient at the most appropriate time.

Occasionally, a patient’s **mental capacity** can become a cause for concern if it becomes difficult for the clinician to assess whether the patient understands and desires treatment or if the motivation for treatment is parentally driven. Mental capacity may be defined as the ability to make one’s own decisions. An individual lacking mental capacity (e.g. due to learning difficulties or mental health problems) may find it difficult to:

- understand the information given to them
- retain the information for long enough to enable their decision-making
- weigh up the information provided to reach a decision
- communicate their decision.

In such situations sound judgement from the clinician is paramount, and in some circumstances treatment may need to be delayed and advice sought from the appropriate medical or mental health professionals (see Chapter 5).

When explaining to patients that there are different treatment options, clinicians should beware that patients often misinterpret the presentation of choice, and may think that the clinician is either uninformed or lacks the judgement to reach a decision. This possibility may be negated by clearly explaining that there is good information about how these

treatment options differ and that you will discuss the pros and cons of each approach with them.

Generally speaking, there are four potential orthodontic treatment options:

- No treatment
- Treatment with limited objectives
- Orthodontics alone
- Orthodontics in association with multidisciplinary care.

No Treatment

For a patient presenting with a malocclusion, there are two important questions to be answered. The first question is 'Does the patient need treatment?' If the answer is yes, the second question is 'Does the patient desire treatment?' If the impetus for referral is either from the referring dentist or possibly parents, and the patient does not desire treatment, this may well affect their compliance with any treatment and thereby its potential success or failure.

Orthodontic treatment should not be considered in patients with potential BDD; for those with malocclusions combined with excessive levels of anxiety, treatment should not be considered unless the patient is first assessed by an appropriately trained mental health clinician.⁴

Treatment with Limited Objectives

The three overriding aims of orthodontic treatment are 'ideal' dentofacial aesthetics, 'ideal' occlusal function and 'ideal' stability of the obtained result. Realistically, even with highly experienced clinicians, these are not always achievable due to patient-related factors. For a variety of reasons, a patient may not desire or be able to tolerate long and complicated treatment, or may prefer to avoid multidisciplinary treatment, or may prefer a more aesthetic result even if it might compromise stability. The clinician's judgement remains paramount in deciding which compromises are feasible in order to obtain the result most favoured by the patient. Therefore, treatment with limited objectives is effectively an agreed trade-off between what the clinician could achieve despite lengthy and/or complex treatment versus what the patient can realistically tolerate to achieve an acceptable, albeit compromise in the treatment result. With appropriate concessions and cooperation from the patient/parents/carers, and realistically achievable aims, a successful outcome is more likely. Clearly, treatment should only be undertaken if the clinician considers it to be in the patient's best interest.

Treatment with limited objectives should never be undertaken due to lack of experience on the part of the clinician. In such circumstances, appropriate referral to a more experienced clinician should be instigated without hesitation.

Orthodontics Alone

For many patients, fixed appliance orthodontic treatment in the hands of an appropriately trained clinician can provide exemplary results. Difficulties may arise when patients present with underlying skeletal problems. In growing patients, the decisions are whether a malocclusion is amenable to a functional appliance, orthopaedic headgear or facemask treatment and, if so, whether the patient will wear such appliances. In older patients, the question is essentially one of orthodontic camouflage treatment versus orthognathic surgery, as previously discussed.

For patients with a Class I malocclusion on a skeletal Class I pattern, treatment planning is generally undertaken in the lower dental arch, with preservation of the sagittal position of the mandibular incisors and the intercanine width. This is based on consideration of the development of the teeth within the zone of neutral pressure between the lips/cheeks and tongue. Although maintenance of these parameters does not automatically confer stability, in the absence of other reliable predictors, it is considered clinically advisable. Maxillary arch mechanics to achieve a Class I incisor and canine relationship follow.

However, when Class II or III skeletal discrepancies are evident, the treatment approaches include either growth modification/dentofacial orthopaedics in growing patients, orthodontic camouflage treatment, or orthognathic surgical correction.

Orthodontics in Association with Multidisciplinary Care

Orthodontic treatment may have to be considered in conjunction with other dental, surgical or medical specialties as required, depending on the requirements of each specific case. These include maxillofacial surgery for orthognathic patients, oral surgery for patients requiring exposure of impacted/ectopic teeth, frenectomies or other oral surgical procedures, restorative dentistry for patients with hypodontia, and cleft or craniofacial teams. In such situations the clinician will require the appropriate training.

With any of the options described, the risk/cost/harm versus benefit considerations must be discussed in full, allowing the patient to make an informed decision regarding their choice of treatment (see section Informed Consent).

How do we decide whether or not to Extract Teeth?

The debate between extraction and non-extraction treatment is almost as old as the orthodontic profession.

However, a practical and common-sense approach with sound judgement is the main requirement in the decision-making process. The obvious perceived disadvantage for the patient of dental extractions is the loss of the permanent teeth involved. The other disadvantage is the potential detrimental facial soft tissue aesthetic changes from excessive retraction of the incisor teeth leading to retrusion of the lower face in profile view (sometimes referred to as ‘dishing-in’ of the profile), resulting from reduced dentoalveolar support for the labial soft tissues. The latter is essentially an issue related to incorrect planning, poorly controlled mechanics, or both. Other possible disadvantages of dental extractions are the potential complications of surgery, poor patient experience, the anxiety involved for some patients, and the unattractive appearance of some extraction spaces, although this is usually short term.

The advantages of dental extractions are to provide space for other teeth in the presence of crowding severe enough not to be amenable to other forms of space creation, to allow incisor retraction in cases of excessive protrusion, or in Class II or Class III camouflage treatment. Dental extractions may also be necessary for other reasons, such as surgical removal of extremely ectopic teeth not amenable to alignment, or broken down/carious/hypoplastic teeth. Appropriately undertaken dental extractions may even be beneficial in terms of facial aesthetics; for example, maxillary first premolar extractions providing space to retrocline and retract excessively prominent maxillary incisors can improve labial competence and reduce labial prominence.

There are a number of methods of gaining space available in orthodontics (discussed in more detail in Chapter 14). Of these, extractions should be at the bottom of the list, which means that if the treatment plan calls for dental extractions, other possibilities have been exhausted and it is in the best interests of the patient.

In some ‘borderline’ patients, it may not be obvious at the outset whether treatment can be successfully carried out on a non-extraction basis by expansion of the dental arches or other forms of space creation. In such situations, treatment may be undertaken with a **therapeutic diagnosis** approach, i.e. begin non-extraction and reassess during treatment. If the incisors begin to appear excessively prominent and the patient agrees with the finding, dental extractions may be undertaken. If this approach is contemplated, it should be discussed in full at the planning and consent stages of treatment.

The idea that extraction treatment automatically leads to retrusion of the labial part of the facial profile or that non-extraction treatment always leads to protruded incisors and broad dental arches is inaccurate and misleading. The outcome of treatment is dependent on correct

treatment planning by a competent clinician, combined with logical mechanics based on a thorough understanding of anchorage (e.g. how to close space with mesial movement of buccal segments as opposed to excessive retraction of incisors) and competent handling of the chosen appliance.

The decision of whether dental extractions are required should never be taken lightly, and should always take into consideration the following.

- **Lip–incisor relationship:** this important aesthetic relationship is the foundation stone of dentofacial aesthetics in treatment planning.¹ The best possible sagittal, vertical and transverse position and inclination of the maxillary central incisors is the main target for the end of treatment. If the maxillary incisor labial crown face is relatively parallel to the true vertical line in a smiling profile view of a patient in natural head position, any proclination will likely be detrimental to smile aesthetics.^{1, 14}
- **Facial soft tissue form and thickness:** the presenting facial soft tissue form and likely change with extraction versus non-extraction treatment are important. For example, thin retrusive lips can tolerate incisor proclination or protraction from expansion treatment, and any further labial retraction from extraction treatment should be avoided if possible, or if extractions are required, space closure should be controlled to reduce incisor retraction as far as possible. Conversely, in patients with thick flaccid lips, there may be very little effect on the lip posture or prominence in relation to sagittal movement of the incisor teeth.
- **Stability:** the potential stability of the result is an important parameter; for example, excessive proclination of the teeth into the labial soft tissues may lead to greater risk of relapse, particularly in the lower arch. However, retroclined teeth may have a greater ability to be proclined, albeit avoiding dehiscence of thin labial alveolar bone and potential gingival recession.
- **Space analysis:** occlusal factors should be evaluated methodically, ideally with a formal and thorough space analysis (see following section).

When dental extractions are required, the choice of teeth will depend on a number of factors:

- **Degree and site of crowding:** if crowding is severe enough to warrant extractions, in an otherwise healthy dentition, the teeth usually planned for removal are the premolars. As a general guideline, the further a tooth is situated from the site of crowding, the less space will be available for tooth alignment. Therefore, the greater the degree of labial segment crowding (usually equating to dental arch crowding of anything more than 8–9 mm), the more likely that first premolar extractions

will be required. In growing patients with erupting canines that are short of space, appropriately timed first premolar extractions may allow the eruption of the canines and some spontaneous relief of crowding. If space requirements are less (between 5 and 8 mm), consideration should be given to second premolar extractions.

- Type of malocclusion:** in *Class I malocclusions* requiring premolar extractions, the decision to extract is first made in the lower arch. The corresponding extraction is undertaken in the upper arch, for example if mandibular first premolars are to be extracted, the extraction pattern in the maxilla is also the first premolars. This helps to correct or maintain a Class I buccal segment relationship. In a *Class II malocclusion* requiring incisor relationship correction as well as relief of crowding, the space requirements will usually be greater in the maxillary arch. If first premolar extractions are required for relief of crowding in the mandibular arch, the corresponding teeth will usually be extracted in the maxillary arch. If the space requirements are less in the mandibular arch, a common extraction pattern is the extraction of upper first and lower second premolars. This aids buccal segment correction, as it reduces the tendency for forward movement of the upper molars and allows greater forward movement of the lower first molars, which moves the molar relationship towards Class I. Alternatively, if there is mild crowding in the lower arch, it may be treated on a non-extraction basis, extracting premolars in the upper arch only, finishing to a Class II molar relationship. This extraction pattern helps maintain the sagittal position of the lower incisors, which forms the limit to maxillary incisor retraction, reducing the likelihood of their excessive retraction. In *Class III malocclusions*, the converse is true, in that the mandibular incisors usually need to be moved lingually, potentially increasing the space requirement in the lower arch. As such, the usual extraction pattern is mandibular first premolars and maxillary second premolars. Alternatively, if the maxillary arch is well aligned or only mildly crowded and the sagittal incisor position acceptable, the maxillary arch may be treated on a non-extraction basis, finishing to a Class III molar relationship.
- Presence of teeth:** in patients with hypodontia, if one maxillary lateral incisor is congenitally missing, in the presence of crowding, consideration may be given to removal of the contralateral lateral incisor (particularly if it is diminutive in form) in order to avoid the requirement for future prosthetic tooth replacement and to provide symmetry to the dental arch and final aesthetic result. Factors that need to be considered with

this approach include the degree of gingival exposure on smiling and the size, shape and colour of the maxillary canines.²⁵ The canines may eventually require some lateralisation, which refers to modification to their shape (usually by enamel removal at the tip, and sometimes addition of composite resin mesial and distal to the tip) to appear more like lateral incisors (Figure 1.14). If both lateral incisors are severely crowded, and erupted lingually/palatally, their extraction can simplify treatment and reduce treatment time, so long as the canines make suitable substitutes, i.e. are of suitable morphology to mimic or be modified as lateral incisors. Severely ectopic canines may be considered for surgical removal; although removal of canines is not commonly undertaken, in appropriately selected cases it may significantly reduce treatment time, and the lateral incisor–first premolar contact can be aesthetically and occlusally satisfactory.

- Health of the teeth:** compromised teeth (caries, heavily restored, hypoplastic or previously traumatised) with a poor long-term prognosis should always be considered during treatment planning when extractions are required. Even if the teeth are not those usually selected to correct the presenting malocclusion, nevertheless with appropriate anchorage management and carefully planned mechanics, their extraction may be in the patient's best interests. However, if treatment time would be significantly increased, this would need to be discussed with the patient. Caries and hypoplasia often affect the first permanent molar teeth, as these are the first molar teeth to erupt, and their extraction may help create space for second and sometimes even third molar teeth (though third molar eruption and position is unpredictable). Maxillary central incisors are the usual teeth to be involved in trauma and if extraction is unavoidable, consideration should be given to either maintain the space for a prosthetic replacement or, occasionally, to removal of both central incisors and modification of the lateral incisors as central incisors. The latter approach is uncommon and would need to be planned carefully with restorative dental specialists from the outset.

Space Analysis and Space Planning

Space analysis of the dental arches may be defined as the assessment of the amount of space required for alignment and occlusal correction and the space creation and utilisation planned to achieve those aims.^{26,27} As such, in terms of occlusal parameters, orthodontic treatment may

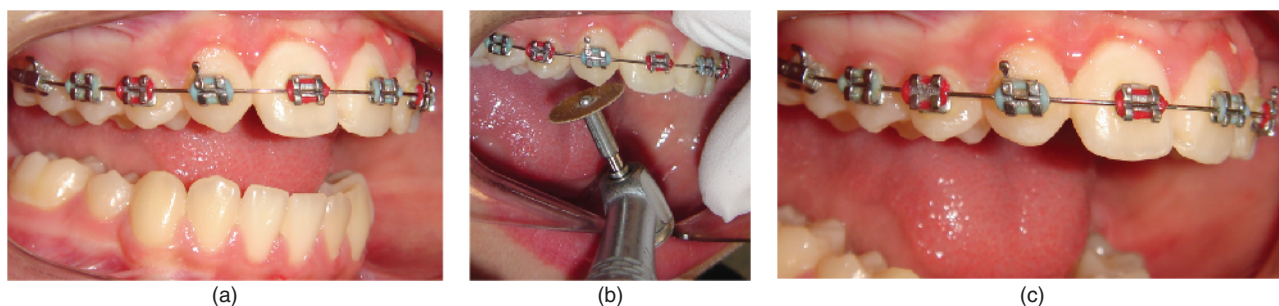


Figure 1.14 (a) Missing maxillary lateral incisors, with treatment undertaken by space closure, positioning the canines adjacent to the central incisors. (b) Lateralisation of the canines may be undertaken with enameloplasty of prominent canine tips. The authors favour the use of flexible contouring discs (beginning with the coarse abrasive grade for reshaping of the enamel, followed by the finer grades for polishing) mounted on a mandrel in a slow-speed contra-angle handpiece. (c) Canine tip has been reshaped. If the patient desires, composite may be added to the mesial and/or distal of the canine tip in order to mask its appearance further.

be viewed as the **redistribution of space**. Although a number of methods of space analysis have been described, we favour the comprehensive space planning system developed for the permanent dentition at the Royal London Hospital over many years (described in detail in chapter 10 of *Orthodontics: Principles and Practice*).²⁸

In our view, the absolute measurements and values derived from space analysis are perhaps not as important as the systematic nature of the assessment. It is very easy for an inexperienced clinician to view a set of orthodontic study models and just ‘see’ crowding or spacing, and not consider all the other parameters that are relevant to space requirements and space utilisation. For example, a crowded dental arch may be treated on a non-extraction basis if the plan requires transverse arch expansion and incisor proclination. Alternatively, a well-aligned dental arch may require extractions if significant incisor retraction is planned. A logical order to case assessment and space analysis means it is less likely for the clinician to miss something or make an error in the planning process. The methodical approach of this system helps to develop ordered thinking, and is particularly helpful for those in training. It is important to reiterate that space planning for the dentition should always be undertaken with due consideration for dentofacial aesthetics, particularly regarding the position of the incisor teeth in relation to the face, and of the stability of the end result.

The Royal London Hospital space analysis consists of two parts, summarised as follows.

1. Assessment of the space requirements in each dental arch (Table 1.2).
2. Planning the creation and utilisation of space, i.e. how the space will be created and used in treatment.

Of the factors assessed, crowding and incisor sagittal retraction have the most significant space implications,

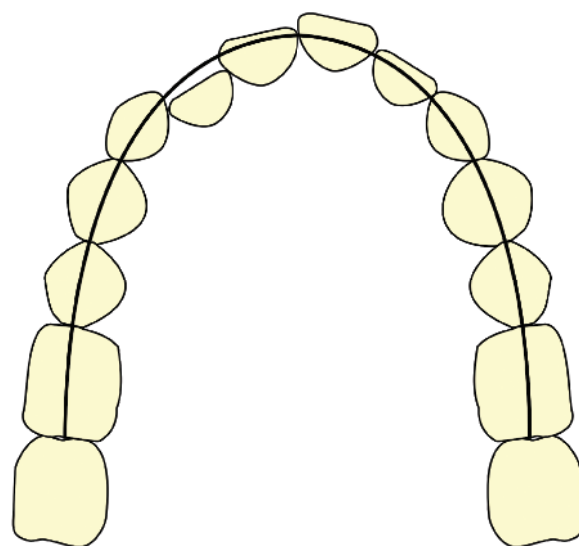


Figure 1.15 Dental arch crowding should be measured in relation to the arch form that best reflects the majority of the teeth. The ideal labiolingual position of the incisors should be considered, which is not necessarily the most prominent incisor.

with levelling, arch width and incisor inclination changes affecting space by no more than 2–3 mm per arch.

Once the space requirements in each dental arch have been calculated, space creation and space utilisation are planned. The following parameters should be considered.

- **Tooth reduction and enlargement:** the amount of tooth material in both dental arches should be in proportion for a good occlusion. Disproportion between the sizes of individual teeth in a patient is termed a **tooth size discrepancy**. The most common tooth size discrepancy is narrow maxillary lateral incisors (normal-width upper lateral incisors are usually approximately two-thirds the width of the central incisors and should always be wider than the mandibular lateral

Table 1.2 Summary of space requirements in space analysis.

Space requirements	Assessment method	Notes ^(a)
Crowding and spacing (Figure 1.15)	Study models	Crowding should be quantified in relation to an arch form that reflects the majority of the teeth, usually established as passing through the majority of the buccal cusps and incisor tips (avoiding individual teeth displaced from the arch form) Measure mesiodistal widths of the teeth (using a clear ruler) that do not lie on the selected arch form anterior to the first molars in each arch. Crowding is calculated by subtracting the space available in each arch The incisors which contribute to the arch form should be the same as those which will be traced on the lateral cephalometric radiograph (see below)
Levelling occlusal curve (Figure 1.16)	Study models	Increased occlusal curves are due to slipped contacts in the vertical plane. Levelling the occlusal plane involves restoring the contact point relationships The sagittal curve of the occlusion is assessed in relation to a flat plane from the distal cusps of the first molars to the incisal edges. The depth of the curve is measured from the premolar cusps to the flat plane Only one value is provided for each arch For the lower dental arch: • No space allowance for a depth of <3 mm • Allow 1 mm of space for 3 mm depth of curve • Allow 1.5 mm of space for 4 mm depth of curve • Allow 2 mm of space for a 5 mm depth of curve For the upper dental arch: • 1 mm space is recorded in Class II division 2 cases with a significant sagittal occlusal curve
Arch width change	Study models	Allow 0.5 mm space for each millimetre posterior arch width change (0.7 mm/mm expansion if using rapid maxillary expansion) The overall effect of 1 mm expansion across the upper intermolar width is 0.6 mm of space creation, e.g. 5 mm expansion will result in approximately 3 mm of additional space in the arch Arch width contraction reduces the available space in the same proportion. Arch contraction has a space requirement, i.e. all else being equal, space would need to be created by interdental enamel reduction, extraction or incisor protrusion
Incisor sagittal position change (bodily retraction or protraction) (Figure 1.17)	Lateral cephalometric radiograph ^(b)	Allow 2 mm of space for each 1 mm of planned incisor retraction, i.e. for each 1 mm of planned retraction of the maxillary incisors, 1 mm of space will be required per side Conversely, protraction (bodily advancement) of the upper incisors by 1 mm will create 1 mm of space distal to the incisors per side (i.e. 2 mm per arch) This is evaluated in relation to the planned target incisor overjet (usually 1.5–4 mm)
Incisor inclination change (Figure 1.18)	Lateral cephalometric radiograph ^(b)	Applies only to the maxillary incisors Allow 1 mm space for every 5° change affecting all four incisors, and 0.5 mm space if only two incisors affected
Incisor mesiodistal angulation change (Figure 1.19)		Applies only to the maxillary incisors Although 0.5 mm space is appropriate for correction of each parallel-sided vertical tooth, no allowance is usually given as angulation corrections tend to be included in the crowding assessment

(a) In our view, the figures quoted should be seen as guidance and should not be viewed as absolute or prescriptive.

(b) We suggest that this assessment is supplemented with clinical evaluation of the maxillary incisor crown face inclination in a profile smiling view of the patient in their natural head position.



Figure 1.16 Increased occlusal curves are due to slipped contact points in the vertical plane. Levelling the occlusal plane involves restoring the contact point relationships. This requires space if arch lengthening by incisor proclination is to be avoided.

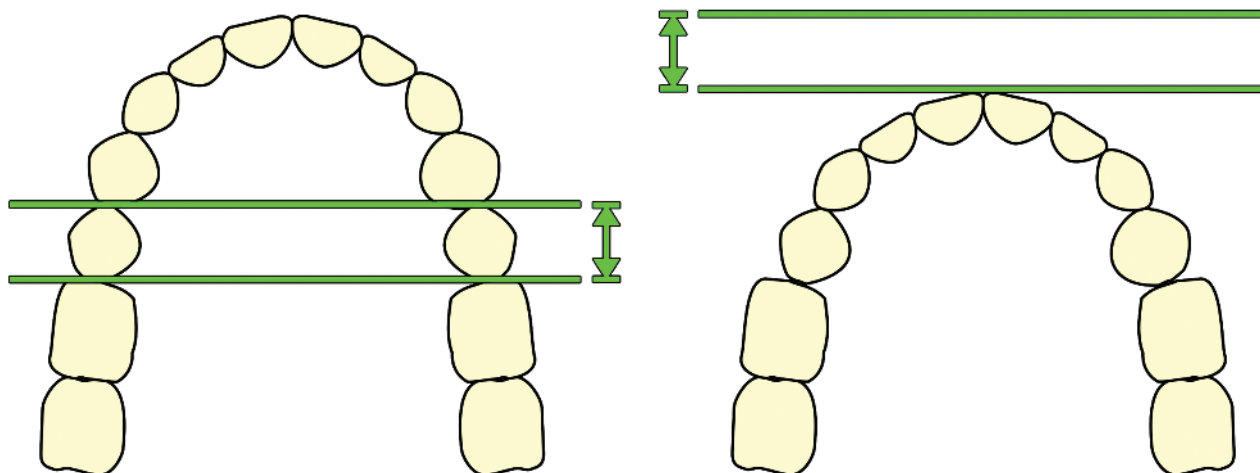


Figure 1.17 Bodily incisor retraction by a distance requires the same amount of space in each buccal segment. In this example, the space required for incisor retraction has been achieved by mid-arch premolar extractions.

incisors), although premolar size may also be variable. When individual teeth are of reduced size/width relative to the others, it may be necessary to create space around them for eventual enlargement in order to achieve a good dental occlusion (e.g. restorative building up of narrow maxillary lateral incisors). Conversely, if a tooth is unusually wide, the mesiodistal width may be reduced by interproximal enamel reduction. In an intact dental arch, there are 11 contact areas mesial to the first molars, and removal of 0.5 mm of enamel per contact point (i.e. 0.25 mm per tooth surface) can provide approximately 5.5 mm of space, provided that there is enough enamel thickness and tooth morphology of anterior teeth is favourable (triangular incisors are amenable to interproximal enamel reduction, whereas narrow parallel-sided incisors may be unsuitable).

- **Missing teeth:** the decision to open space for prosthetic replacement of missing teeth is similar to the principle of building up narrow teeth discussed above.

- **Extractions:** the mesiodistal width of permanent teeth to be extracted is recorded. For example, extraction of maxillary first premolars, each 7 mm in width, will create 14 mm of space.
- **Molar distal movement:** this results in an increase in arch length. For example, 2 mm of molar distal movement per side results in 4 mm increase in overall arch length. This was particularly applicable to the maxillary dental arch with headgear used for distal movement, but the use of temporary anchorage devices (TADs) permits distal movement in the mandibular arch in selected cases.
- **Molar mesial movement:** the space gained from dental extractions is not entirely available for relief of anterior crowding or incisor retraction as some of the space will be 'lost' by forward movement of the posterior teeth. This is significant when decisions regarding the requirement for **anchorage reinforcement** are being considered, for example significant incisor retraction will lead to

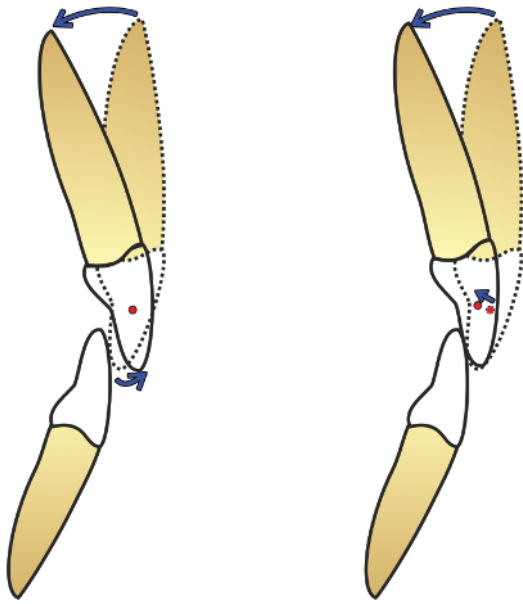


Figure 1.18 Correcting the inclination of retroclined maxillary incisors requires space if an increase in the incisor overjet is to be avoided. Superimposition of maxillary incisors by registration on the contact point (*left*) demonstrates an increase in the overjet after palatal root torque. However, registration on the point of occlusal contact with the mandibular incisor (*right*) demonstrates a gingivopalatal movement of the contact point after palatal root torque. Either way, additional space is required in the arch to accommodate for palatal root torque.

greater forward movement of the posterior dentition. A very approximate percentage estimation is that 60% of mandibular first premolar space is available for labial segment alignment without anchorage reinforcement, reducing to 40% if second premolars are extracted. The space available from similar extractions in the maxillary arch is lower, as there is a greater tendency for maxillary molar mesial movement. If forward movement of the molars is not desired, anchorage reinforcement should be planned, by adding intraoral anchorage reinforcement (e.g. Nance palatal arch), extraoral anchorage such as headgear, or TADs.

- **Growth considerations and space:** provision should be made for the potential effects of differential mandibular growth in growing patients. Growth estimation is unpredictable, but must be considered. Mandibular growth usually exceeds maxillary growth in the sagittal plane by a few millimetres between the ages of 9 and 16 years. This may be beneficial in Class II cases and detrimental in Class III cases. If Class III growth is likely, additional space will be required for dental compensation and retroclination of the mandibular incisors.

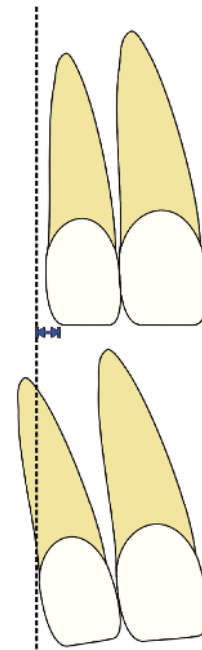


Figure 1.19 Teeth that are angulated tend to occupy slightly more space in the arch.

If space analysis is carried out accurately, with due consideration of the treatment aims, the balance of space required and how this is created and utilised should equal zero. If not, the process should be reviewed, including the treatment aims, to assess whether they are achievable, or whether appropriate modifications are required, such as different extraction pattern or greater anchorage reinforcement. This is very useful for the clinician and in terms of patient information for informed consent.

The information acquired from the space planning process should be integrated with the information gathered from the patient interview, clinical evaluation and analysis of other diagnostic records in order to formulate the treatment plan.

Informed Consent

From a modern and ethical standpoint, medical treatment is viewed as something done for the patient with their involvement in the decision-making process, rather than something done to the patient because the clinician has deemed it necessary and in their supposed best interests. The latter approach, termed the **paternalistic model**, is no longer justified, and is deemed unethical and legally indefensible in most situations, particularly for elective treatment. The former or **autonomous model**

is the preferred approach in most societies, and the clinician responsible for obtaining consent should act with sensitivity and mindfulness of each patient's particular needs.

If a patient is to have autonomy in their choice of treatment, they must be provided with sufficient information using easily understandable, jargon-free terminology that will allow them to make an informed decision. During the informed consent discussion, the clinician should discuss and explain the following.

- **Patient's presenting complaint:** the patient's presenting problems need to be fully explained to the patient, to ensure that patient and clinician are not unwittingly misunderstanding each other. It is easier than one might think for patient and clinician to be talking at cross purposes; for example, the patient with a midline diastema and an anterior open bite who complains of 'the space between my teeth' may only be referring to one or other of the spaces. It is important to ensure that the clinician has identified the patient's main concern(s), and that the treatment plan will address those concerns.
- **Alternative treatment options:** these must be discussed, and the advantages, disadvantages and potential outcomes of each approach considered, including that of no treatment. It is no longer justified to provide only a written information sheet or to ask the patient to sign a consent form (often containing medical jargon), neither of which constitutes valid consent.
- **Treatment time:** the likely average length of treatment should be discussed for each option, and *never* underestimated. Patients should also be aware that treatment sometimes takes longer than expected, particularly if the teeth move more slowly than expected, or if patients continuously damage their appliances, do not maintain a high standard of plaque control, continuously miss appointments or do not comply with instructions, such as requirements for intraoral elastic wear. Patients should also be made aware of the risks of discontinuation of treatment before its completion against the clinician's advice, resulting for example in extraction spaces remaining.
- **Compromises:** if compromises are unavoidable, they must be discussed with the patient, with reasonable explanations provided.
- **Consequences of no treatment:** the potential consequences of not undergoing treatment, including not undergoing treatment at that time, should be discussed

(e.g. if functional appliances or other growth-related treatments are being considered).

- **Need for retention:** the long-term requirement for retainer wear, the type of retainers required, and their long-term management must all be discussed and agreed.
- **Risk/harm/cost versus benefit considerations:**²⁹ these should be discussed for each option. Clinicians should always remember that what you tell a patient before treatment is sound professional advice; what you tell them after treatment is viewed as an excuse. The clinician should be absolutely candid and unambiguous about the details and potential risks of treatment, even if such information causes the patient to decline treatment. The patient should be fully aware of the potential **risks** or **harms** associated with both the orthodontic treatment (e.g. decalcification, root resorption) and any concomitant multidisciplinary care. The **cost** of treatment does not equate to monetary cost in the UK National Health Service (except for long-term costs of replacing retainers, and the potential financial implications of parents taking time off work to accompany their children to appointments), but to the imposition of treatment on a patient's daily life (see 'treatment burden' in following paragraphs); in other words, the **inconveniences** and **sacrifices** required of the patient in undergoing treatment, both in terms of **social costs** (e.g. time off school, university or work, the potential social impact of having fixed orthodontic appliances on a long-term basis, the extra effort required in maintaining a very high standard of oral hygiene, and avoidance of certain dietary products due to having an orthodontic appliance) and **emotional costs** (e.g. the effect of initial worsening of the appearance with some forms of treatment such as Class III preparation for orthognathic surgery, or possible psychological effects such as the potential anxiety of having treatment). Only when the balance between risks/costs and benefits has been discussed unequivocally with the patient and the proposed treatment has a high likelihood of success should treatment proceed.
- **Shared decision-making:** this concept refers to an approach where clinicians and patients share the best available evidence when faced with the task of making decisions, and where patients are supported to consider options in order to achieve informed preferences.³⁰ This concept rests on supporting a process of deliberation for the patient, and on understanding that decisions

should be influenced by exploring and respecting what matters most to patients as individuals. It also rests on the clinician accepting the core principle that individual self-determination is a desirable goal in which clinicians need to support their patients. This makes good communication skills mandatory as patients' abilities to assimilate potentially esoteric information or conceptualise different outcomes from different treatment approaches will be variable. The process of shared decision-making is difficult for many reasons, including limitations of the evidence base, challenges in comparing diverse outcomes, and the time needed to have these discussions. The wide spectrum of harms and benefits of importance to a patient should be discussed, including **treatment burden**. Treatment burden, sometimes referred to as 'patient burden',³¹ is a concept initially described in relation to respondents involved in health survey research.³² In the context of orthodontics, treatment burden may be defined as the patient's subjective experience of hardship from the psychological, physical, and economic effects of undergoing treatment. Occasionally, in their desire to do the best for patients, and with clinical experience of successful comparable treatment on previous patients, clinicians may inadvertently bias the patient's decisions by emphasising the uncertainty related to risks/harms while implying certainty around benefits. This may contribute to a tendency for patients (and sometimes clinicians) to perceive treatment predominantly in terms of benefits, with reduced emphasis of potential risks. However, the purpose of shared decision-making combined with patient autonomy is missed if patients are not provided with accurate unbiased information. The language used by a clinician will guide the patient's decision, and behavioural science has demonstrated that even minor changes in language or framing can significantly alter judgements and decisions.³³ Therefore, it is incumbent upon clinicians to avoid medical jargon when communicating with patients, and to discuss the pros and cons of any viable option carefully. 'True consent' has been defined as 'the informed exercise of choice, and that entails an opportunity to evaluate knowledgeably the options available', which includes 'the degree of harm threatened' and the 'potential benefit of the therapy'.³⁴

In orthodontic treatment, involvement of the patient/parents in the decision-making process has the added

advantage that the patient will feel that they have some responsibility in the treatment process and the necessary effort required on their part, which may help in compliance with treatment.

Having provided all these explanations, the clinician needs to be certain that the patient has the capacity to provide **valid consent**. It should be evident to the clinician that:

- the patient is able to understand and retain the information provided
- the patient is able to use and weigh the information in the decision-making process.

At this stage it is worth providing the patient and parents with validated information leaflets, such as those designed by the British Orthodontic Society, and giving them time to consider their options. At the following appointment, following further discussion and answering any questions the patient may have, if these conditions have been satisfied and the patient has selected their treatment of choice, their option becomes the **definitive treatment plan**.

What Should be Included in a Treatment Plan

Table 1.3 considers the most pertinent factors to be included in the definitive treatment plan.

Treatment Mechanics

The approximate sequencing of the treatment and technical details (e.g. archwire sequencing, tooth movements and mechanics required to achieve them at each visit) constitutes the final stage of treatment planning. This is a very important exercise, particularly for trainees. It forms the step-by-step framework that the clinician will follow, and is able to refer back to, throughout the treatment process. As with any specialty dealing with human biology, alterations may be required during treatment; for example, a plan to align an impacted maxillary canine will change if the tooth becomes ankylosed during treatment. Nevertheless, a well thought out and logical plan can usually be followed reasonably well, albeit with some modifications, throughout the treatment process.

Table 1.3 What to include in the definitive treatment plan.

Factors	Relevance
Resolving dental health issues	This should be undertaken prior to instigating orthodontic treatment: • Oral hygiene and gingivitis • Periodontal problems • Dental caries • Trauma, e.g. vitality testing, root canal treatment if required • Cessation of habits (e.g. digit sucking, nail biting)
Aims of treatment	Facial aesthetic aims: • Effect of molar extrusion/intrusion on lower anterior face height • Effect of incisor protrusion/retrusion or proclination/retroclination on sagittal lip prominence and lip posture • Comprehensive aims will be discussed for orthognathic treatment Smile aesthetic aims: • Inclination of the maxillary incisor labial crown face tangent (in profile smiling view and frontal view) • Lip–incisor relationship: particularly if intrusion of the maxillary incisors is contemplated, as incisor exposure will reduce Dental–occlusal aims: • Incisor relationship • Canine relationship • Buccal segment relationship • Arch forms Dental aesthetic aims: • If tooth morphology is to be altered (e.g. lateralisation of maxillary canines, or build-ups of narrow maxillary lateral incisors) • Any required restorative/prosthetic treatment (e.g. prosthetic replacement of missing maxillary lateral incisors)
Growth estimation and treatment timing	If growth-dependent treatment is planned (e.g. functional and dentofacial orthopaedic appliances), these should be timed to coincide with the maximal pubertal growth spurt (see section Relevance of Growth and Growth Estimation)
Methods of space creation	Increasing arch length: • Incisor protrusion or proclination • Distal movement of molars/buccal segments Transverse arch expansion Interdental enamel reduction Dental extractions: which teeth and why, based on dentofacial aesthetics and dental–occlusal space analysis
Timing of extractions	If dental extractions are planned, should they be removed before placement of fixed appliances, ensuring minimal or planned space loss? Is anchorage reinforcement required prior to dental extractions? Is therapeutic diagnosis planned, i.e. begin alignment on a non-extraction basis and decide on necessity of dental extractions during treatment?
Type of appliance(s)	Removable appliances: • Anterior bite plane to aid bonding of the lower arch in deep overbite malocclusions • Expansion of the maxillary dental arch Functional appliances: • For sagittal dental arch improvement as an aid to the proposed fixed appliance treatment Fixed appliances: • Labial (stainless steel, ceramic, gold) • Self-ligating • Lingual • Other (e.g. Begg or Tip-Edge appliances)

Table 1.3 (Continued)

Factors	Relevance
Bracket prescription	Which bracket prescription is planned for use, and why? Advantages and disadvantages in relation to the particular case?
Bracket variations	Are any bracket variations planned, and if so, why? For example: • Inverting maxillary lateral incisor brackets if in-standing • Contralateral mandibular canine brackets in Class III camouflage cases Additionally, will a particular bracket from another appliance or prescription be required for a specific task?
Archwire sequence	The approximate archwire sequence should be planned, including the aims of treatment with each wire (e.g. alignment, sliding mechanics, retraction vs. retroclination, space closure)
Special mechanics	Examples include the use of: • Orthodontic mini-implants/ temporary anchorage devices (TADs) • Headgear • Sectional mechanics, e.g. Burstone or Ricketts arches
Retention (type and duration)	Type: • Removable retainers (e.g. Hawley, Essix-type vacuum-formed, Begg, Barrer spring-loaded) • Fixed (bonded) retainers, which teeth and in which arch? Why is a fixed retainer required? Usually provided for tooth movements known to be prone to relapse, and are usually in addition to, not instead of removable retainers Duration: • How long full-time wear is required • When part-time wear may be instigated • Overall duration of wear (usually advised long-term wear will be required)
Regular dental and hygiene visits during treatment	This should be agreed with the patient and dentist/hygienist prior to instigating treatment. Patients must understand the importance of regular monitoring of dental health by their dentist throughout orthodontic treatment, as occasionally patients incorrectly assume that dental check-ups are not required when they are undergoing orthodontic treatment
Oral hygiene	Maintenance of oral hygiene at a high level is expected throughout treatment, and its importance must be relayed to the patient The outcome of poor oral hygiene, including potential early cessation of treatment, should be explained to the patient and parents/carers
Timing of input from other specialists	The timing should be considered prior to instigating fixed appliance treatment, ideally by seeing the patient jointly with the appropriate specialist. Examples include: • Combined orthodontic–restorative/prosthetic treatment for missing teeth • Combined orthodontic–periodontal/implantologist treatment (e.g. creating ridge thickness for placement of dental implants) • Combined orthodontic–endodontic treatment to aid either specialist • Combined orthodontic–oral surgical treatment (e.g. surgical removal of teeth, surgical exposure of teeth, frenectomies) • Combined orthodontic–maxillofacial surgical treatment for orthognathic patients
Multidisciplinary care	Complex treatments requiring multidisciplinary care (e.g. orthognathic, cleft or craniofacial care) must be with an appropriately trained multidisciplinary team, and the input from each specialist should be planned prior to treatment
Limiting factors to treatment	Patient-related limiting factors: • Medical problems • Dental health problems • Age: if contemplating dentofacial orthopaedic treatment • Compliance: does the patient desire treatment or are they going along with their parents' wishes? Will they look after the appliances, wear elastics, etc? Malocclusion-related limiting factors: • Severe skeletal discrepancy in patients not desiring orthognathic surgery may be difficult to correct with camouflage treatment • Tooth size discrepancies, when present, may create difficulties in obtaining an optimal occlusion

(Continued)

Table 1.3 (Continued)

Factors	Relevance
Mouthguards	These are required for anyone playing contact sports, and appropriate sports mouthguards are available that protect the patient's soft tissues during sport but do not interfere with orthodontic tooth movement
Wind/brass instrument players	Wind instrument players may be reassured that orthodontic treatment is possible, but must be made aware that there will be some initial difficulties in creating an embouchure, and they are likely to require wax placement over their appliances, at least initially Those playing at a high level or with examinations approaching may wish to delay placement of fixed appliances to a more appropriate time
Correspondence with GDP and GMP	It is important for the clinician to maintain correspondence with the patient's GDP regarding the proposed plan and their part in it (e.g. timing of dental extractions). This is also true for the GMP if there are any underlying medical problems that need to be addressed or kept under observation

GDP, general dental practitioner; GMP, general medical practitioner.

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