Recognizing and correcting developing malocclusions
A problem-oriented approach to orthodontics
Dedications

To my family, particularly my wife Teresa, my orthodontist-daughter Kika and my son Chico for the support and constant inspiration. To my parents, especially my father who, through his example, led me into dentistry. And to each of my mentors, alumni from PUCMinas and SLU, present residents, colleagues, and to each one of my patients who helped me to become a better clinician and professor. Also to Drs. Orlando Tanaka, Jose Mauricio and Roberto Vieira for their help and friendship.

Eustáquio Araújo

Also to my family, particularly my wife Joyce, whose support and wisdom has sustained me. And to the orthodontic faculty, alumni, and residents that I have been privileged to work with – they have helped me to see the way. Together, they have made it all worthwhile.

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Orthodontic educators are often confronted by loaded questions where the questioner really just wants to know if his/her biases are shared by the educator. One of the most common questions is: “Do you teach early treatment to your students?” From experience, I know that the answer either lines up with the questioner’s bias and a conversation of great agreement will follow, or the answer does not line up with their bias and a conversation of great disagreement will follow, so I prefer to provide neither expected answer, but instead aim to stimulate thought. So my answer might well be “Yes, we teach early treatment and late treatment and also very early and very late treatment. We also perform 1-phase treatment, 2-phase treatment, 3-phase, 4-, 5-, 6-, 7-, 8-, and even 9-phase treatment . . . or more, if need be.”

Of course, this answer is very perplexing and I am asked to explain what I mean – which I am happy to do. To provide support to my answer, I provide several examples. For one of these, I talk about a study that was performed long ago by a former graduate student named Greg Dyer [1]. He took a sample of treated adolescent females and a similar sample of treated adult females and compared the outcomes of the treatments performed. Importantly, in the adolescent group he found that growth provided 70% of the correction (i.e. the mandible outgrew the maxilla) while only 30% of the correction was due to tooth movement. In the adult sample, the growth was nil, or in some cases the maxilla outgrew the mandible and the amount of tooth movement that was necessary to correct the malocclusion was 119% – that is, the practitioner had to do all the work, and more, to make up for the poor growth, in order to correct the problem. For me, this is ample evidence that it is better to treat early (as an adolescent) as opposed to late (as an adult) in this particular situation. This example points to the meaning of my response to the question posed initially. It is not whether I am biased so that I believe only in early treatment or only in late treatment as a single choice that must be made, but rather it is that the question can only be answered in the context of the situation that is presented. In this example, my answer would be to treat early (in this case, adolescence) when you are confronted by a Class II female adolescent; don’t wait till they become adults.

In the case of treatment performed in multiple phases, again it is the context of the patient’s situation that dictates what to do. There is plenty of research and clinical experience available that suggests that a cleft palate patient is best treated early and often over many years, according to the many types of treatments that are arranged across many phases. There are also questions as to how many phases of treatment should be involved in an orthognathic surgery case.

So, the point that I am trying to make is that it matters little whether a practitioner “believes” in early treatment or not, and it makes little difference whether the practitioner “believes” in single-phase treatments or some other number of phases. What really matters is that the practitioner evaluates the condition that the patient presents, and then applies the best available evidence to the situation in deciding if, when, and how the treatment should rendered. To believe otherwise suggests that the doctor can decide the approach before even seeing the patient. But, adopting a prefabricated approach is seldom the best choice because patients are all custom-made.

What follows in the pages to come is blended (some old, but mostly new) information concerning genetics, normal, and abnormal growth of the craniofacial skeleton, and the development of the occlusion. Such information will form the basis for understanding and determining the timing of treatment.

You will also find important information on the construction of a diagnosis, treatment plan, and estimation of prognosis, all based on available diagnostic records produced by both old and new technologies. All three types of Angle classes will be considered in terms of development, etiology, and treatment; that is the meat of this book.

Finally, information will be provided with regard to certain overriding topics such as biomechanics, and what might be considered “orphan topics” including problems.
attendant to abnormal eruption, function, aesthetics, congenitally missing teeth, autotransplantation, and habits.

So, how is this book different from previous books on the topic of early and preventive orthodontic treatment? Considering the comments made earlier in this preface, this book is based on available evidence, not bias, passion, or faith; it is meant to make you think and then apply what is proven. This book is also different in that the authors are very knowledgeable each in their own areas, and each is cognizant of the value of current science and the knowledge that science generates.

Those readers who are open to the development of new information and new ideas should enjoy and embrace the knowledge and direction contained within. For those who are very biased in their thoughts and actions, do not be afraid to read this book; it will open your mind and help you adjust your thoughts and actions in a positive way.

Have a good read; I think you will find it worth the effort in terms of thought and then reasoned actions that will prove beneficial to your patients.

Reference


Rolf G. Behrents
When the decision was made to work on this book, the heavy responsibility of embracing the topic without bias or radicalism increased. Clinicians and academicians were initially consulted and asked to provide questions that would help to establish priorities for early interventions. The responses came rapidly and contained all the sorts of questions one would imagine. Recognizing and Correcting Developing Malocclusions will try to address the collected questions and themes.

The term “early treatment” has been used for a long time, and it seems now to be fixed. Although “early” could suggest “too soon,” for the sake of practicality it will be used in this book. The text will eventually also refer to timely or interceptive treatment.

Initiating orthodontic treatment during the growth spurt was often used to be considered as the “gold standard” for treatment timing. The pendulum that regulates the initiation of orthodontic treatment has been swinging in different directions for many years. At present, this balance seems to have been shifting, as the pendulum appears to be swinging toward an earlier start, preferably at the late mixed dentition. The possibility of successfully managing the E-space has dramatically influenced the decision-making on the timing of orthodontic treatment [1].

At the beginning of the 20th century, some consideration was given to early treatment. A quote from Lischer [2] in 1912 says,

Recent experiences of many practitioners have led us to a keener appreciation of the “golden age of treatment” by which we mean that time in an individual’s life when a change from the temporary to the permanent dentition takes place. This covers the period from the sixth to the fourteenth year.

Soon after, in 1921, a publication [3] titled “The diagnosis of malocclusion with reference to early treatment,” discusses concepts of function and form, and gives notable consideration to the role of heredity in diagnosis – so the topic with its controversies is an old one.

“The emancipation of dentofacial orthopedics,” an editorial by Hamilton [4] supports early treatment. In summary, he states that:

a healthcare professionals must do everything possible to help their patients, including early treatment;

b it is irresponsible and unethical to prescribe treatment for financial betterment and for the sake of efficiency;

c if the orthodontist is not willing to treat patients at a young age, others in the dental profession will, and it is in the patients’ best interest that we, as specialists, treat these patients. After all, our flagship journal includes “Dentofacial Orthopedics” in its title;

d it is the highest calling of healthcare professionals to incorporate prevention as a primary means of treatment, and therefore early treatment is important;

e pediatric dentists and other health professionals are incorporating early treatment in their practice because orthodontists are waiting too long to initiate treatment;

f orthodontic programs have the responsibility to educate orthodontists about early treatment.

On the other hand, Johnston [5] indicates in “Answers in search of questioners” that:

a little evidence exists that two-phase early treatment has a significantly greater overall treatment effect compared with treating in one phase and considering E-space preservation;

b treatment aimed at the mandible typically has an effect on the maxilla;
Chapter 1

Early treatment is not efficient for the patient or doctor and results in an increased burden of treatment; functional appliances do not eliminate the need for premolar extraction, as bone cannot grow interstitially and arch perimeter is not gained with their use; patients occasionally endure psychological trauma due to dental deformity, but these isolated instances are not enough to “support what amounts to an orthodontic growth industry.”

In an effort to establish grounds to initiate treatment earlier or later we must try to answer two key questions:

1. Should developing problems be intercepted and treated in two phases?
2. Which malocclusions should receive consideration for treatment at an early age?

Undoubtedly, there is much agreement on what to treat, but there is still great disagreement on when to intervene.

What are achievable objectives for early treatment? Some of the most relevant ones are using growth potential appropriately, taking advantage of the transitional dentition, improving skeletal imbalances, eliminating functional deviations, managing arch development, improving self-esteem, minimizing trauma and preventing periodontal problems.

Among possible advantages are higher compliance, emotional satisfaction, growth potential, the possibility of a more simplified second phase, a possible reduction of extractions in the second phase and, of course, issues related with practice management. Disadvantages also exist such as inefficiency, extended time of treatment, immaturity, inefficient oral hygiene, inability to take care of appliances, and cost. It is important for the orthodontist to weigh each of these benefits and risks to offer sound evidence and convincing reasoning for their decision to treat or not to treat. In this chapter a guide to timing orthodontic treatment is presented.

The ideal timing for treating malocclusions in growing patients has been a controversial and widely discussed topic throughout the history of orthodontics [1,6–10]. One of the most important debates in our field is whether to interrupt the development of problems with early treatment or to postpone therapy until later [1,9]. Such controversies are likely due to the lack of a scientific basis for therapeutic clinical decisions [8]. Historically, dentistry has been an empirical science. Even today, most dentists choose to employ solutions and techniques that were first learned in dental school, or those that they believe will work [1,9]. In such cases, there is a high probability of treatment failure or a low-quality treatment outcome.

During the search for excellence in orthodontics, the concepts of effectiveness and efficiency have been emphasized [1]. Orthodontic clinical decisions should be scientifically based. Accordingly, treatment must be postponed until strong arguments in favor of beginning the therapy are present [9].

A follow-up protocol in which patients are re-examined periodically during growth and the development of occlusion allows the clinician to decide whether the cost/benefit of early treatment is justifiable. At this time, the program “preventive and interceptive orthodontic monitoring,” or simply PIOM, as devised by Souki [11] is introduced.

Conceptually, PIOM is a program of sequential attention that aims to monitor the development of “normal” occlusion and seeks to diagnose any factors that may compromise the quality or quantity of orthodontic treatment and the establishment of an appropriate occlusion. Seven objectives govern PIOM:

1. Provide prospective monitoring with a minimal intervention philosophy;
2. Provide comprehensive orthodontic care with functional and aesthetically harmonious adult occlusion as the ultimate goal;
3. Establish parameters so that orthodontists are not in a hurry to start treatment but are able to have a deadline to complete treatment;
4. Establish scientific parameters as guidelines for beginning therapy at each stage of maturation;
5. Respect the normal range of occlusal development;
6. Reduce dependence on patient compliance;
7. Delay phase II, if possible, until the time when second permanent molars can be included in the final occlusion.

During the years that separate the eruption of the first deciduous tooth and the full intercupation of the second permanent molars, many morphogenetic influences and environmental factors act on the maturation of the dental arches and the occlusal pattern. Therefore, human occlusion should be viewed dynamically.

Clinicians must understand that during occlusal development, there is not just one line of ideal characteristics, but a wide range of normal characteristics. In the mixed dentition a larger variety of normal characteristics compared to the deciduous and permanent dentitions is encountered. Knowledge of normal features of occlusal
maturation is important for the practice of orthodontics within PIOM. Throughout the history of medicine/dentistry, identifying signs or symptoms of a deviation from normal has been viewed as a situation requiring interceptive action. In lay terms, it has been thought that allowing a disease to evolve naturally (without therapy) may possibly make the disease more difficult to treat or even make it incurable [7]. This belief, when applied to orthodontics, may produce unnecessary interventions for occlusal characteristics that are totally within the range of normal (Figure 1.1), treatment of transitional deviations for which interceptive treatment (phase I) is not needed (Figure 1.2), and interceptive treatment before the appropriate time (Figure 1.3).

As mentioned previously, the orthodontist should focus on two key questions: the first deals with the ideal timing for interceptive orthodontics, incorporating the decision between one- or two-phase treatment, and the second hinges on identifying malocclusions that would benefit from an early intervention.

### 1.1 Occlusal deviations with indications for interceptive orthodontic treatment

Interceptive problems are those that, if not stopped during the course of their maturation, may become sufficiently severe to increase the complexity and difficulty of definitive treatment, compromise the final quality, or expose the individual to psychosocial conditions while waiting for a final corrective solution. Disagreements certainly exist among scholars regarding the clinical situations with indications for early orthodontic treatment. The list of issues presented by the American Association of Pediatric Dentistry [12] may serve as the starting point for this guideline. Based on their list, the following situations are suggested as candidates for early treatment: 1) prevention and interception of oral habits; 2) space management; 3) interception of deviations in eruption; 4) anterior crossbite; 5) posterior crossbite; 6) excessive overjet; 7) Class II

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**Figure 1.1** a) Eight-year-old boy during “ugly duckling” phase presenting labial-distal displacement of maxillary lateral incisors and a diastema between the central incisors. b) Same patient three years later without any orthodontic treatment. The incisors’ alignment and leveling were naturally achieved.

**Figure 1.2** a, b) Nine-year-old girl presenting deep bite and positive space discrepancy. Such transitional deviations (deep bite and positive space discrepancy) have no indication of interceptive orthodontics unless palatal soft tissue impingement is observed, or aesthetics is a major concern. c, d) Same girl five years later presenting significant natural improvements in the deep bite and space discrepancy with no phase I treatment.
malocclusion, when associated with psychological problems, increased risk of traumatic injury and hyperdivergence; 8) Class III malocclusion.

1.2 Ideal timing for early treatment

Several aspects must be considered by the clinician when deciding on the ideal timing for early treatment. Four basic considerations are: 1) psychosocial aspects; 2) the severity and etiology of the malocclusion; 3) the concepts of effectiveness and efficiency; 4) the patient’s stage of the development.

1.2.1 Psychological aspects

Psychological aspects are often neglected by orthodontists and unfortunately have not been routinely considered during the early treatment decision-making process [13,14].

At a time when bullying has been extensively discussed [15] and has been widely studied by psychopedagogues, clinicians must be constantly aware of the fact that, as providers, they can in many instances improve the self-esteem and quality of life (QoL) of their patients [16].

For many, the relationship between a patient’s well-being and his/her malocclusion, along with possible associated sequelae has been thought to be of only minor importance [17]. Consideration must be given to each patient’s QoL and the associated impact that postponement or avoidance of treatment may carry. Although somewhat vague and abstract, the concept of QoL is current and should be emphasized in orthodontics [18].

The literature provides evidence of an association between QoL and malocclusions. The methodologies of QoL studies, however, have not been homogeneous, and the samples are often constructed on the basis of convenience, making it difficult to offer a reliable analysis. The lack of randomized samples hinders the interpretation of the evidence [18,19].

Young people are motivated to seek orthodontic treatment because of their aesthetic dissatisfaction (13), referrals from dentists (20), parental concerns (13), and the influence of peers (21). Orthodontic treatment does improve QoL (19), but over time, the gain in QoL may be lost. When a malocclusion causes discomfort to a patient with the potential for generating a psychological imbalance (20), there is certainly an indication for early...
treatment (13), despite the fact that efficiency may be adversely affected [1].

1.2.2 Severity of the malocclusion
Malocclusions differ among patients presenting a wide range of severity. Therefore, it seems reasonable to think that, in infancy and adolescence, a mild malocclusion has a lower interceptive priority than a more severe one. For example, a posterior crossbite with mandibular shift (Figure 1.4) should have treatment priority as compared to malocclusions with minor shift or not associated with functional deviations. In the first scenario, the deviation can lead to asymmetric facial growth, making future therapy more complex [22]. There is less urgency for treatment of a single lateral incisor crossbite than a two-central-incisor crossbite, although there is a lack of evidence in the current literature (Figure 1.5). It must be understood that the severity of the malocclusion is not the only criterion for deciding on interceptive treatment. For example, if a Class III malocclusion is very severe in childhood, with skeletal components indicating that surgical correction may be required in the future, it is reasonable to consider delaying treatment until the end of growth to reduce extensive interceptive treatment [23]. In other words, in some situations, it is advisable to postpone the correction of the malocclusion until a single-phase orthodontic-surgical treatment can be undertaken. On the other hand, many other Class III malocclusions in children may benefit greatly from an interceptive approach [24,25].

1.2.3 Effectiveness and efficiency concepts
The decision on the best time for orthodontic treatment must also consider the aspects of effectiveness and efficiency [10]. Effectiveness is a concept that expresses the ability to effectively solve a problem. Will it work at all? How much improvement will be produced? This concept is important in the search for excellence in orthodontics. Orthodontic interceptive actions should be considered if there is evidence that the problem to be treated will, in fact, be solved by early treatment. If the problem is not intercepted, will it lead to a less acceptable final result or cause greater difficulty in obtaining a good result?

Efficiency is a formula that correlates result with time. How much time will be needed to achieve the goals? Will the financial, biological, and interpersonal burden be worth the outcome? In the contemporary world, the concept of efficiency has been an important criterion in deciding implementations of actions and services. If the cost–benefit of a phase I is unfavorable, should one consider the benefits of early orthodontic treatment?

Figure 1.4  a) Posterior crossbite with mandibular shift, b) Posterior crossbite with no mandibular shift.

Figure 1.5  a) Eight-year-old boy, Class I dental-skeletal pattern, presenting a single lateral incisor crossbite, b) Seven-year-old girl, Class I dental-skeletal pattern, presenting two central incisors crossbite. Because periodontal and growth impairments are more likely to happen in “b,” it is reasonable to infer that interceptive approach should be addressed urgently.
In summary, the treatment of malocclusions in children should be considered as an acceptable option if there is evidence that the outcome will add quality (effectiveness) and will be obtained with less effort (efficiency). Be sure to get the best result in the shortest amount of time possible.

1.2.4 Maturational stage of development

The orthodontist should consider several maturational aspects [26–28]. The presence of a minimal emotional maturity is essential for beginning any orthodontic procedure, even in patients with low-complexity malocclusions [29]. These considerations are essential to improve patient comfort [30] and to reduce the risk of accidents in young children. Thus, the cooperation of the child in the clinical examination becomes the first parameter used by orthodontists in judging the potential for early treatment. Depending on the child’s behavior and compliance, the clinician will decide if orthodontic records should be taken. Psychosocial maturity is normally associated with chronological age. The American Association of Orthodontists (AAO) in its brochure Your Child’s First Check-up recommends that children have a check-up with an orthodontist specialist no later than age 7. However, decisions about early treatment should be undertaken on an individual basis. Other parameters of maturity should also be considered. Assessment of the dental age should be made when intra-arch problems suggest early treatment. On the other hand, skeletal age should be used as a guide for the best time to intercept sagittal and vertical interarch problems [26,27].

In conclusion, it seems clear that a thorough consideration of all the factors described here will serve two purposes: 1) to determine whether or not early treatment is necessary; 2) to provide guidelines for determining when treatment should be initiated.

References

CHAPTER 2
Development of the occlusion: what to do and when to do it

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This chapter presents the rationale for preventive and interceptive orthodontic monitoring (PIOM) in relation to the seven stages of dental occlusal development. If occlusal development from the deciduous dentition until the end of the eruption of permanent cuspids and permanent second molars is correctly classified into stages, and if irregularities in each stage are identified, proper treatment decisions can be made in a timely manner. By the time that the permanent dentition is completed, deviations would have been adequately managed, respecting the contemporary concepts of effectiveness and efficiency. These stages (Table 2.1), if well understood and identified, represent a unique opportunity for rendering high-quality orthodontic care. While the chronological ages and developmental sequences may vary considerably among individuals, the anatomic entities are the foundations of occlusal management.

2.1 Stage 1 – eruption of deciduous teeth

Dental eruption is a biological process subject that is highly variable, both in sequence and in chronology [1]. The eruption of deciduous teeth into the oral cavity begins most often by the sixth month of postnatal life with the emergence of the mandibular central incisors (Table 2.1). At 30 months, all deciduous teeth will have erupted in approximately 70% of children, but a high degree of variation is likely to occur. At 14 months, both a child who has had no teeth erupted and a child who has all of their deciduous teeth in the oral cavity may be considered normal [2]. If a child has had no deciduous teeth erupted by 16 months, a radiographic investigation should then be performed.

An early eruption pattern of the deciduous dentition may indicate a tendency for an early transition between deciduous and mixed dentition [3]. Variations in the eruption sequence are very common but do not appear to cause significant disturbance in the development of the deciduous dentition, and are usually not important unless teeth erupt in an ectopic position and block the eruption of other teeth. This is rare at this stage of occlusal development. The most prevalent eruption sequences for the deciduous dentition are A, B, D, C, and E (2).

2.1.1 Biogenesis of the deciduous dentition

The biogenesis of the deciduous dentition can be divided into four phases:

Phase one comprises the eruption of the maxillary and mandibular deciduous incisors (Figures 2.1a and 2.1b). Due to the absence of posterior primary teeth, there is an excessive overbite, and the mandibular excursions are large. The immature anatomy of the temporo-mandibular joint (TMJ) favors this type of movement [4]. At this stage, the condyles are incipient, and the articular fossae are flat.

Phase two begins with the eruption of primary molars and their intercuspation (Figures 2.1c and 2.1d). This phenomenon promotes the first gain of the occlusal vertical dimension. Thanks to this upearing of the bite, there is a reduction in the excessive overbite. The occlusal morphology of the deciduous molars promotes the first occlusal reference and stimulates the morphological maturation of the TMJ [5].
Table 2.1 Clinical stages of occlusal development.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eruption of deciduous teeth</td>
</tr>
<tr>
<td>2</td>
<td>Completion of the deciduous dentition</td>
</tr>
<tr>
<td>3</td>
<td>Eruption of the first permanent molars</td>
</tr>
<tr>
<td>4</td>
<td>Eruption of the permanent incisors</td>
</tr>
<tr>
<td>5</td>
<td>Eruption of the mandibular canines and of the first premolars</td>
</tr>
<tr>
<td>6</td>
<td>Eruption of the second premolars</td>
</tr>
<tr>
<td>7</td>
<td>Eruption of maxillary canines and second molars</td>
</tr>
</tbody>
</table>

Phase three starts with the eruption of the deciduous canines (Figure 2.1e). This phase is important for the establishment and maintenance of the primate spaces. In the maxillary arch, the primate space is located between the lateral incisors and the canines. In the mandible, it is located between the canines and first deciduous molars [6]. The size of the primate spacing varies from less than 1 mm to 5 mm.

Phase four is marked by the eruption of the deciduous second molars (Figure 2.1f). This phase includes the consolidation of the primary occlusion and of the vertical dimension, initiated with the eruption of the first deciduous molar. This period ends with the intercuspation of all deciduous teeth, between the 30th and 36th months of life.

2.1.2 Dimensional changes of the dental arches at stage 1:
There is evidence [7] that significant gains in arch perimeter happen during the first two years of life (i.e. during the eruption of the deciduous dentition).

2.1.3 Management of occlusal development at stage 1:
The incidence of a malocclusion at this stage is very low; however clinicians should provide guidance to parents about the wide range of normality in regards to the chronology and sequence of tooth eruption. During the eruption of the deciduous dentition interceptive

Figure 2.1 Stage 1: Eruption of deciduous teeth.
orthodontic treatment is not indicated. Even when there is an early diagnosis of abnormalities in occlusal development, such as crossbites or space problems, it is recommended to wait until the deciduous dentition matures to decide on the best therapeutic approach. Radical attempts to encourage the abandonment of thumb sucking are not needed at this time. The use of a pacifier is acceptable during most of this stage in the vast majority of children, since there is no permanent damage to the occlusion [8]. There is evidence that suppressing the pacifier at the end of this stage (approximately 2–3 years of age) will permit self-correction of dentoalveolar sequelae [9]. When dealing with late pacifier use, a closer evaluation of the patient’s skeletal pattern should be implemented. A pacifier in a hypodivergent subject may be much less harmful than in a hyperdivergent one [10].

During Stage 1, clinicians should also be able to detect mouth breathing. Upper airway obstruction by adenotonsillar hyperplasia may disrupt the harmony of facial development in this age group. There is evidence that breathing patterns should be normalized during the first 4 years of life, when 60% of facial growth is attained.

2.2 Stage 2 – completion of the deciduous dentition

Although it is sometimes overlooked because only the deciduous teeth are present, occlusal normality during this stage favors the development of a good permanent dentition. However, even in Stage 2, a child with a normal occlusion has a significant chance that irregularities in the following stages of development may still occur. Figure 2.2 provides a panoramic radiograph and

Figure 2.2 Panoramic radiograph of 3-year-old child.

Figure 2.3 Normal characteristics of the deciduous dentition.

Figure 2.3 an intraoral view of a child with a normal occlusal relationship at this stage.

Most frequently, this stage includes children from 3 to 6 years of age. At the earliest part of Stage 2, immediately after the eruption of the deciduous second molars, diastemas are usually present between the crowns of these teeth and the adjacent deciduous first molars (Figure 2.4a). However, over the coming months, this physiological spacing tends to disappear, depending on the natural mesial migration of the maxillary and mandibular deciduous second molars, which drift as a response to the development of the adjacent first permanent molars (Figure 2.4b). The child at the end of the deciduous dentition (approximately 6 years of age) has no more spacing between the deciduous teeth except for the incisors in a Baume Type I occlusion (Figure 2.4c). There is a marked reduction of the arch perimeter. Generally, there is no crowding in the late deciduous dentition [11]. Spacing in the anterior region during this stage, however, is highly desirable considering that the succedaneous permanent incisors have a greater mesio-distal diameter and need room to be aligned [12].
Figure 2.4  Interdental spacing closure in the deciduous dentition.

Table 2.2, based on charts from white North American boys [13], provides the average diameter of the deciduous and permanent incisors and provides a comparison between the average values for each dental unit and for the entire incisor region. The negative sign indicates a negative balance resulting from the larger size of the permanent teeth.

According to Baume [14], deciduous arches may or may not have generalized interdental spacing. Both forms are considered normal [6]. However, in dental arches with physiological or developmental spacing, known as Type I, a transition to mixed dentition with a lower risk of space deficiency is more likely to occur [12].

Deciduous teeth roots in their bony bases are nearly perpendicular, and the dental crowns are vertically positioned with no buccal-lingual angulation. Therefore, during deciduous dentition, the interincisal angle is close to 180°. In the posterior region, the curve of Wilson does not exist, and the curve of Spee is flat to mild [11]. Light to moderate abrasion wear on the incisors is considered normal in deciduous dentition [15].

Currently, the relationship of the deciduous cuspids has been used as the major reference for sagittal classification during this stage of development [6,16]. The occlusion is considered normal when the long axis of the deciduous maxillary cusp is in the direction of the

Table 2.2  Mesiodistal measurements of deciduous and permanent incisors, discrepancy of the size of deciduous vs. permanent incisors, and anterior segment discrepancy.

<table>
<thead>
<tr>
<th>Arch</th>
<th>Incisor</th>
<th>Deciduous Mean size (mm)</th>
<th>Permanent Mean size (mm)</th>
<th>Deciduous vs. permanent tooth discrepancy (mm)</th>
<th>Anterior segment discrepancy (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary</td>
<td>Central</td>
<td>6.41 ± 0.43</td>
<td>8.91 ± 0.59</td>
<td>-2.50</td>
<td>-8.24</td>
</tr>
<tr>
<td></td>
<td>Lateral</td>
<td>5.26 ± 0.37</td>
<td>6.88 ± 0.64</td>
<td>-1.62</td>
<td></td>
</tr>
<tr>
<td>Mandibular</td>
<td>Central</td>
<td>4.06 ± 0.35</td>
<td>5.54 ± 0.32</td>
<td>-1.48</td>
<td>-5.36</td>
</tr>
<tr>
<td></td>
<td>Lateral</td>
<td>4.64 ± 0.43</td>
<td>6.04 ± 0.37</td>
<td>-1.40</td>
<td></td>
</tr>
</tbody>
</table>

Based on charts of white North America boys, extracted from Moyers (13)
interproximal surface of the lower deciduous first molar and lower deciduous cuspid (Figure 2.3). This relationship is called normo-occlusion. Analogous to the classification suggested by Angle for the permanent dentition, this occlusal pattern is clinically known as a “Class I canine relationship.” The prevalence of a normal sagittal relationship, characterized by the key deciduous canines, is approximately 80% [8]. A 0 mm to 3 mm overjet during Stage 2 is considered normal [6].

A normal transverse relationship is characterized by a positive overjet of the buccal cusps of the deciduous molars relative to the same cusps of the lower arch and the palatal cusps of the deciduous molars resting in the pits of their antagonist lower molars. The palatal surfaces of the upper deciduous canines maintain occlusal contact with the buccal surface of the deciduous canines and the first deciduous molars.

There is a wide range of normality for overbite in Stage 2. Overbites of 3/4 the incisal coverage as well as an edge-to-edge bite are considered normal. In this period, due to the high prevalence of non-nutritive sucking habits, the prevalence of an anterior open bite tends to be higher [17].

### 2.2.1 Dimensional changes in the dental arches at stage 2:

Evidence indicates that, in most children, the deciduous maxillary and mandibular arch length and perimeter undergo a small reduction between 3 and 6 years of age [18]. Conversely, some investigators have found that the arch length of the deciduous dentition does not decrease, whereas Baume [14] reported an 89% and an 83% rate of maxillary and mandibular change or sagittal decrease respectively. No increase in the length of the arch during this developmental stage of occlusion was observed.

The deciduous dental arch width, measured at the intercanine and intermolar distances, is reported to be stable during Stage 2 [18,19], but transverse changes from the ages of 4 to 6 were found in other studies [13].

#### 2.2.2 Management of occlusion development at stage 2:

During this period several factors may contribute to malocclusion exposing children to the risk of developing occlusal abnormalities. Table 2.3 presents a synthesis of the preventive and interceptive orthodontic procedures recommended for each of the seven stages of occlusal development.

- **Oral habits:** Mouth breathing habits should be evaluated, and a referral to an ENT should be provided. Figure 2.5 illustrates a 3-year-old girl immediately before adenotonsillectomy and 48 hours after surgical airway clearance. There was a marked improvement in the muscular facial balance with the normalization of the breathing pattern.

As with other controversial issues, any extreme decision on sucking habits is not correct [9,10]. Clinicians should recognize the individual variations among children and their sucking habits and should be aware

**Table 2.3** Orthodontic interceptive procedures and their indication in each of the 7 stages of occlusal development, according to color-coded convention.

<table>
<thead>
<tr>
<th>Procedures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage oral habits</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space maintenance</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space regaining</td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space creation</td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior crossbite</td>
<td></td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior crossbite</td>
<td></td>
<td></td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class II malocclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class III malocclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✅</td>
<td></td>
</tr>
</tbody>
</table>

- Yes
- Maybe
- No
that some children do, in fact, rely on digit sucking for emotional support and security, whereas others find it a meaningless and empty habit that can be discontinued without psychological trauma [20].

Bruxism in this stage is also frequently noted and should be a problem only if excessive tooth abrasion is identified (Figure 2.6a). A small amount of occlusal wear on the deciduous teeth may be considered physiologic (Figure 2.6b).

- **Space maintenance:*** When only the first deciduous molar is lost, space maintenance can be accomplished with simple fixed or removable devices. However, when early loss of a second deciduous molar occurs before the eruption of the adjacent first permanent molars, therapeutic options are limited, and the prognosis is less favorable. In the anterior region, from the perspective of space maintenance, there is no need to install removable or fixed devices if the loss of one or more incisors occurred after the eruption of the primary canines [22]. The early loss of deciduous canines at this stage is rare; in the event that it occurs, any intervention, if considered, has to be carefully planned.

- **Space regaining:** Premature loss of a deciduous first molar most likely allows the mesial drifting of the adjacent deciduous second molar, resulting in loss of the dental arch perimeter. Space regaining with fixed or removable appliances should be considered.

- **Space creation:** Permanent incisors require more space than their deciduous predecessors (Table 2.2). In the absence of interdental spacing of the deciduous incisors, a significant arch development may be necessary to avoid crowding in the anterior region during the transitional stage. However, there is no scientific evidence to prove the effectiveness of deciduous arch development with orthodontic or orthopedic techniques.

- **Anterior crossbite:** Anterior crossbites may interfere with normal skeletal growth, as well causing tooth abrasion and gingival recession. Early treatment is usually indicated [21] with the objectives of reestablishing a normal development and preventing traumatic injury (Figure 2.7). Patient maturity and compliance is the key in deciding when to intercept an anterior crossbite.

- **Posterior crossbite:** It is recommended to eliminate occlusal interferences (prematurities) that lead to mandibular anterior and lateral shifts (Figure 2.7). The literature indicates that posterior crossbites should be treated, if possible, as soon as detected, taking advantage of the immaturity of the midpalatal suture.

- **Class II malocclusion:** At this stage, in general, an interceptive treatment for a Class II malocclusion is not recommended. However, in very selected cases of severe mandibular micrognathia with a medical recommendation for mandibular advancement, the orthodontist may be part of the team responsible for

![Figure 2.5](image1.png) **Figure 2.5** A 3-year-old mouth-breathing girl. a) Night before adenotonsillectomy, b) 48 hours after airway normalization.

![Figure 2.6](image2.png) **Figure 2.6** Bruxism in the deciduous and early mixed dentition. a) Severe abrasion, b) Moderate abrasion.
performing a therapeutic intervention, particularly when there is evidence of sleep apnea (OSA). The efficiency of such an intervention is questionable at this stage of skeletal maturation.

- **Class III malocclusion**: Depending on the emotional maturity of the patient there are strong indications for early treatment of Class III malocclusions at this stage (Figure 2.8). Chapter 7 describes procedures that may be implemented.

### 2.3 Stage 3 – eruption of first permanent molars

Generally, the mixed dentition begins with the eruption of the mandibular central permanent incisors. The mandibular first permanent molars erupt at about the same time, followed by their maxillary counterparts, although it is common to observe the first permanent molars erupt before the lower central incisors. These sequences do not seem to convey clinically significant differences. The eruption of the permanent incisors and first molars is known as the first transitional period. For didactic reasons, this chapter will presume that the first permanent molars erupt first. Although the average age for the eruption of the first permanent molars is 6 years, the normal range is ages 4 to 8.

The first permanent molars are added to the deciduous dentition utilizing the space created by appositional growth distally to the second deciduous molars. At birth, the lower first permanent molar is located near the junction of the mandibular corpus and ramus, with the crown mesially inclined. In very young children, the upper first permanent molars are located in the maxillary tuberosity, with the crown distally tipped. During the process of eruption, the maxillary first permanent molars gradually incline mesially and are guided by the distal surfaces of the second deciduous molars to their final occlusion.

Thus, it is generally agreed that the pattern of the terminal plan of the deciduous second molars is of paramount importance in the early intercuspation of the first permanent molars. However, as mentioned in Stage 2, the analysis of the terminal planes of the deciduous molars should be evaluated along with the deciduous canines’ relationship.

The eruption of the first permanent molars coincides with the juvenile growth spurt [23] and with the second physiological gain in the vertical dimension of the occlusion.

Normal occlusion during Stage 3 most often has the following characteristics: a Class I relationship or a cusp-to-cusp sagittal relationship of the first permanent molars; a Class I relationship of the deciduous canines; an overjet of 0–3 mm; an overbite ranging from edge-to-edge to 3/4 incisal coverage; and a normal transverse interarch relationship.

#### 2.3.1 Management of occlusion development at this stage

- **Oral habits**: same as Stage 2.
- **Space maintenance**: After the first permanent molar eruption, it is easier to install fixed space maintainers supported by these teeth.
- **Space regaining**: Ectopic eruption of the maxillary first permanent molars is quite common. A detailed
description on the management of this deviation is given in Chapter 8.

- **Space creation:** Not indicated in this stage.
- **Anterior crossbite:** Same indications as in Stage 2.
- **Posterior crossbite:** Same indications as in Stage 2. However, after the eruption of the first permanent molars, regardless of whether the permanent incisors have erupted or not, a critical appraisal of the posterior crossbite should be performed to determine whether or not maxillary permanent first molars need to be incorporated in the appliance (Figure 2.9a). If no functional deflection is observed, or no transverse growth restriction is detected in the deciduous canines area, the crossbite correction limited to the first molar can be postponed (Figure 2.9b).
- **Class II malocclusion:** No treatment may be indicated at this stage as the effectiveness will not be greater than if done at a later time, and the efficiency is less. Treatment is indicated only when there are psychosocial concerns or a high risk of trauma to the incisors.
- **Class III malocclusion:** Same indications as in Stage 2.

### 2.4 Stage 4 – eruption of permanent incisors

During the first transitional period, there is the exchange of the deciduous for the permanent incisors. The first transitional period lasts approximately 2 years (6–8 years of age). Then, an intermediate rest period occurs, lasting approximately two years. Some children experience a longer intermediate period.

While in the previous three stages deviations from an “ideal” position of the teeth were less frequent, during Stage 4 the incidence of deviations from the “ideal” is very high. It is important to note that although the term “normal” development means “naturally occurring,” during this stage some malpositioning of the incisors may be considered normal, and “ideal” occlusion would be difficult to find. Understanding the mechanisms that lead to these deviations from ideal tooth positioning is essential for appropriate clinical management favoring observation rather than intervention.

The mandibular permanent incisors develop in a lingual position in relation to the predecessor deciduous teeth. During eruption, these teeth often emerge in a lingual position in the oral cavity. Due to this lingual eruption pattern, the roots of the deciduous incisors often may not be naturally resorbed, and natural exfoliation can be impaired.

During the eruption of the maxillary permanent incisors, they often participate in the root resorption of deciduous incisors and emerge with acceptable alignment in the oral cavity. But the maxillary lateral incisors may sometimes erupt palatally, particularly in patients with space deficiency.

During this stage, the maxillary incisors may have a distal crown angulation with the lateral incisors in particular more angulated. Earlier literature describes this positioning of the upper incisors as the “ugly duckling phase” (see Chapter 1 Figure 1.1). This dental compensation is a natural mechanism of the permanent incisors root structure protection from traumatic contact with the enamel of the adjacent erupting permanent canines. The closure of the diastema between the incisors, as well as a change in the inclination of the lateral incisors, tends to happen naturally during the eruption of the permanent canines (Stage 7).

In the mandible, however, the incisors are most frequently in proximal contact from the time of their eruption. The interincisor diastema is rarely observed. Some crowding is considered normal, and when the spacing in this region is generous, the clinician should suspect an oral habit.

### 2.4.1 Dimensional changes in the dental arches at this stage

It should be noted that the dental arch length of the mandible is stable, with no significant changes after the eruption of the first permanent molars and permanent incisors. However, there is a significant increase in the