Evidence-Based Clinical Orthodontics

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Dedication

This book is dedicated to our families, teachers, mentors, students, and in particular to our patients. More importantly, this book is dedicated to you, the reader, the present and future of orthodontics.

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In Memoriam

Dr Tiziano Baccetti (1966–2011)

Chapter 9 of this book, "The Effectiveness of Treatment Procedures for Displaced and Impacted Maxillary Canines," was written by Dr Tiziano Baccetti. This may well have been his last scholarly work; he completed this chapter just a few weeks before his untimely and tragic death on November 25, 2011, at the young age of 45. While posing for a photograph on a historic bridge in Prague, Czech Republic (he was the Keynote Speaker at the 9th International Orthodontic Symposium held November 24 to 26, 2011), he slipped on old stonework at the base of one of the saintly statues that decorate the bridge and fell 8 meters to the rocks below. It was the Charles Bridge—Ponte Carlo in Italian, the same name as Tizanio's beloved father, who knows that bridge well and for whom the picture was intended.

Tiziano authored over 240 scientific articles on diverse orthodontic topics. He has been described by those who knew him best as a "superman." This is supported by what he had accomplished in his short life. In 2011, Tiziano gave the Salzmann Lecture at the 111th Annual American Association of Orthodontists Session on "Dentofacial Orthopedics in Five Dimensions." In concluding his presentation, he explained how his grandfather in Italy had told him as a young boy that one day he would "find his America" and fulfill his dreams. Tiziano said at the end of his lecture, "I have found my America, fulfilled my dreams." Few, even with a long life, can say that they have fulfilled their dreams, their ambitions. We can be comforted that Tiziano did.

We feel fortunate that we can share Tiziano's excellent chapter with our readers.

Foreword

This text can serve as a reference guide for research and studies in many difficult clinical areas where there is a lack of evidence-based information. The distinguished editors are all involved in education, research, and practice, and they have invited other well-known experts and authorities to critically evaluate the literature and topics such as early treatment, extraction and nonextraction, Class III treatment, asymmetries, temporary skeletal anchorage devices (miniscrews), impacted canines, root resorption, temporomandibular disorders, retention, stability, and accelerated orthodontic tooth movement. These are all critical areas in the full scope of clinical orthodontic practice. I am sure that every orthodontist will learn from the enormous contributions provided so clearly in this text. The first chapter introduces and defines *evidence-based clinical practice*. Every other chapter provides evidence for and against each controversy and concludes with a summary and points to remember.

The topics are covered in detail with extensive illustrations, cases, diagrams, and references. All discussions are based on current research findings, and when evidence is not available, it is clearly stated as such. As the editors point out, the purpose of this book is to provide the orthodontist with an evidence-based perspective on selected important orthodontic topics and to stimulate practicing orthodontists to reflect on their current treatment protocols from an evidence-based view. In the future, clinical decisions should be based ideally on evidence rather than personal opinion, and treatment strategies should be proven to be both efficacious and safe.

I am very honored and privileged to have been asked to present this foreword because this text should be the evidence-based text for EVERY orthodontist and student.

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Preface

The specialty of orthodontics has evolved from an apprenticeship to a learned profession requiring academic training. Nevertheless, many in our profession still cling to biased beliefs and opinions rather than embracing evidence-based practice. When evidence conflicts with what experience has taught, it becomes even more difficult for such practitioners to change their views. Hence, there is complacency and resistance within the profession to adopt evidence-based treatments.

Most orthodontists experience at least enough treatment success to support a practice. Yet treatment success does not necessarily equate with treatment efficacy or even verification of an appropriate diagnosis. This success can be the biggest obstacle to change. Clinical success may be associated with a multitude of appliances, strong belief in a particular philosophy, financial motivations (even unethical ones such as inappropriate phase I treatments), the difficulties involved in switching from an experience-based practice to an evidence-based practice, and a simple lack of understanding of evidence-based clinical practice (described in chapter 1). In our profession, therefore, treatment efficacy is currently evaluated broadly in relation to benefits, costs, risks, burden, and predictability of success with various treatment options.

No longer can the role of evidence-based decision making be shunned and ignored in favor of clinical experience alone. From both ethical and legal perspectives, sound clinical judgment must be based on the best evidence available. Today a paternalistic view, whereby the doctor knows what is best for the patient without soliciting patient input, is unacceptable. Patients have a right to autonomy and input into their treatment provided that it does no harm.

The 2001 Institute of Medicine report estimated that it takes an average of 17 years for new, effective medical research findings to become standard medical practice.[1] For example, there was a reemergence of the use of self-ligating brackets in the mid-1990s amid claims not only of faster ligation but also of quicker and more comfortable treatment. Several prospective clinical trials began to be published in 2005 and then two systematic reviews in 2010 concluded that in fact there was no difference in discomfort or treatment time when self-ligating brackets were used compared with conventional brackets. Yet despite the weight of evidence, these claims of faster treatment times and less discomfort are still made and supported by many orthodontists. As Dr Lysle Johnston, Jr, pointed out, our specialty tends to have a pessimistic attitude toward evidence and a minimal capacity to judge its quality. But what effect does this pessimism have on our patients? Can we as an orthodontic profession really wait 17 years to incorporate emerging quality evidence into our clinical practices?

With the exponential growth of information in today's world, how does the busy orthodontist evaluate evidence that will affect his or her practice? This book was conceived out of a need for evidence regarding relevant clinical topics and ongoing controversies in orthodontics such as early treatment, bonding protocols, treatment of Class II and Class III malocclusions, asymmetries, impacted canines, root resorption, retention, and accelerated tooth movement. We have done our best to incorporate the best evidence available regarding these topics, and hopefully this book will show you not only how to judge quality evidence but also why it is so important to implement it.

Reference

1. Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academies Press, 2001.

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CHAPTER 3

Bonding and Adhesives in Orthodontics

Introduction

Treatment efficiency in orthodontics relies on several factors, including accurate bracket positioning and effective bonding of brackets to the enamel. The advent of direct bonding of orthodontic attachments to the etched enamel surface as first described by Newman[1] was a major advance in orthodontic treatment. He described a technique using 40% phosphoric acid for 60 seconds, and this technique remained basically unchanged for another 25 years. Shorter etch times were later examined in clinical trials, and no significant difference in bond failure rates were found between 60-second and 15-second etch times.[2,3] Hence, over time we have seen a reduction in practitioner acid etch times from 60 seconds in 1986 to an average of 30 seconds by 1996, which has remained the same up to 2008.[4] Despite this reduction in etch times, the reported average bond failure in orthodontic offices has remained at 5%; however, this data comes from a survey,[4] so it may well underestimate the true breakage rate. Bracket debonding during treatment is inconvenient and costly to both the orthodontist and the patient. In our own practices, our goal is to have as low a bond failure risk as possible, so it is preferable to be 5% or lower. As demonstrated in Table 3-1, a practice with an average of 250 case starts per year and an average treatment time of 24 months can save 4 repairs per day (or 776 per year) if the bond failure risk can be reduced from 10% to 2%.

So what steps should we take and what information can we gather from the literature to help us in such a basic skill as the bonding of orthodontic brackets? Some may choose to base their choice of adhesive or primer on the myriad of laboratory studies that have been published over the years. However, there are a number of problems with this approach. The American Dental Association Council on Dental Materials reported that most laboratory bonding studies cannot predict the clinical behavior of the adhesives tested.[5] Some of the limitations of in vitro studies include that most in vitro studies are conducted within a short time after bonding (often within 24 hours), so the potential influence of the oral environment on the bonding material cannot be taken into account. Thermocycling cannot replicate the effects of bond degradation by saliva, and the loading rates are slow compared with chewing. Bond strength can also be affected clinically by pH and microbial degradation.[6,7] In a systematic review of bond studies, many factors were found to play a significant role in the final bond strength measured in laboratory studies.[8] For example, water storage can decrease bond strength by an average 10.7 MPa, each second of curing time with a halogen light can increase bond strength by 0.077 MPa, and each millimeter per minute of greater crosshead speed of the Instron machine increases bond strength by 1.3 MPa. The authors of the review concluded that many in vitro studies fail to report test conditions that could significantly affect the outcome.[8]

Some clinicians will judge or select an adhesive from a laboratory study based on its mean or median bond strength without also considering the variation. For example, Fig 3-1 shows two curves representing bond strengths in MPa for two adhesives, both having the same mean bond strength of 13 MPa, which is considered adequate for the orthodontic bonding of brackets. However, if we pick an arbitrary bond strength of about 8 MPa, as suggested by Reynolds[9] as the minimum (6 to 8 MPa) required bond strength to survive clinically, we can see that the adhesive represented by the blue curve has substantially fewer brackets that could potentially fail compared with the adhesive represented by the pink curve. For these reasons, even a well-controlled, statistically valid laboratory study of bond strength should merely serve as a precursor to a controlled clinical investigation. It is important for the clinician to realize that most bond strength tests are

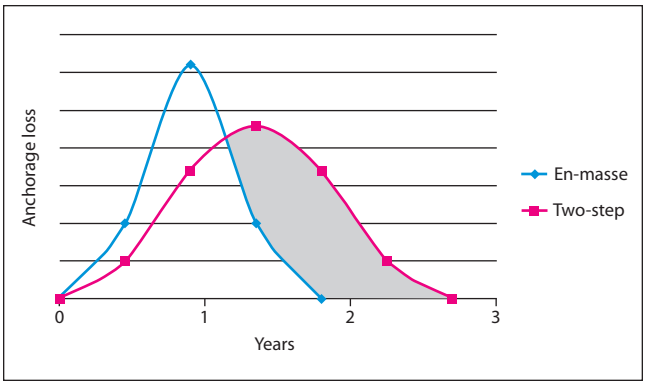

Fig 5-1 Plotting normal curves based on the average and standard deviation data from Heo et al.[8] Note that a sizeable proportion of the two-step cases moved slower than the en-masse cases (shaded area under the pink two-step curve). En-masse space closure saved an average 4.8 months (0.4 years) of treatment time with no noticeable difference in anchorage loss.

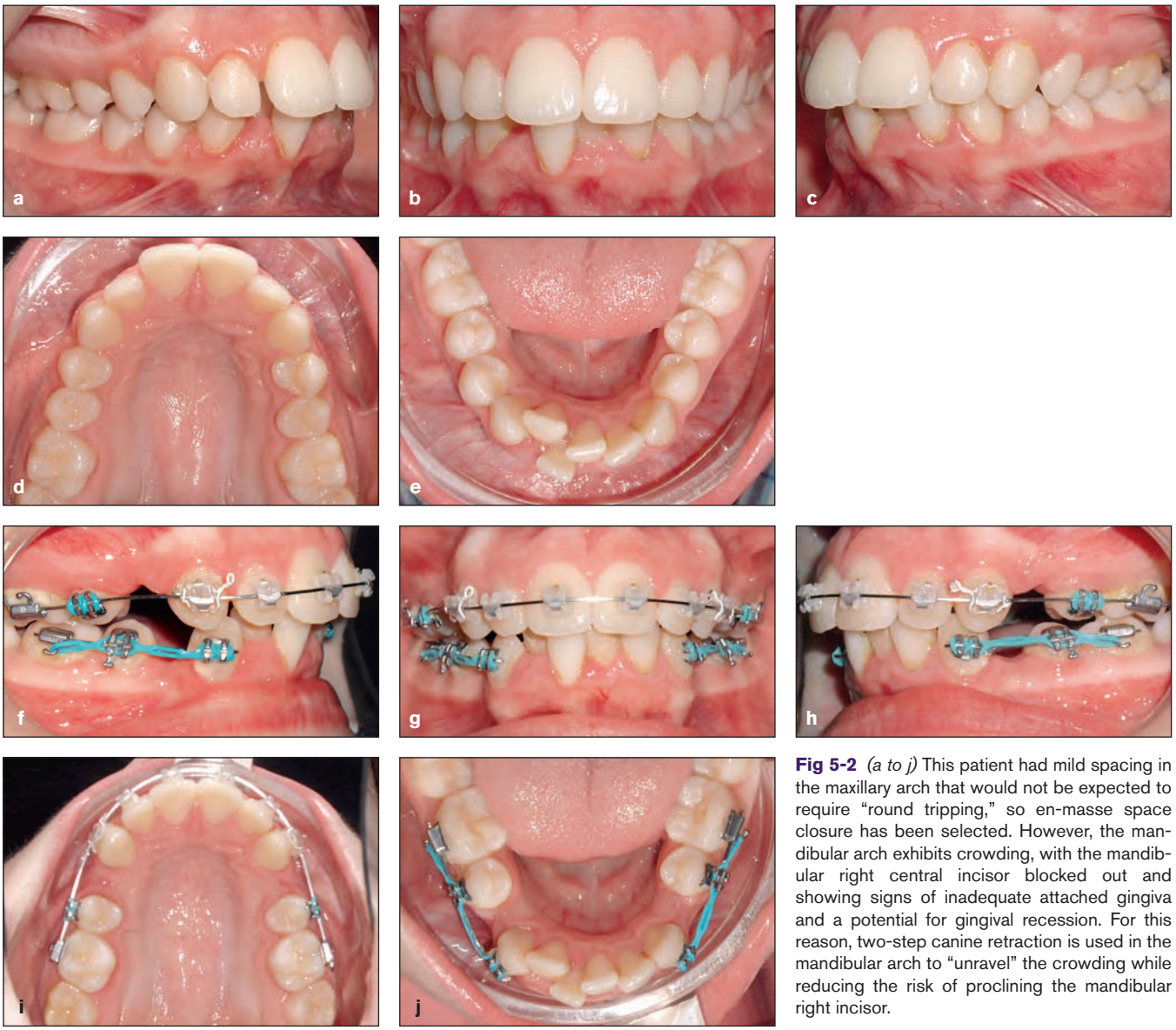

Fig 5-2 *(a to j)* This patient had mild spacing in the maxillary arch that would not be expected to require "round tripping," so en-masse space closure has been selected. However, the mandibular arch exhibits crowding, with the mandibular right central incisor blocked out and showing signs of inadequate attached gingiva and a potential for gingival recession. For this reason, two-step canine retraction is used in the mandibular arch to "unravel" the crowding while reducing the risk of proclining the mandibular right incisor.

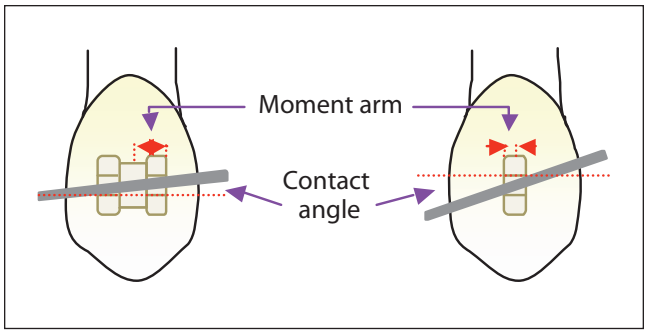

Fig 5-3 The width of the bracket determines the size of the moment arm (one-half the bracket width) and the contact angle between the wire and the bracket corner. The wider bracket thereby requires less force to generate the moment necessary to upright the root. (Adapted from Proffit.[13])

the spaces were 0.9 years (1 standard deviation = 0.6 to 1.3 years) in the en-masse group versus 1.3 years (1 standard deviation = 0.6 to 2.0 years) in the two-step retraction group (Fig 5-1). Two-step retraction demonstrated no benefit in terms of anchorage loss and a tendency to take longer than en-masse retraction. No difference in anchorage loss was also found in a pilot randomized controlled trial (RCT) comparing en-masse retraction with two-step retraction.[9] Therefore, en-masse retraction is the treatment of choice for efficiency. However, there are individual cases in which initial sectional canine retraction or a trapped coil on a continuous archwire is preferred to alleviate anterior crowding (Fig 5-2), such as when not "unraveling" the crowded anterior teeth first would "round trip" them and possibly create periodontal concerns. This treatment philosophy is supported by Burstone,[10] who argued that separating the retraction of canines from that of the incisors makes little sense because all six teeth can be retracted at once with relatively low forces; the only patients for whom separate canine retraction is appropriate, he continued, are those with anterior crowding as a result of arch-length problems. With the trend toward longer treatment times with two-step retraction, there may be an associated risk of greater root resorption. However, in a clinical trial investigating this, no clinically or statistically significant difference could be found.[11]

Some believe that tipping mechanics during canine retraction may be more efficient than bodily retraction. However, a split-mouth study in 14 subjects found that bodily retraction was faster than tipping because of less time spent uprighting the roots, with anchorage loss similar in both groups (17% to 20% or 1.2 to 1.4 mm).[12] The authors also found that the use of a Nance button did not provide absolute anchorage. A previous study had found no difference in the rate of canine retraction but did not measure tipping or time spent uprighting.[13] The split-mouth study also recorded a greater anchorage loss with the tipping mechanics. Another option when retracting canines is to use either a single wing or a twin (also called a *Siamese*) bracket. The advantage of a wider bracket in this situation is that it allows better tip control because it is easier to generate the required moments needed to bring the roots parallel to one another at extraction sites.[14]

When sliding mechanics are used, a wider bracket has a smaller contact angle and requires less force to generate the moment during space closure (Fig 5-3). Conversely, single wing and narrow brackets, including some self-ligating bracket designs, potentially require more force or demonstrate a greater resistance to sliding because of the greater contact angle and smaller moment arm. This is supported by two clinical trials evaluating the rate of maxillary canine retraction and en-masse space closure.[15,16] Both studies found a conventional twin bracket resulted in a slightly faster rate of space closure (1.2 mm/month) compared with the slightly narrower self-ligating brackets (1.1 mm/month and 0.9 mm/month).

Anchorage

As previously described, it appears from the best evidence available that there is no advantage to two-step retraction over en-masse retraction when it comes to anchorage. However, there are other options available for reinforcing anchorage, such as transpalatal arches (TPAs), headgear, and, more recently, temporary skeletal anchorage devices (TSADs) or miniscrews. When examining the effect of the TPA during extraction treatment, Zablocki et al[17] found no significant effect on either the anteroposterior or vertical position of the maxillary first molars. In a study comparing TPAs, headgears, and TSADs, the TSADs and headgears helped to control anchorage during leveling and alignment while the TPA group experienced anchorage loss (mean of 1.0 mm; $P < .001$).[18] However, during the space closure phase, only the TSAD group was stable. Overall, the anchorage loss per incisor retraction was 2% for the TSAD group, 15% for the headgear group, and 54% for the TPA group. A potential confounder in this study was that compliance with headgear wear was not measured, so compliance was assumed when molars remained stable and noncompliance suspected when they were not, representing what would happen clinically. Other authors found a similar 1.2-mm anchorage saving with 1.4 mm greater retraction of the anterior teeth when using skeletal anchorage (miniplates, miniscrews, or microscrews),[19] while others have found palatal implants to be at least as effective as

Fig 6-4 *(a to j)* An 8-year-old boy presented with an anterior crossbite and a maxillary transverse deficiency. *Green outlines* indicate optimal tooth positions within the jaws.

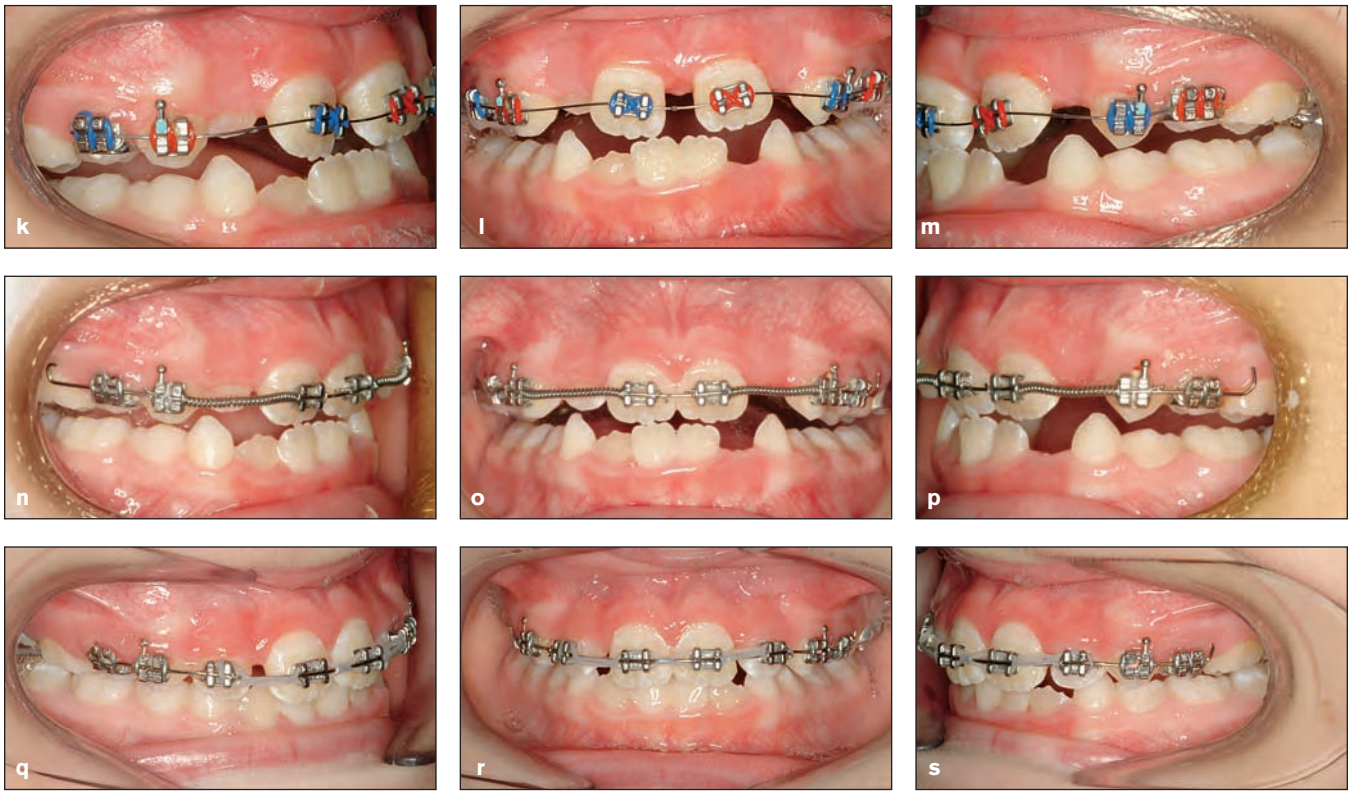

Fig 6-4 *(cont) (k to s)* Treatment with a Hyrax expander and fixed appliances.

Early Orthodontic Treatment

Indications

Objectives of early Class III treatment may include *(1)* preventing progressive hard or soft tissue damage, such as enamel abrasion and bony or gingival dehiscence; *(2)* improving skeletal discrepancies and possibly avoiding orthognathic surgery; *(3)* improving occlusal function; *(4)* developing arch length; and *(5)* improving dental and facial esthetics.[17] Common conditions warranting early treatment are anterior or posterior crossbites with or without functional shifts and blocked-out maxillary lateral incisors. Favorable factors for successful early treatment include mild to moderate skeletal disharmony, no familial mandibular prognathism, a convergent facial type, symmetric condylar growth, and expected good cooperation. Patients and parents should be informed that unpredictable dysplastic skeletal growth in the future may necessitate orthognathic surgery despite early intervention.

Borrie and Bearn[18] published a systematic review of 45 articles to identify the appropriate method for anterior crossbite correction. The authors found low-level evidence, and no statistical methods were employed for the analysis. They stated that higher-level studies are necessary before definitive conclusions can be made.

Maxillary expansion and partial fixed appliances

Figure 6-4 shows a patient who presented with an anterior crossbite and a maxillary transverse deficiency. Associated with the transverse discrepancy is inadequate arch length for the unerupted maxillary lateral incisors. This particular patient had a near optimal anteroposterior positioning of the maxilla and mandible, as indicated by the relationship of the optimal incisors to the GALL (Fig 6-4j). The panoramic radiograph (Fig 6-4h) showed that the lateral incisors were ready to erupt but were blocked out of the arch. The primary first molars had minimal root resorption and, along with the permanent first molars, provided good anchor units for rapid maxillary expansion (RME).

A Hyrax expander was inserted, and brackets were bonded to the central incisors and primary canines (maxillary premolar brackets were used on the primary canines) (Figs 6-4k to 6-4m). Skeletal expansion was accomplished with two turns per day for 10 days. The expander was tied off, and a 0.012-inch nickel-titanium (Ni-Ti) wire was inserted from the right primary first molar through the right canine, central incisors, left canine, and left primary first molar. Six weeks later, a 0.018-inch Ni-Ti wire was inserted, and a Ni-Ti open coil was compressed between the incisors and the primary canines (Figs 6-4n to 6-4p). The archwire was cinched distal to the primary first molar brackets to direct

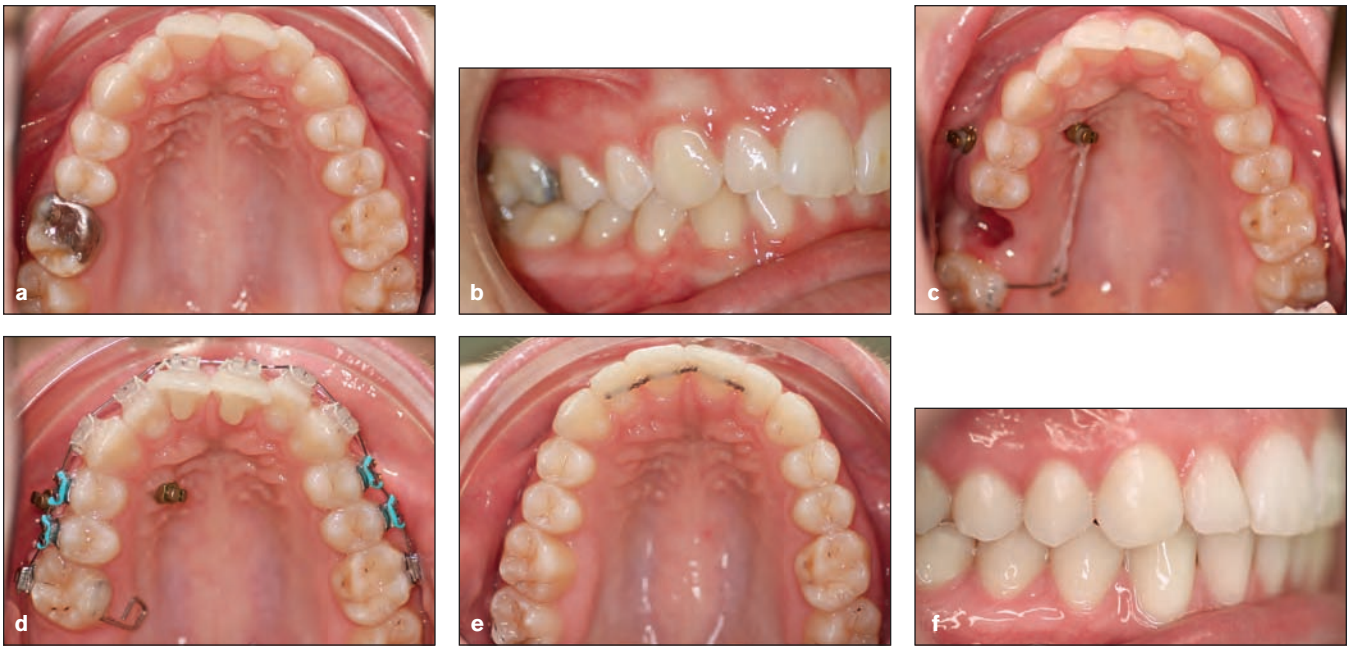

Fig 7-10 *(a to d)* The maxillary right first molar required extraction, so miniscrew anchorage was used to protract the second molar into its place. This was done prior to placement of full fixed appliances to reduce the overall time in full braces. *(e and f)* The second molar has taken the place of the maxillary right first molar, and the third molar erupted and aligned to replace the second molar.

Fig 7-11 *(a to q)* Inappropriate extraction of the maxillary right first premolar as a child resulted in a midline shift and Class III canine relationship. Space was reopened in the less visible second premolar position for implant and crown placement.

Other Asymmetries

Asymmetries can also be created by the inappropriate extraction of teeth in crowded dentitions, by congenitally absent teeth or impacted teeth, or by the loss of teeth. For example, the patient in Fig 7-10 had an internally resorbing maxillary right first molar that required extraction. Because she had only minor crowding in a Class I occlusion, a nonextraction approach was preferred. After consultation with the family, miniscrews were placed to protract the second molar into the first molar space. After 6 months and six visits, the extraction space was closed with no movement of the anterior teeth (Figs 7-10c and 7-10d). Full braces were then placed to commence aligning the remaining teeth and permit root uprighting on the second molar. Use of the miniscrew maintained the canine relationship, thereby preventing an asymmetry from developing in this case.

Inappropriate removal of a tooth can result in an asymmetry that was not originally present. The patient in Fig 7-11 had a blocked-out maxillary right premolar removed as a child, which resulted in a reasonable alignment but also created a Class III subdivision malocclusion with the maxillary midline skewed to the right side. In this case, treatment would involve either extraction of three other teeth to match or the reopening of the space for prosthetic replacement, which was the option chosen by the patient.

Fig 7-11 *(cont)*

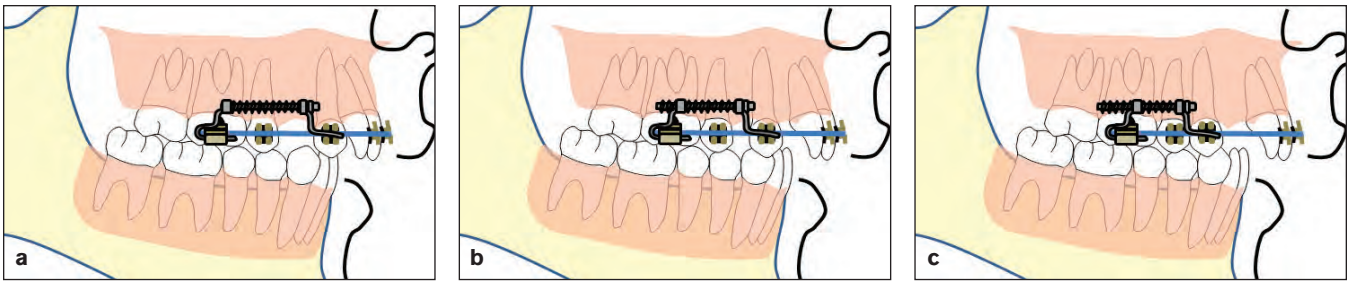

Fig 13-2 *(a to c)* Schematic illustrations of maxillary rapid canine retraction through distraction of the PDL with an intraoral distraction device.

Surgical-Assisted Approach

Surgical-assisted accelerated orthodontic tooth movement is currently the most effective technique experimentally and clinically in accelerating orthodontic tooth movement. This approach includes the techniques of rapid canine retraction through distraction of the PDL,[91–95] rapid canine retraction through distraction of the dentoalveolus,[96–98] corticotomy-assisted rapid orthodontic tooth movement,[99,100] and corticision.[101]

Rapid canine retraction through distraction of the PDL

This technique is beneficial in treating adult patients, for whom treatment duration may be a deciding factor toward the acceptance of treatment. The rate of orthodontic tooth movement in adults, particularly in the beginning of treatment, is slower than in adolescents.[102–104] Two basic components, the alveolar bone and PDL, are encountered during orthodontic tooth movement and affect its rate based on factors such as cellular activity,[105,106] mechanical strength of the PDL,[107] and bony resistance of alveolar bone.[108–110] In the initial stage of tooth movement, Young's modulus (stiffness) of the PDL is higher in adults than in adolescents, and this might produce a reduction in the biologic response of the PDL, leading to a delay in the early stage of tooth movement.[107] However, Young's modulus decreases markedly 4 to 7 days after application of orthodontic force and does not last through the entire period of orthodontic tooth movement.[111] The rate of tooth movement is shown to depend on the state of alveolar bone resistance, and it is faster in alveolar bone with loose bone trabeculae.[108–110,112]

Mechanism

By incorporating a surgical procedure on the interseptal bone distal to the canine at the time of extraction of the first premolar, the resistance on the pressure side of canine retraction is reduced, thus enhancing rapid canine retraction through distraction of the PDL[91] (Fig 13-2). This approach is based on the bifocal distraction osteogenesis technique. On the pressure side, the canine–interseptal bone complex is transported distally inside of the extraction socket. On the tension side, it is a distraction of the PDL followed by osteogenesis and ossification.[91]

Clinical and surgical procedures

Bonding and banding are performed before extraction of the first premolars. The first molars and second premolars are the anchor units. A triple tube is welded on the buccal side of the canine band and the molar band. No archwire or active appliance is placed on the anchor units before extraction, but a segment of Ni-Ti archwire is placed in the anterior teeth for the initial alignment and activation of the periodontal cells. The period of predistraction preparation is 1 to 2 months.

At the time of the first premolar extractions, surgery is performed with surgical burs to undermine and reduce the thickness of the interseptal bone distal to the canine. The surgery is then performed inside the extraction socket of the first premolar without a mucoperiosteal flap and osteotomy. The length of the canine can be either obtained directly from cone beam computed tomography (CBCT) or estimated by applying the ratio of the premolar length (which can be measured after extraction) to the canine length on the periapical film.

The socket of the first premolar is deepened to the same depth as that of the canine with a 4-mm carbide surgical round bur (Figs 13-3a and 13-3b). Then a cylinder carbide surgical bur is used to reduce the thickness of the interseptal bone distal to the canine. This procedure is critical to the distraction results. The interseptal bone is better reduced to 1.0 to 1.5 mm in thickness. The last step is to undermine the interseptal bone distal to the canine. A 1-mm carbide fissure bur is used to make two vertical grooves, running from the socket bottom to the alveolar crest, on the mesiobuccal and mesiolingual corners inside the extraction socket. These two vertical grooves extend and join obliquely toward the base of the interseptal bone (Figs 13-3c and 13-3d).

A custom-made intraoral distraction device (Fig 13-4) is delivered immediately after the extraction and surgical procedures. It is activated 0.5 mm/day right after the surgery until the canine is distracted into the desired position (Fig 13-5). Patients are seen once a week during the distraction procedure.

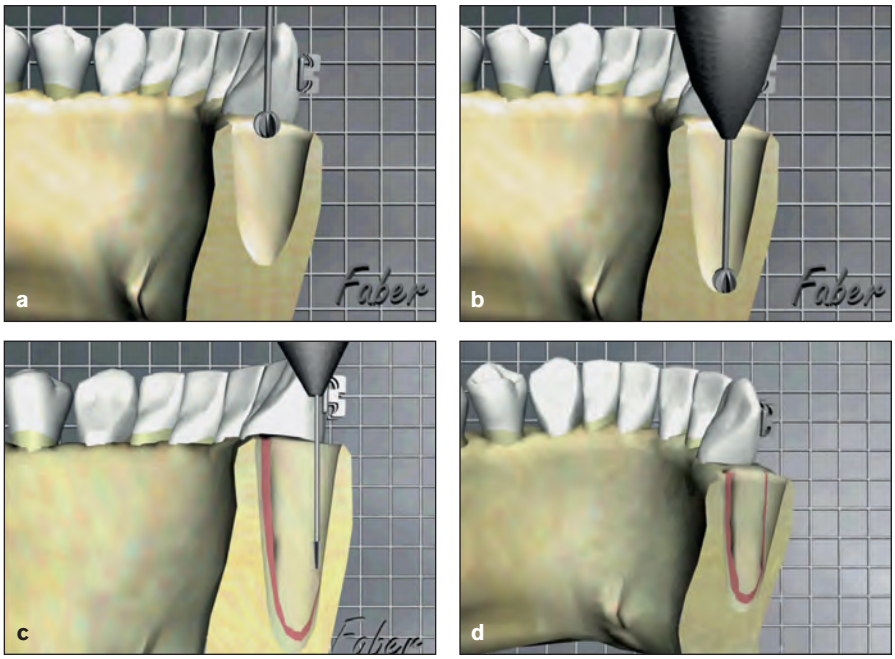

Fig 13-3 Schematic illustrations of the surgical procedure for undermining the interseptal bone distal to the canine in rapid canine retraction through distraction of the PDL. *(a and b)* The socket of the first premolar is deepened to the same depth as that of the canine with a 4-mm carbide surgical round bur. *(c and d)* A 1-mm carbide fissure bur is used to make two vertical grooves, running from the socket bottom to the alveolar crest, on the mesiobuccal and mesiolingual corners inside the extraction socket, and these two vertical grooves extend and join obliquely toward the base of the interseptal bone.

Fig 13-4 The intraoral distraction device for rapid canine retraction through distraction of the PDL.

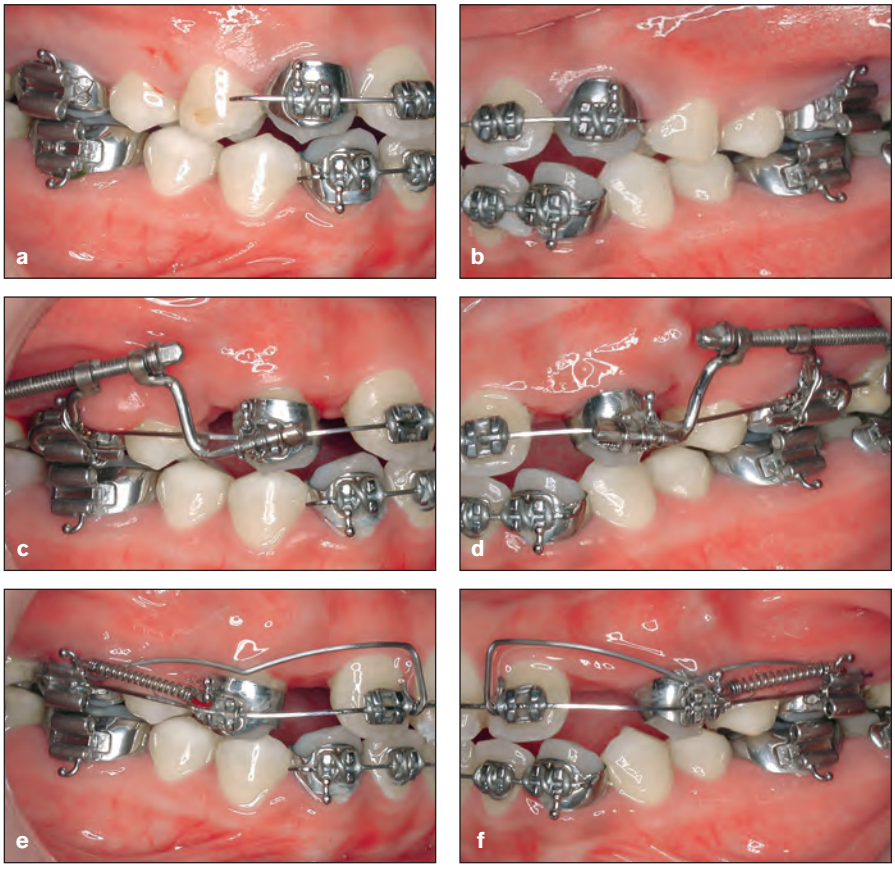

Fig 13-5 The clinical progress of maxillary rapid canine retraction through distraction of the PDL in a 23-year-old woman. The canine retraction was completed in 3 weeks. *(a and b)* Before distraction. *(c and d)* After 2 weeks of distraction. *(e and f)* After 3 weeks of distraction.

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