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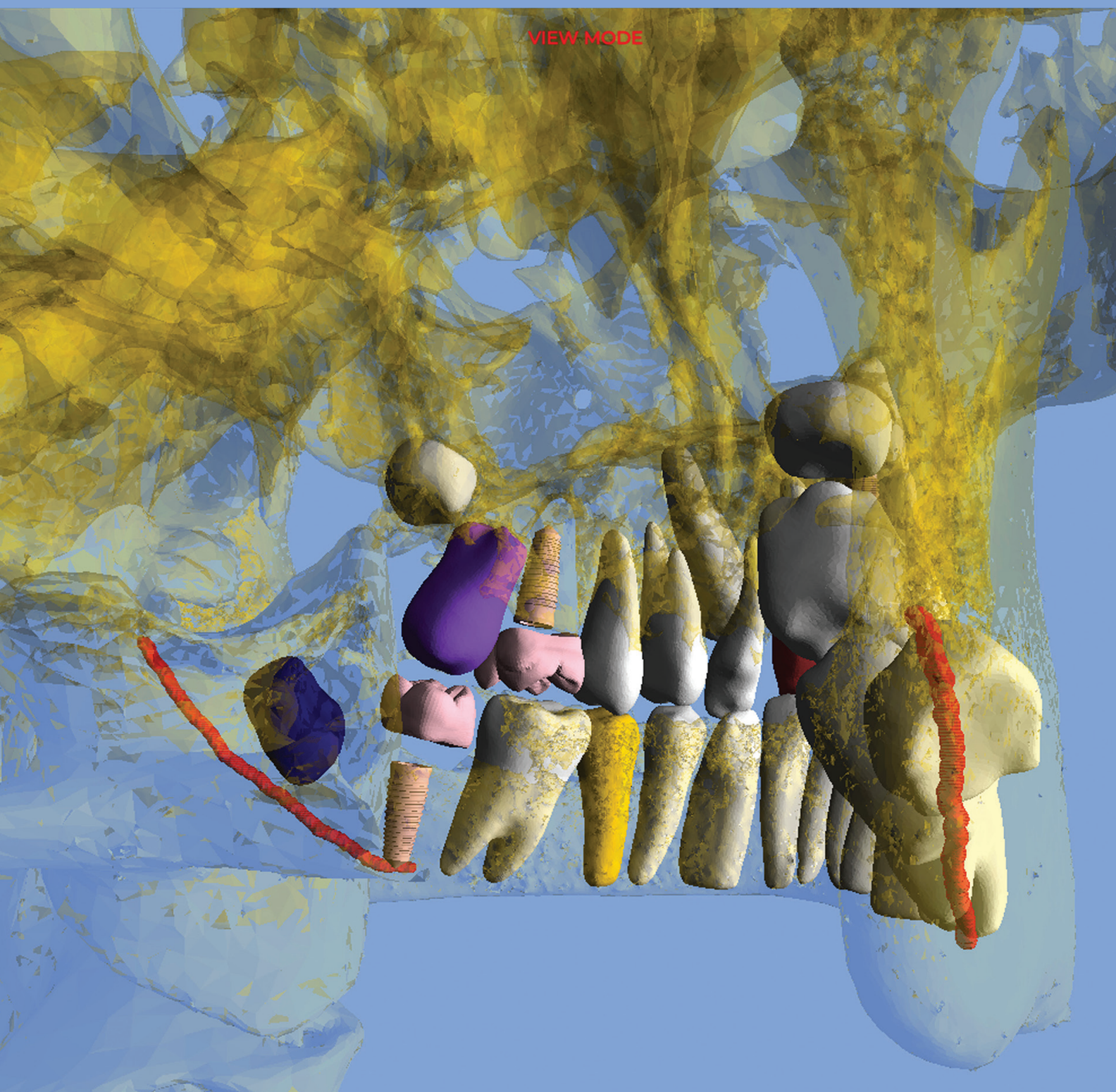

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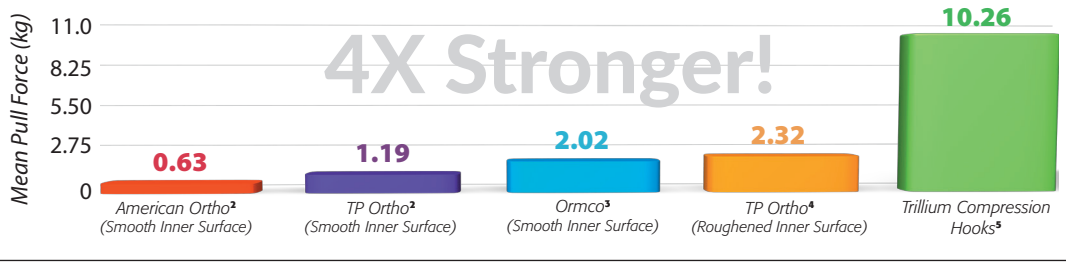

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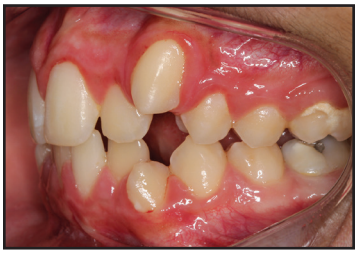

CASE REPORT

First Molar Extractions in a Patient with Marfan Syndrome

CRISTINA SOLA MARTIN, DDS, MS
JAIME GIL LÓPEZ-AREAL, DDS, MSc
HARRY L. DOUGHERTY JR., DDS, MS

This is the second in a series of case reports from the three finalists for the 2021 Eugene L. Gottlieb JCO Student of the Year Award.

DEPARTMENTS

The Cover

Three-dimensional, CBCT-derived segmented imaging is illustrated on the cover, as described in The Cutting Edge by Drs. Lewit Borohovitz, Abraham, and Redmond.

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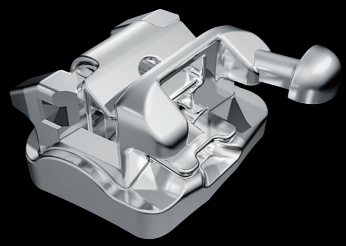

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THE EDITOR'S CORNER

The Evolution of Orthodontic Radiography

The use of radiographs in orthodontics, and in almost every dental and medical field, is pretty much taken for granted nowadays. It is difficult for us even to imagine orthodontic, medical, or dental practice without diagnostic radiography. Yet dental radiography was developed in relatively recent times, considering that dentistry has been practiced as a necessity throughout history and as a recognized profession since the time of Pierre Fauchard (1678-1761). The German physicist Wilhelm Conrad Röntgen is given credit for taking the first radiograph in 1895—using his wife's hand, presumably because it was the most convenient thing available—with his new imaging invention, which was made from a Crookes tube and photographic plates. According to Riaud, the German dentist Otto Walkhoff took the first dental radiograph, two weeks after the publication of Röntgen's work.[1] Walkhoff, still considered one of the founders of modern endodontics, captured the radiograph of his own teeth with an exposure time of about 25 minutes! Fortunately, the technology has progressed considerably since then.

The early pioneers of dental radiology used glass photographic plates or roll film to capture their images. The plates were cut down by the dentist, wrapped in black paper, and enclosed in rubber dam material. These glass plates were extremely fragile and quite uncomfortable for the patient. In 1903, Kells opened the first dental x-ray laboratory in the United States. In 1925, Raper originated the bite-wing technique, and in 1948, panoramic radiography was introduced. With specific reference to orthodontics, A.J. Pacini is credited with taking the first standardized lateral radiograph in 1922. Also in 1922, Paul Simon of Germany became the first to use planes and angles in what was eventually referred to as "cephalometrics," now an integral part of orthodontic practice.[2]

Over the years, a great many authors have published new and supposedly improved cephalometric analyses. To my mind, however, the most important recent innovation in orthodontic diagnostic radiography occurred in 1998, with the introduction of cone-beam computed tomography (CBCT) to dentistry by Mozzo and colleagues.[3] Its application to orthodontics was a natural progression.

In this month's Cutting Edge column, JCO's Technology Editor, Dr. Marc S. Lemchen, presents a fascinating article written by Drs. Chen Lewit Borohovitz and Zeev Abraham of Tel Aviv University, Israel, and Dr. Ronald Redmond of the University of the Pacific in San Francisco. With the challenging title "The Diagnostic Advantage of a CBCT-Derived Segmented STL Rendition of the Teeth and Jaws Using an AI Algorithm," this paper represents another step in the development of orthodontic diagnostic radiography. Using artificial intelligence, the authors' technique "segments" individual teeth or groups of teeth out of a CBCT image for closer analysis. Two cases demonstrate the direct clinical applicability of this technology and its diagnostic benefits for the orthodontist, mainly in allowing the visualization of structures and anomalies that would not have been apparent in standard radiographs. This could be another game changer. RGK

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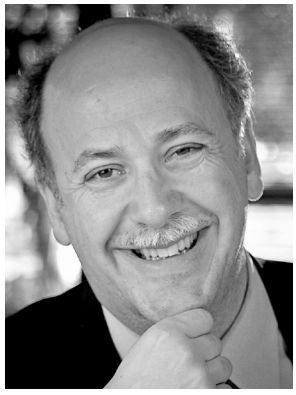
MASTER CLINICIAN

David B. Kennedy, BDS, MSD, FRCD(C)

Associate Editor Peter Sinclair conceived this department devoted to recognizing the Master Clinicians who have made the orthodontic specialty what it is today. Every few months, Dr. Sinclair will delve into the career story and treatment principles of one of these seminal figures. We welcome your nominees for future Master Clinicians.

Dr. David Kennedy of the University of British Columbia (UBC) is our featured Master Clinician this month. He addresses an issue that has been a point of contention among orthodontists throughout the history of the specialty: early treatment. There are valid arguments regarding early treatment, both pro and con, with highly respected practitioners on each side of the debate. In this article, Dr. Kennedy presents a number of treated cases as excellent examples of what can be accomplished. RGK

Dr. Kennedy



Dr. Sinclair

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DR. SINCLAIR Who were your mentors?

DR. KENNEDY I attended two outstanding graduate programs where the department chairs—Drs. Jim Roche, pediatric dentistry at Indiana University, and Don Joondeph, orthodontics at the University of Washington School of Dentistry—respected the students, held the highest standards, and led by example. Both served as directors on their respective American boards. They encouraged their students to become board-certified, something that I did for both specialties and would highly recommend; it helped me be more critical of my work. They were my mentors, along with selected faculty from the University of Washington, including Bob Little, Vince Kokich, and Peter Shapiro.

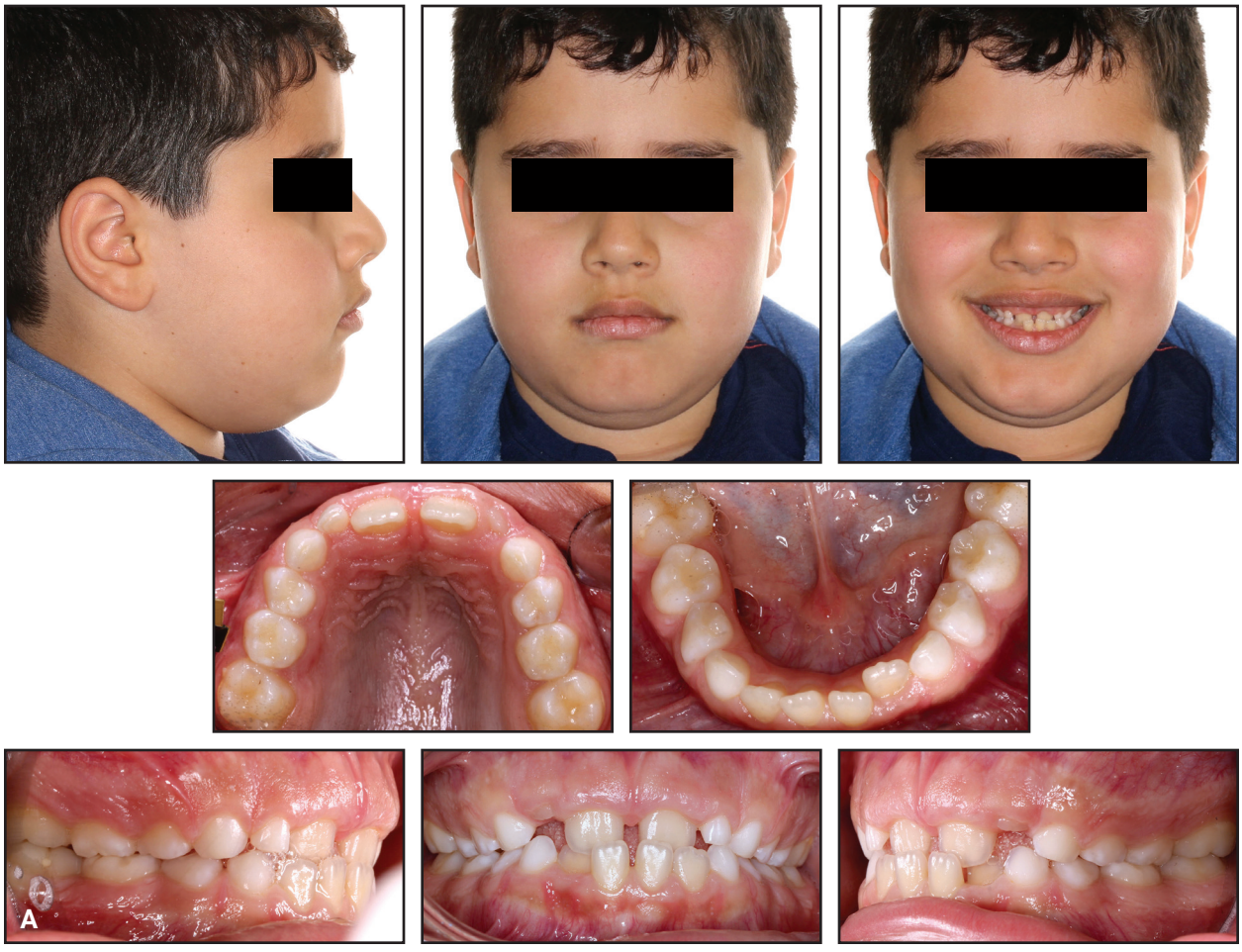

Fig. 1 Case 1. A. 7½-year-old male patient with anterior crossbite and forward mandibular shift before treatment (continued on next page).

DR. SINCLAIR What is your philosophy, and how does it guide you?

DR. KENNEDY When I do a clinical exam, I ask myself the following three questions:

1. What do you see? Are the occlusion, dental development, and eruption sequence normal?
2. What should you see? This requires a comprehensive knowledge of growth and development. The clinician must be able to recognize normal and abnormal development at various stages of the mixed dentition.
3. What is the difference? Usually you treat the difference, based upon the scientific evidence of treatment success.

I ask and answer three philosophical questions when considering early treatment, and I use evidence-based research to determine my decision-making.[1]

1. Can I treat this permanently? Examples are anterior and posterior crossbite correction. For nonskeletal anterior crossbite correction, a maxillary removable appliance can often be used, unless significant incisor rotational and torque control are needed (Fig. 1). Correction is usually accomplished

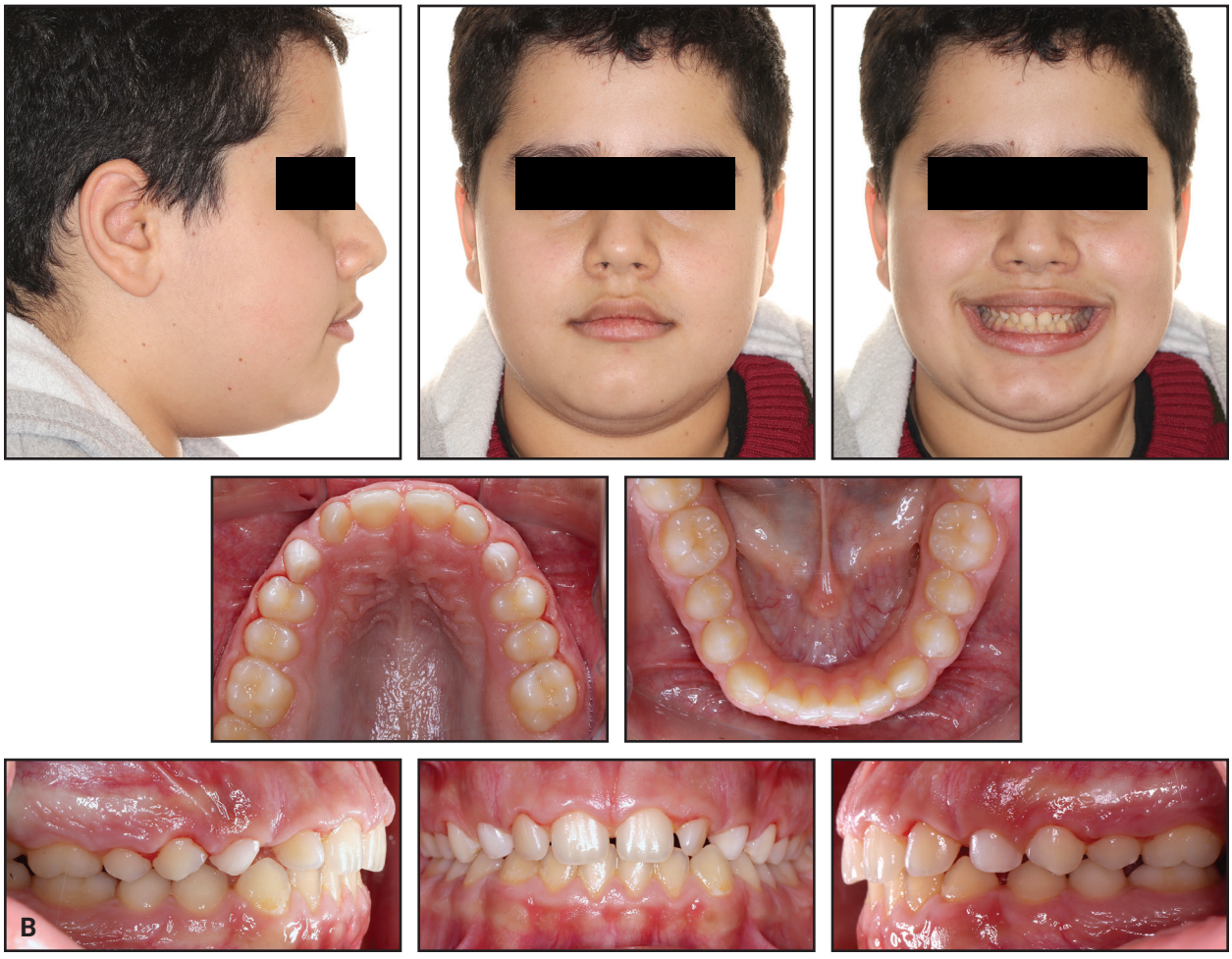

Fig. 1 (cont.) Case 1. B. Anterior crossbite corrected after nine months of treatment with removable maxillary appliance; mandibular incisors show spontaneous improvement in alignment.

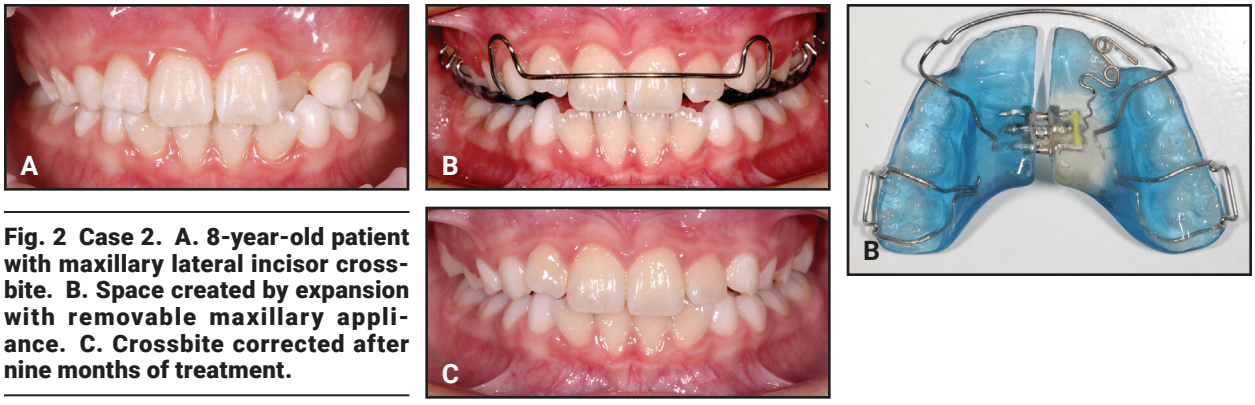

Fig. 2 Case 2. A. 8-year-old patient with maxillary lateral incisor crossbite. B. Space created by expansion with removable maxillary appliance. C. Crossbite corrected after nine months of treatment.

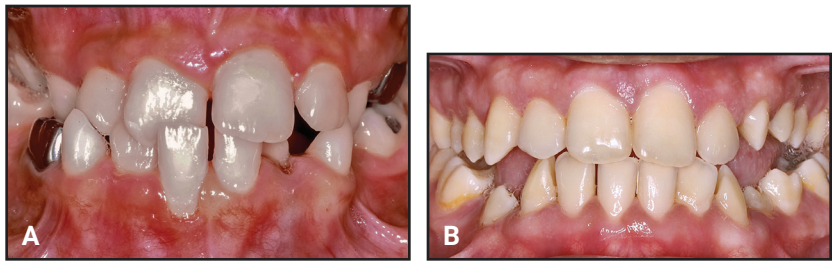

Fig. 3 Case 3. A. 9-year-old patient with crossbite before treatment. B. Two years later, showing improvement in gingival retreat after crossbite correction (six months of active treatment). Deciduous canines extracted to relieve crowding; no retention needed.

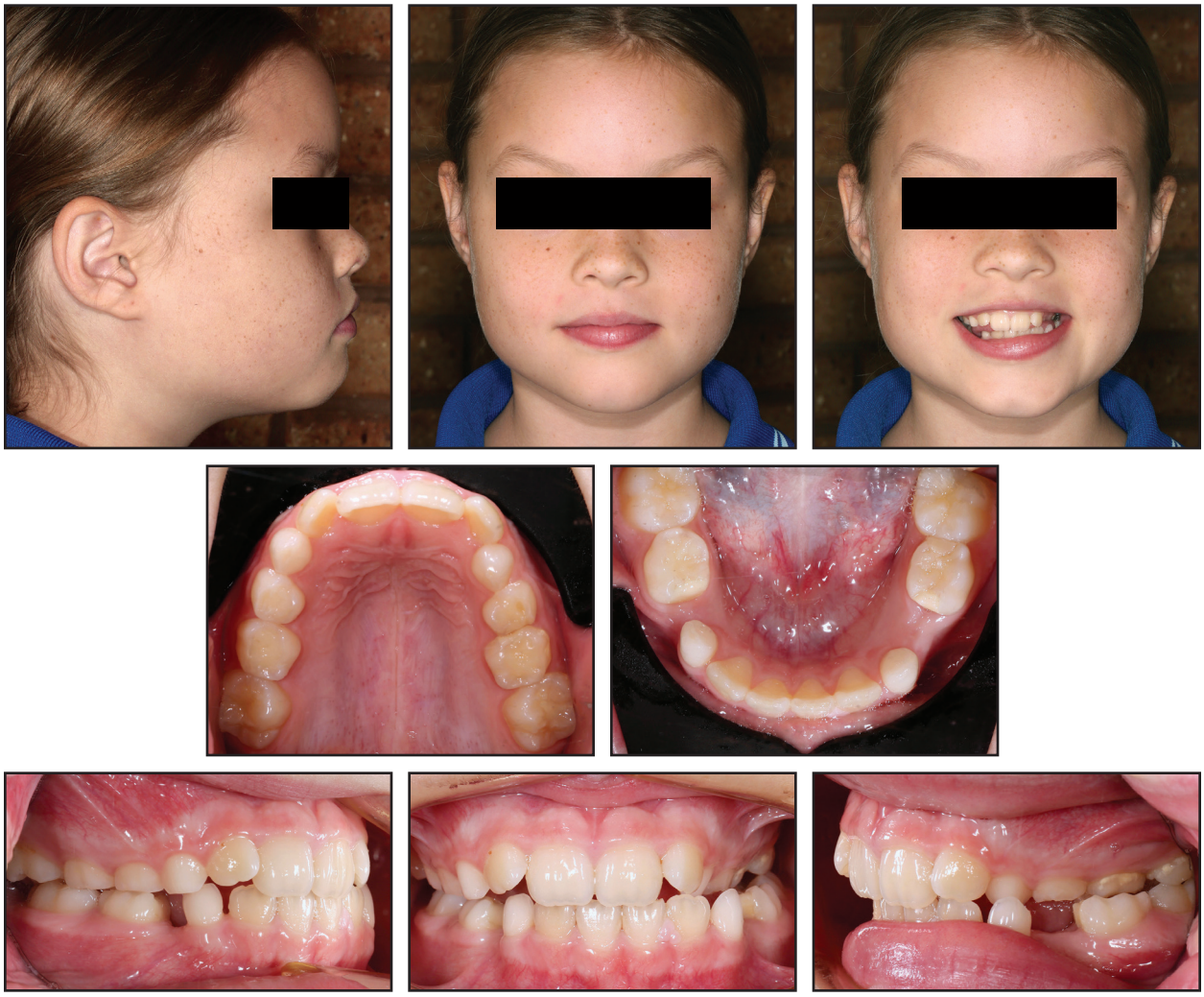

Fig. 4 Case 4. 8½-year-old female patient with unilateral left posterior crossbite, mandible shifted to crossbite side, and chin and mandibular dental midlines deflected to left before treatment. Crossbite side shows Class II tendency.

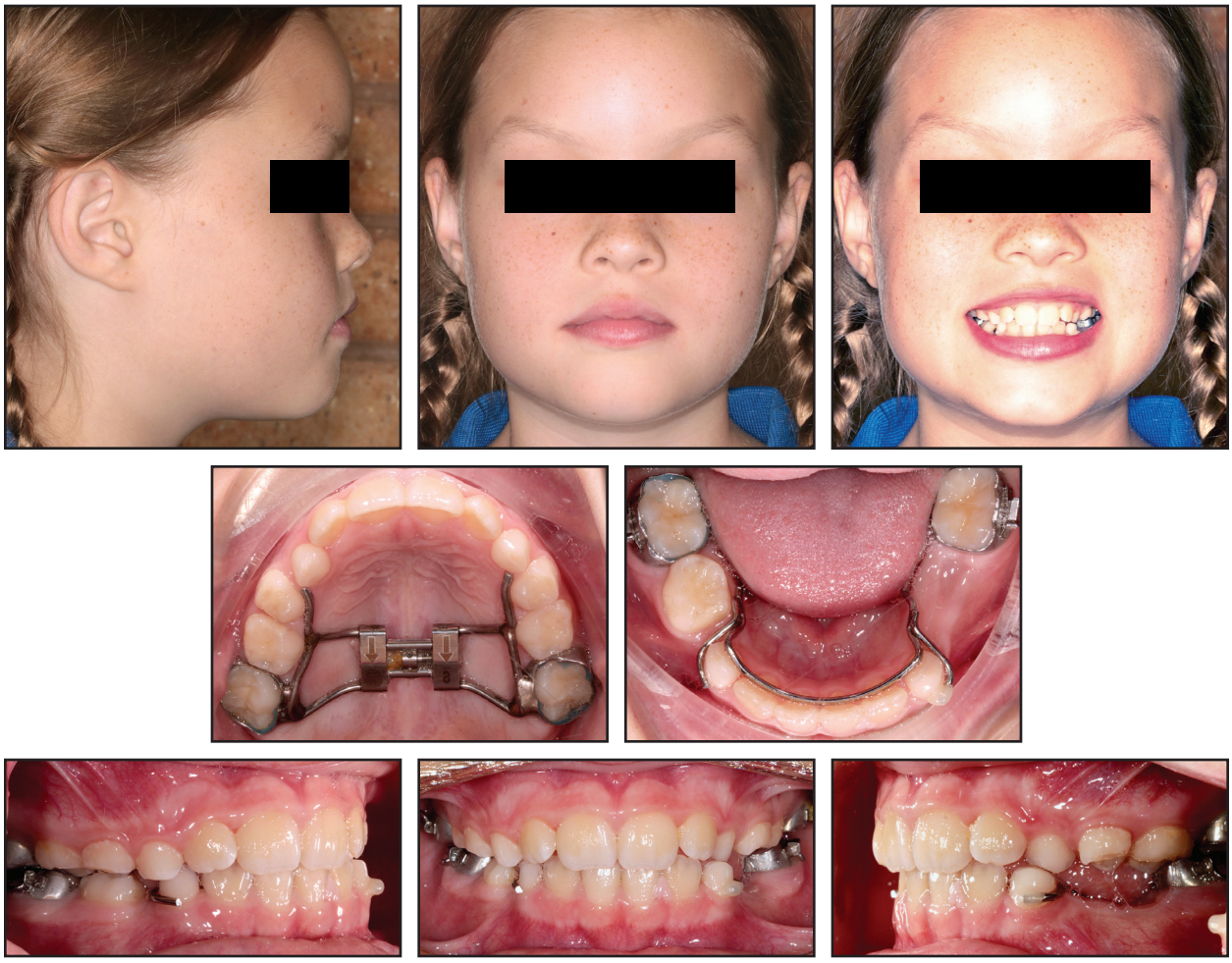

Fig. 5 Case 4. After Phase I treatment involving four months of slow maxillary expansion with fixed Hyrax* expander, followed by six months of retention with same passive appliance. Left Class II tendency improved, with chin and midlines corrected and mandibular shift eliminated.

in four months of full-time wear. A posterior biteplane is used when the vertical overbite exceeds 2-3mm, to allow bite opening for anterior crossbite correction; the biteplane is reduced after the crossbite is corrected to prevent deepening of the overbite. Space must be available for tooth movement to occur; therefore, maxillary expansion may sometimes be needed (Fig. 2). Retention is not needed when the overbite is complete. Any gingival retreat on the mandibular incisors will improve after crossbite correction[2] (Fig. 3). Mandibular incisor irregularity often improves secondary to maxillary incisor alignment, provided adequate space is available.

Bilateral posterior crossbites represent only 10% of mixed-dentition crossbites, with the unilateral presentation being more common. Unilateral mixed-dentition posterior crossbites often show a Class II tendency on the crossbite side, with the non-crossbite side being Class I (Fig. 4). The mandibular dental and skeletal midlines are deflected

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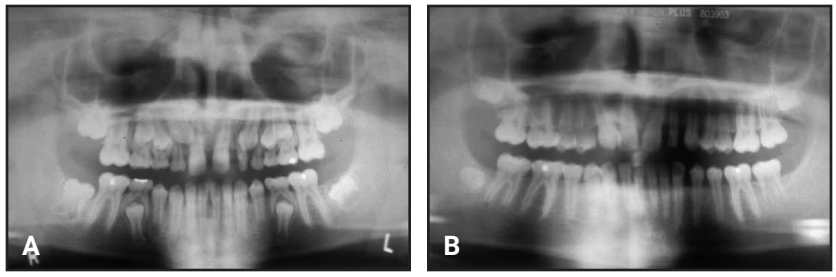

Fig. 6 Case 5. A. 11½-year-old patient with bilateral ectopic maxillary canines, missing maxillary right lateral incisor, and small left lateral incisor before extraction of maxillary deciduous canines. Late eruption for chronological age is common with ectopic teeth. B. One year later, positions of maxillary permanent canines improved after extraction of deciduous canines.

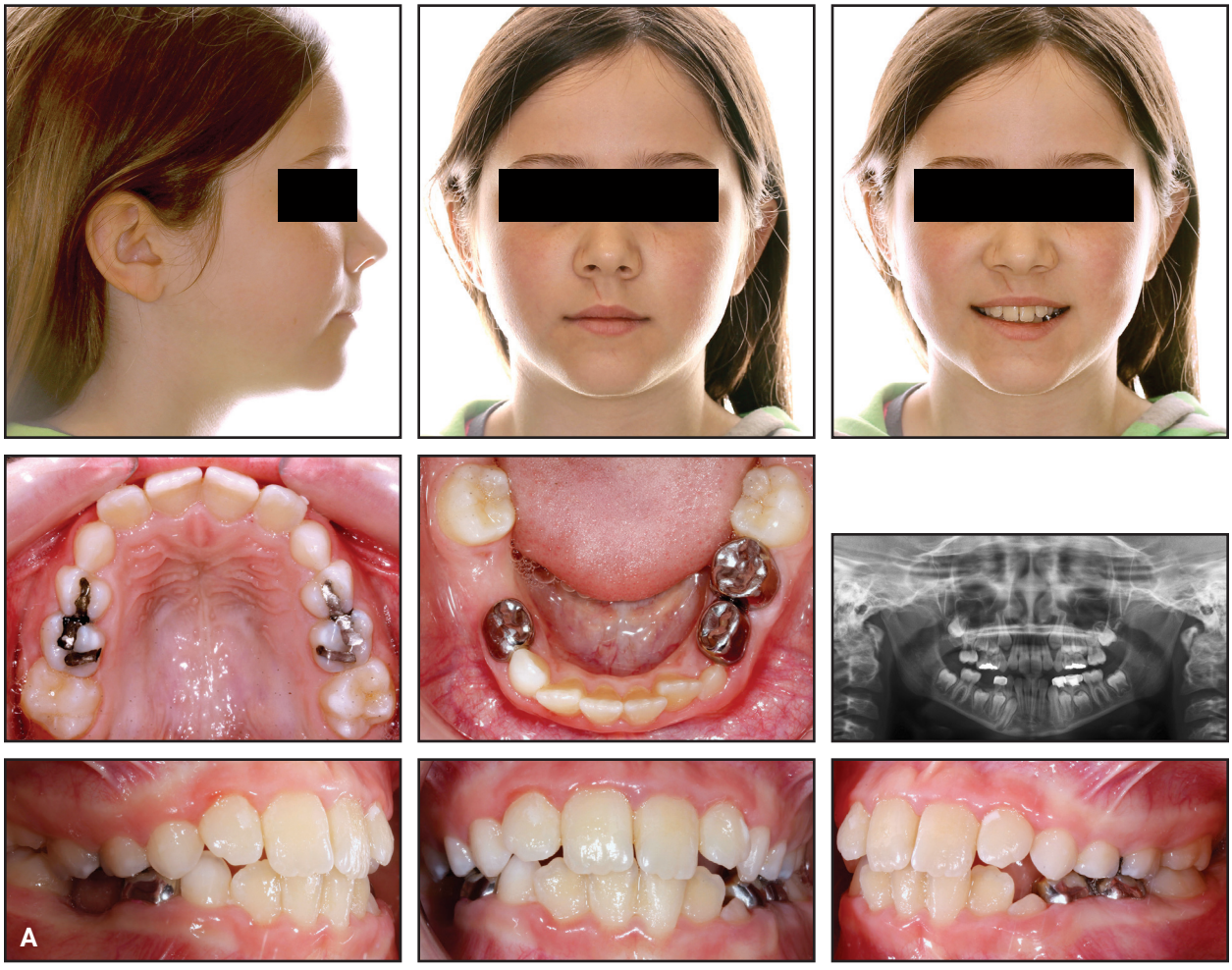

Fig. 7 Case 6. A. 9-year-old female patient with Class I malocclusion, mild mandibular crowding, and early loss of mandibular right second deciduous molar before treatment (continued on next page).

Fig. 7 (cont.) Case 6. B. After 15 months of treatment, with mandibular lingual arch in place.

toward the crossbite side, with asymmetry in the condyle position before treatment owing to the shift of the mandible toward the crossbite side. These asymmetries improve secondary to maxillary expansion, which eliminates the shift of the mandible (Fig. 5). A diagnostic tip relative to the need for maxillary expansion is that the maxilla shows more crowding than the mandible. Both bilateral and unilateral posterior crossbites with functional shifts require maxillary expansion, but the bilateral crossbite presentation requires more expansion.

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In the early mixed dentition, slow maxillary expansion can be used with one-quarter turn every two to three days. Because the suture is immature, lower force levels are required to obtain skeletal expansion. Rapid maxillary expansion in the young child may widen the nasal base, hence the recommendation for slow expansion. Fixed expanders, such as a Haas-type, Hyrax,* or Quad-Helix,** are recommended. About 5-6mm of expansion is usually required for correction of unilaterally presenting crossbites.[3]

Maxillary constriction is sometimes caused by prolonged digit habits; this can be treated simultaneously by incorporating a habit-breaking

crib. Overexpansion of 2mm per side and a minimum six months of fixed retention yield excellent stability.[3] When an open bite exists, retention with the crib should be continued until a positive overbite has been established.

2. Is there something damaging that I cannot leave? Examples are gingival retreat from an anterior crossbite, ectopic canines that can be guided into better positions, and unerupted incisors from mesiodens or trauma to the deciduous incisors.

Palatally displaced ectopic canines occur more often in females and those with small or missing lateral incisors, or with a family history of ectopic canines.[4-8] Distal crown tipping of the maxillary lateral incisors is a normal development in the early mixed dentition, which is called the "ugly duckling" stage. When distal tipping of the lateral incisor persists as the maxillary canines should erupt, however, this hints that the maxillary permanent canines may be ectopic, which calls for radiographic assessment (Fig. 6). A panoramic radiograph or periapical films are warranted at age 10-11 to check the canine positions, especially when the

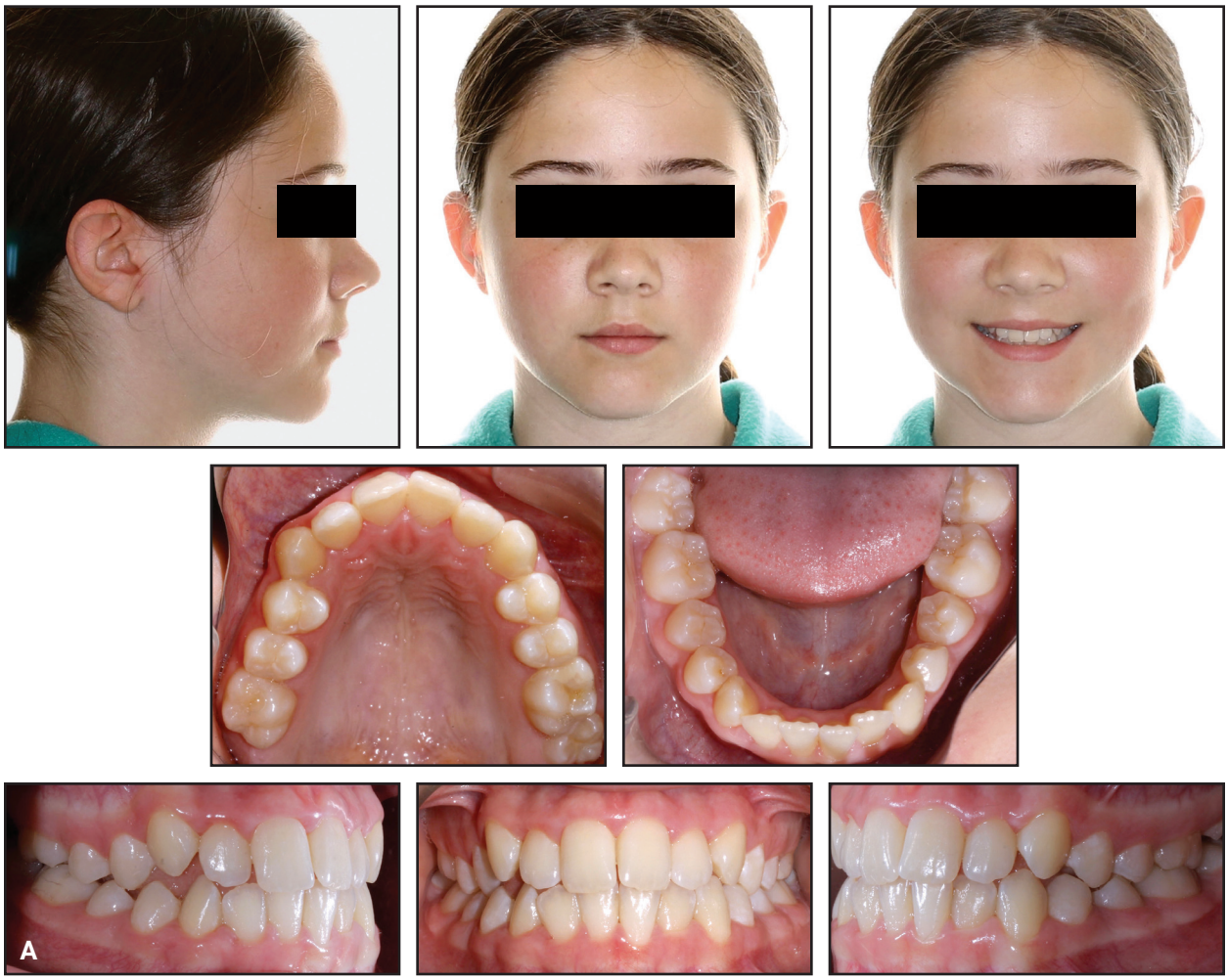

Fig. 8 Case 6. A. Patient at age 12, showing mandibular premolar rotations prior to start of Phase II. Lingual arch removed previously, after second molar eruption (continued on next page).

deciduous canines are not mobile. The maxillary deciduous canines should be mobile six months after mandibular permanent canine eruption.

Extraction of the maxillary deciduous canines, maxillary expansion, and/or headgear treatment frequently improve the ectopic permanent canine positions and encourage normal eruption. Similarly, space opening improves the likelihood that the ectopic permanent canine will erupt without surgical intervention.[9-11] When the tip of the maxillary canine has not crossed the midpoint of the lateral incisor, extraction of the deciduous canine alone results in an improved permanent canine position 91% of the time.[12]

3. Will early treatment help significantly with future Phase II treatment? Will early intervention move the case to nonextraction or make Phase II easier or shorter? Examples are early Class III treatment, leeway space management, and serial extraction.

Mild to moderate crowding can be resolved with leeway space management. In 66-70% of cases, 5mm of crowding can be resolved with a late-mixed-dentition mandibular lingual arch[13] (Fig. 7). The mandibular second deciduous molars may need to be removed to allow the crowding to resolve by distal drifting of the canines and first premolars into the edentulous space.[13] The lingual

Fig. 8 (cont.) Case 6. B. After 18 months of Phase II treatment with fixed appliances.

arch is left in place until the permanent second molars erupt, with good long-term stability (Fig. 8).[14] The intermolar angle between the first and second molars must be evaluated before lingual arch placement, because there is a more of a tendency for mandibular second permanent molar impaction when this angle exceeds 24°.[15]

Serial extraction is appropriate in 15% of cases—those that exhibit severe crowding of 8mm or more[16] (Fig. 9). Indications for serial extraction are Class I occlusions with more than 7-8mm of crowding per arch. These patients should have protrusive dentitions, full faces, shallow overbites or open bites, and no missing or ectopic teeth. Serial extraction is

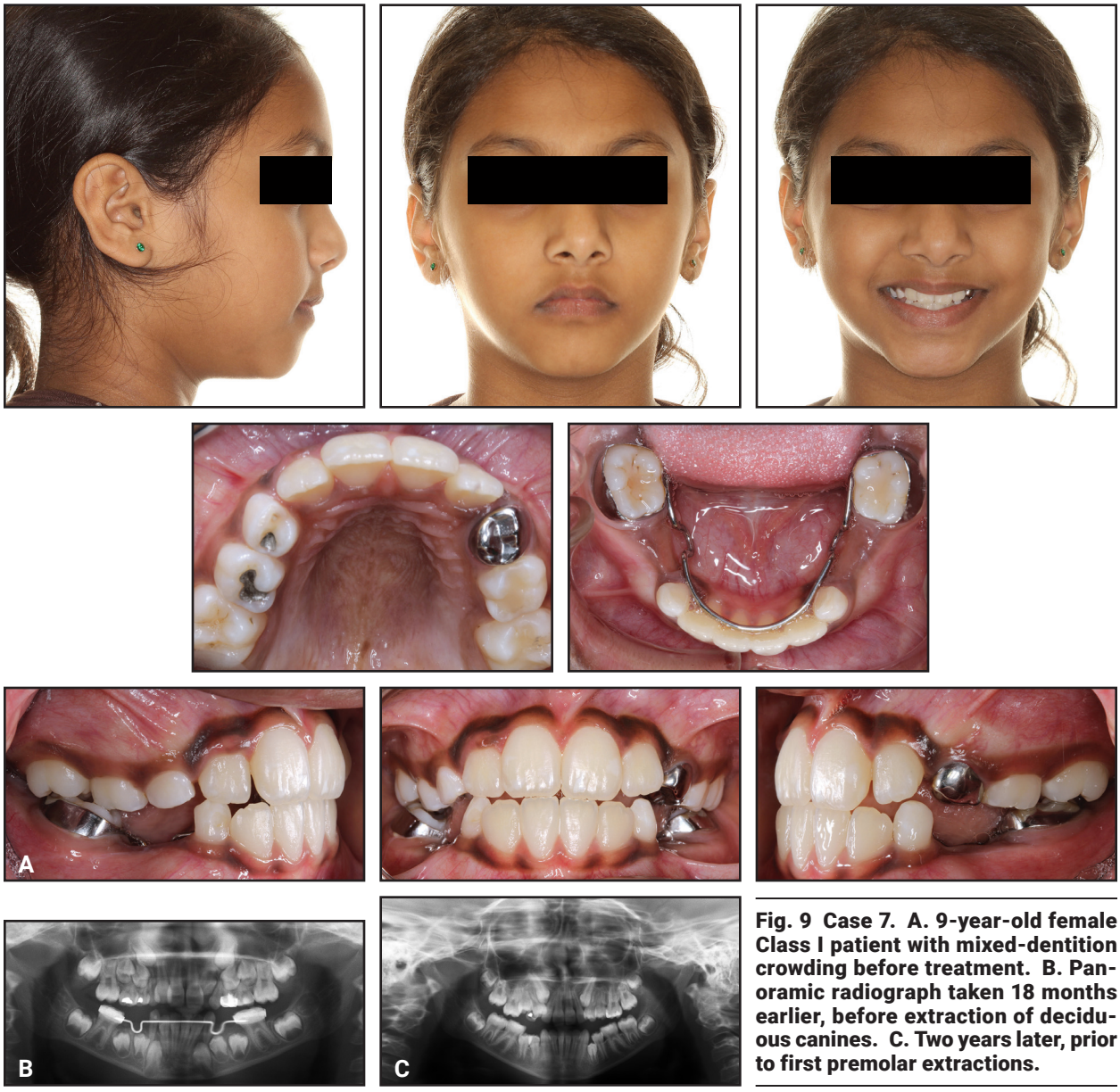

Fig. 9 Case 7. A. 9-year-old female Class I patient with mixed-dentition crowding before treatment. B. Panoramic radiograph taken 18 months earlier, before extraction of deciduous canines. C. Two years later, prior to first premolar extractions.

contraindicated in patients with flat profiles, short lower faces, retrusive incisors, or minimal crowding. Severely bimaxillary protrusive patients, who require maximum retraction of the incisors, are not suitable candidates for serial extraction.

Serial extraction involves deciduous canine extractions as the lateral incisors erupt, allowing the crowded permanent incisors to spontaneously align. At age 9-10, the first deciduous molars are extracted. The purpose is to accelerate the eruption of the first premolars. Because normal maxillary eruption involves the first premolars erupting ahead of the canines, this is seldom needed in the maxilla. The first premolars are then extracted

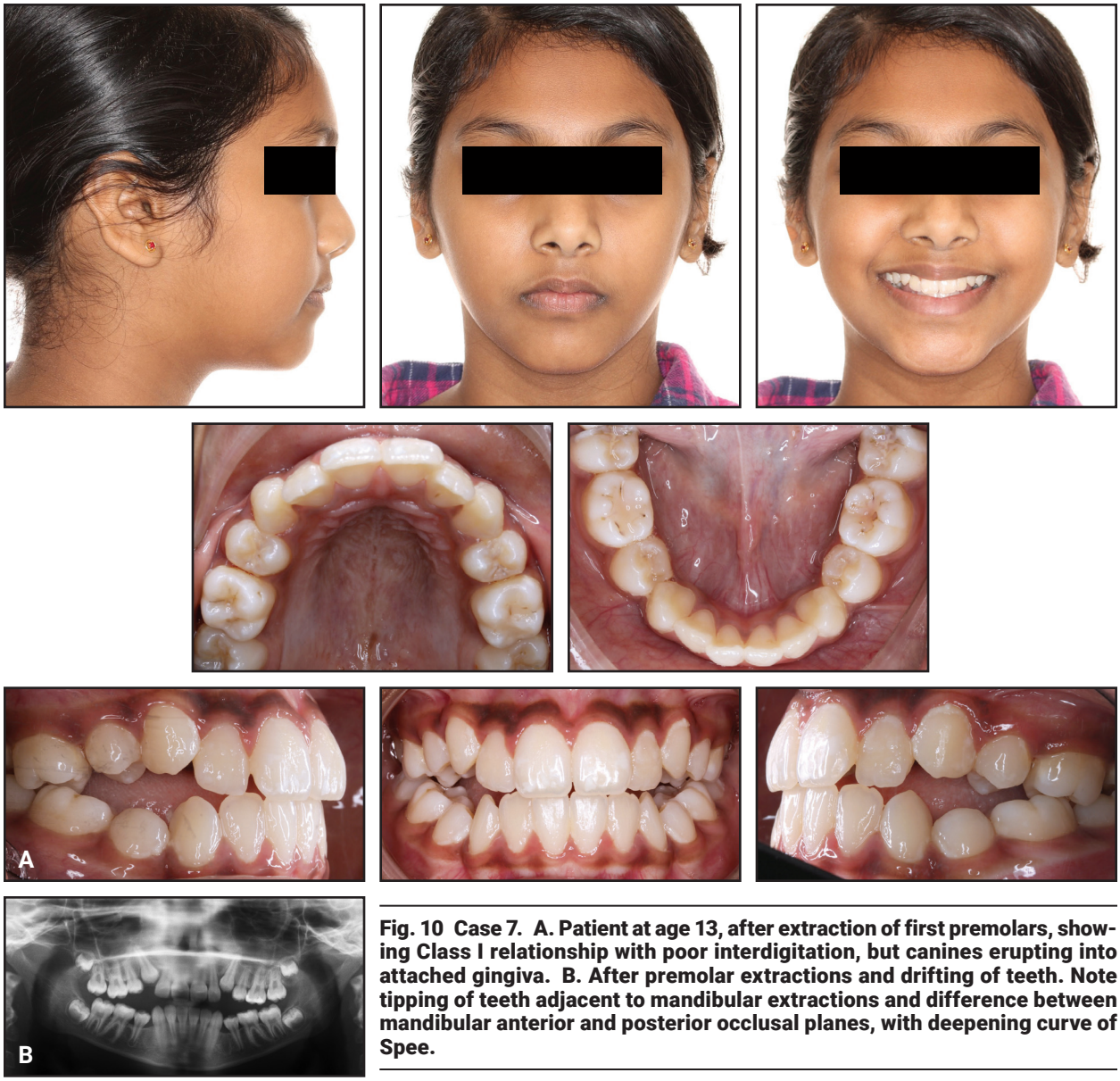

Fig. 10 Case 7. A. Patient at age 13, after extraction of first premolars, showing Class I relationship with poor interdigitation, but canines erupting into attached gingiva. B. After premolar extractions and drifting of teeth. Note tipping of teeth adjacent to mandibular extractions and difference between mandibular anterior and posterior occlusal planes, with deepening curve of Spee.

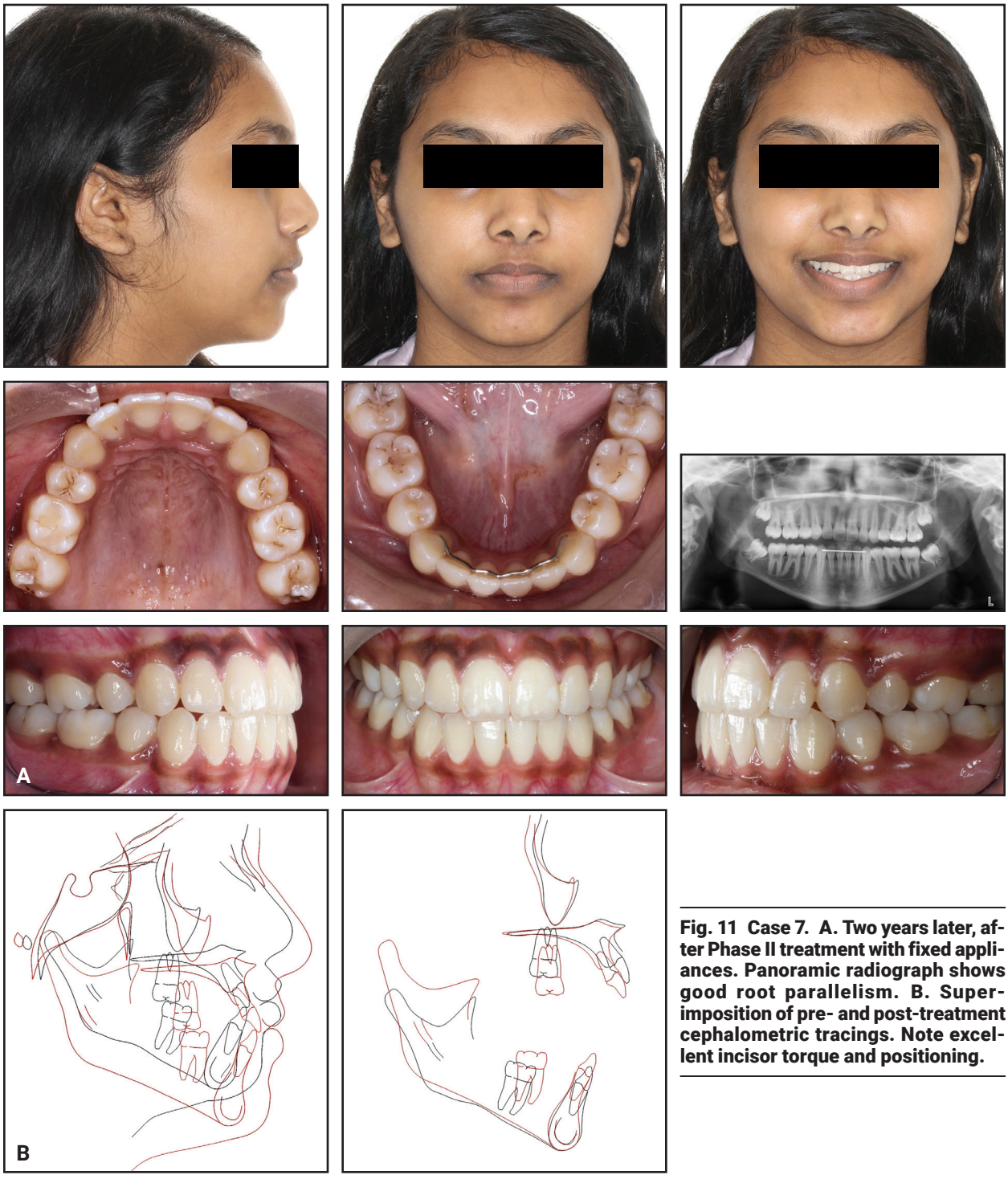

Fig. 11 Case 7. A. Two years later, after Phase II treatment with fixed appliances. Panoramic radiograph shows good root parallelism. B. Superimposition of pre- and post-treatment cephalometric tracings. Note excellent incisor torque and positioning.

upon eruption, usually at age 11-12 (Fig. 10). One modification to be considered is whether the premolars should be enucleated rather than extracted upon eruption. This is particularly indicated when the permanent canine is erupting ahead of the first premolar. Some children are apprehensive about extractions; as a result, serial extractions can become an adverse behavioral issue for needle-phobic children. After extractions and before braces, there is a period of what is commonly called "driftodontics," in which spontaneous alignment occurs.[17]

A major advantage of serial extraction is that the crowded permanent canines are not displaced buccally from the arch, so they erupt into the attached gingiva. Crowding tends to improve because of the extractions,[18] but we commonly see tipping of the mandibular teeth adjacent to the extraction sites. The mandibular curve of Spee also deepens, with a difference between the mandibular posterior and anterior occlusal planes. Comprehensive treatment to detail the alignment, close residual extraction spaces, and parallel the roots should be done in the early permanent dentition, with a reduced treatment time because of the spontaneous alignment[18] (Fig. 11). Serial extraction cases also have a lower Peer Assessment Rating score compared with late premolar extraction cases, making them easier to treat.[18]

DR. SINCLAIR What diagnostic principles do you follow?

DR. KENNEDY Diagnosis is the same for early and late treatment.[19] This is best handled by looking at the face, followed by a "planes of space concept"—looking at the anteroposterior, transverse, vertical, and perimeter planes of space. A family history, especially as it relates to anteroposterior crowding, missing teeth, and parental treatment, is most helpful. Other information, such as the patient's or parents' chief complaint, anticipated child cooperation, and occlusal function, will be useful. Other factors to consider include TMJ, occlusion, and airway.

Full orthodontic records are necessary. Written diagnostic findings with objectives made from the problem list, based on the planes of space database, will lead the clinician to develop treatment alternatives.[19] These alternatives should include the advantages and disadvantages, leading to informed consent. From there, the treatment goals are selected, and, lastly, the appliance is chosen—not the other way around. Too often, a clinician takes a continuing education course and wants to use a certain appliance. Treatment in the mixed dentition should be objective- and not appliance-driven.

"Objective-driven" treatment includes expanding the maxilla to correct a unilaterally presenting posterior crossbite by eliminating a functional shift, thus reducing asymmetry. I try to use a short duration, 12-15 months or less, to achieve the objectives. Patient fatigue is then reduced should future Phase II treatment be needed. Parents may have limited funds or insurance coverage for their children's orthodontic treatment; responsible clinicians will factor this into their best short- and long-term decision-making. Extended, expensive Phase I treatment will unnecessarily increase patient costs and may reduce future insurance coverage if Phase II treatment is needed.

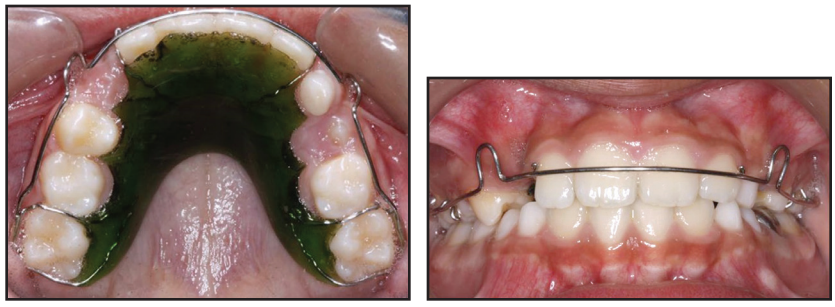

Fig. 12 Mixed-dentition maxillary Hawley retainer with Adams clasps on first molars, spurs to control incisors, and labial bow soldered to Adams clasps; acrylic cleared away from premolars and canines.

DR. SINCLAIR What important mechanical principles do you employ?

DR. KENNEDY Keep it simple. When using slow maxillary expansion, keep the expander in place as its own retainer. After active expansion, tie off the expansion screw with a ligature wire. Use slow maxillary expansion and limited fixed appliances with coils to open up space for crowded canines when needed. Avoid long spans in 2 × 4 appliances; deciduous molars can be bonded depending on their longevity and stability. This reduces the chance of wires coming out with the help of the child's fingers! For retention, I use a Hawley with Adams clasps on the upper first molars and a soldered labial bow, and I keep the acrylic away from the erupting permanent premolars and canines (Fig. 12).

DR. SINCLAIR What is your best clinical tip?

DR. KENNEDY Use fixed appliances as much as possible to eliminate the need for patient compliance. When using partial fixed appliances, be mindful of the deciduous tooth's longevity. Remember that the malocclusion is stable, so don't move teeth beyond the alveolar housing. Maxillary expansion is quite stable, while mandibular expansion is often followed by a reduction in intercanine width and relapse. Therefore, try to avoid lower-arch expansion.[20]

DR. SINCLAIR What is your greatest clinical challenge?

DR. KENNEDY Choosing the best cases to treat early. A great place to start is to select mixed-dentition cases that present with good mandibular arches. The clinician is then faced with changing the maxillary arch to meet the good mandibular arch. The outcomes are usually best when this strategy is used. The earlier mixed-dentition treatment is started, the more extended will be the time available to evaluate its long-term success, since both relapse and normal growth can occur after the initial treatment. Comprehensive knowledge of the normal growth and development of the skeleton and dentition is essential.

There are many other instances of appropriate early orthodontic treatment that have been omitted from this article for space reasons. They will be covered in future articles.

DR. SINCLAIR Thank you for sharing your clinical experience with our readers.

ACKNOWLEDGMENTS: Dr. Kennedy gratefully acknowledges the assistance of Drs. James Andrews and Abdulraheem Alwafi (graduate orthodontic students at UBC), who handled the proofreading, illustrations, and references.

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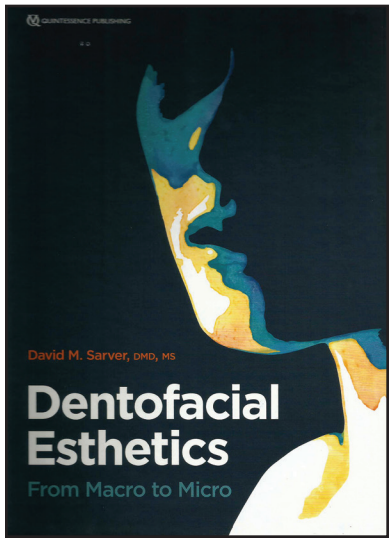
BOOK REVIEWS

Dentofacial Esthetics: From Macro to Micro

DAVID M. SARVER, DMD, MS

512 pages, 2,500+ illustrations. $268. 2020.
Quintessence Publishing Co., Inc.
411 N. Raddant Road, Batavia, IL 60510
(800) 621-0387; www.quintbook.com.

It is indeed my pleasure to review the latest text by David Sarver, whom I have admired as a superb clinician, author, and speaker. This large-format, 512-page book is easy to read and profusely illustrated with treatment histories.



Of the eight chapters, the first is an introduction that describes in personal terms the treatment of a patient who severely damaged her dentition, compromising her smile and facial esthetics. The next chapter discusses Dr. Sarver's soft-tissue paradigm, elaborating with patient examples how problem- and goal-oriented orthodontic treatment planning can be integrated.

Chapter 3 offers a detailed description of macro-, mini-, and micro-esthetics and the components of balanced facial esthetics. A case history-based analysis and strategies are presented for lifetime esthetics in both adolescent and adult patients. Principles of treatment planning are summarized in the subsequent chapter, taking the reader step-by-step through data acquisition and positioning of teeth based on various components, including the smile zone.

Chapter 5 discusses such clinical problems as gummy smile, hypermobile smile, vertical maxillary deficiency, asymmetrical smile, and smile issues related to tooth dimensions. The following chapter covers micro-esthetic improvements involving gingivoplasty for crown lengthening, as well as its timing during treatment. Several case histories are presented, based on a macro-, mini-, and micro-esthetic evaluation. Chapters 7 and 8 describe management of congenitally missing teeth and interdisciplinary care, including esthetic considerations in orthognathic and plastic surgery.

Kudos to Dr. Sarver for tackling the subject of esthetics, which has often received less attention than it deserves. He emphasizes that orthodontics is about more than managing occlusion; "it's about creating faces and smiles that are functional and beautiful." I highly recommend this book to orthodontists and graduate students, and also to dentists and surgeons who seek to manage smile zone and facial esthetics.

RAVINDRA NANDA, BDS, MDS, PhD

CASE REPORT

Resolution of a Complex Malocclusion Using a Hybrid Aligner Approach

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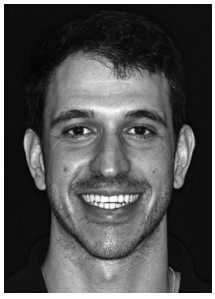
LUCA LOMBARDO, DDS, MS

Clear aligner therapy is often the treatment of choice in today's orthodontic practice, especially for nonextraction cases of mild to moderate difficulty.[1] Aligners offer optimal esthetic properties and patient comfort, making them particularly suitable for adults.[2] In addition, because they are removable, they are less likely to impact periodontal health.[3]

Although diagnostic indications for clear aligner therapy have broadened, some orthodontic movements remain unpredictable, even with good treatment planning.[4] Extrusion, intrusion, bodily movements, torque, and substantial rotations of rounded teeth are difficult to manage using clear aligners alone,[5] making them less efficient than conventional biomechanics in complex treatment.[6] Extrusion or rotation auxiliaries or interarch elastics are therefore often needed.[7,8] Another approach is to use partial or full fixed appliances to correct the most critical problems before or during clear aligner therapy.[9]

One such problem, scissor bite, is an alteration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in the normal relationship between the cusps and fossae of antagonistic teeth. Although the incidence of scissor bite is rare—1.1% of the children investigated in one study[10]—it can create issues with masticatory function and growth patterns in prepubertal patients due to functional displacement of the lower jaw.[11] Since there are discrepancies in both the vertical and buccopalatal dimensions, a scissor bite is difficult to correct using only clear aligners.[11]

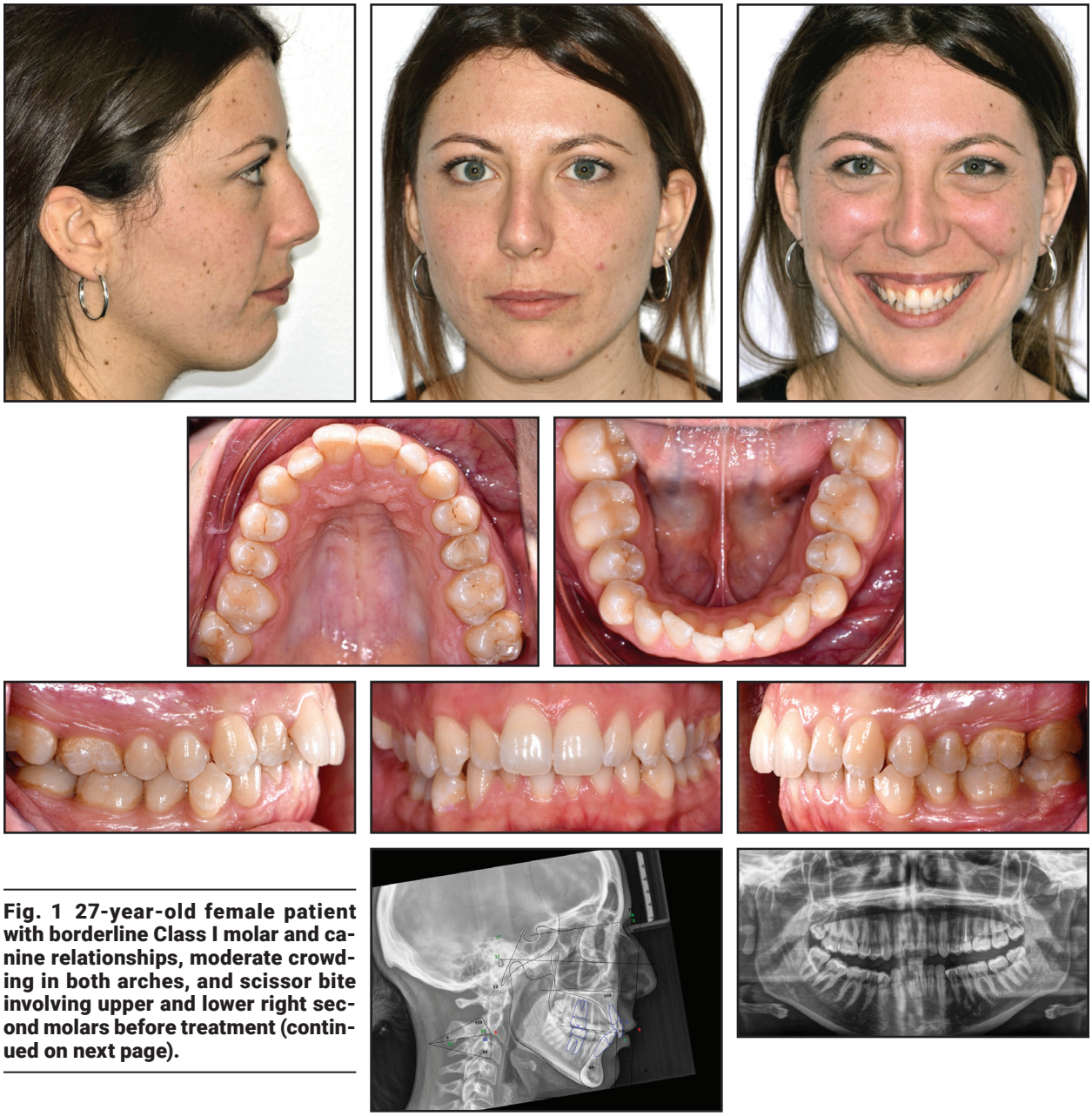


Fig. 1 27-year-old female patient with borderline Class I molar and canine relationships, moderate crowding in both arches, and scissor bite involving upper and lower right second molars before treatment (continued on next page).

Orthodontic miniscrews have made it possible to resolve complex anomalies such as scissor bite without loss of anchorage.[12,13] Miniscrews are safe, inexpensive, and minimally invasive and have a wide range of clinical applications, owing to their small size and ease of placement and removal.

This report shows a patient with a unilateral scissor bite of the upper and lower right second molars who was treated using a hybrid approach—involving clear aligners and fixed buccal sectional appliances with miniscrew anchorage—after aligners alone failed to achieve the planned outcome.

Diagnosis and Treatment Plan

A 27-year-old female presented with the chief complaint of unsightly front teeth and traumatic biting in the right posterior cheek region (Fig. 1). Extraoral analysis found a convex profile, a long lower third of the face, and lip strain from the attempt to achieve lip competence. The patient had a gummy smile with complete incisor exposure, bilateral buccal black corridors, and a slight occlusal cant. She had borderline Class I molar and canine relationships with excessive overbite and overjet. The lower midline was deviated 1mm to the left of the upper midline, and the curve of Spee was accentuated on both sides. Moderate crowding and malalignment were present in both arches. A scissor bite of the upper and lower second molars was observed on the right side.

The patient did not report any TMJ symptomatology, as confirmed by the clinical and functional exam. All teeth were present on the panoramic radiograph. Cephalometric analysis (Table 1) indicated a moderate biretrusive skeletal Class II (ANB = 5.5°) with a primarily mandibular component (SNB = 73.8°) and a hyperdivergent pattern (FMA = 31.5°). Upper and lower incisor inclinations seemed to be normal.

The main treatment objectives were to maintain the bilateral Class I molar and canine relationships, resolve the malalignment and crowding in both arches, reduce gingival exposure in smiling, center the midlines, and improve lip competence. An additional objective was to correct the scissor bite and resolve the traumatic biting issue in the right cheek region.

Because the patient requested esthetic treatment, conventional fixed labial appliances were not

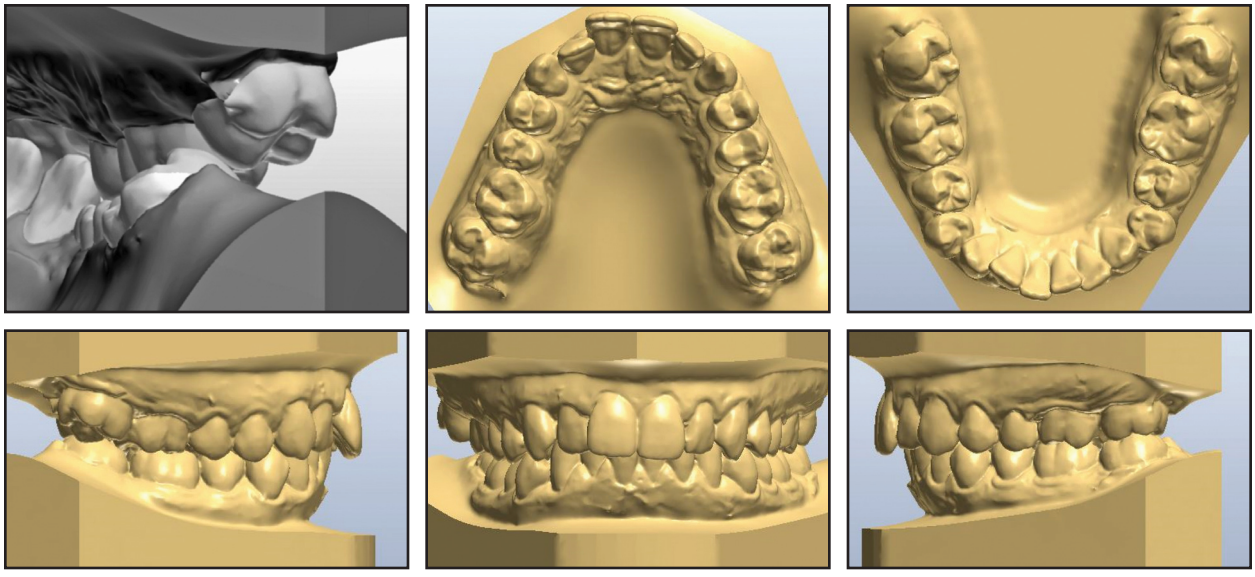


Fig. 1 (cont.) 27-year-old female patient with borderline Class I molar and canine relationships, moderate crowding in both arches, and scissor bite involving upper and lower right second molars before treatment.

TABLE 1
CEPHALOMETRIC ANALYSIS

	Normal	Pretreatment	Post-Treatment
Horizontal skeletal			
SNA	82.0°	79.2°	79.3°
SNB	80.0°	73.8°	73.7°
ANB	2.0°	5.5°	5.7°
A-Na perp	1.0mm	−0.5mm	−0.9mm
Pg-Na perp	−2.0mm	−9.3mm	−10.6mm
Wits appraisal	−1.0mm	+6.3mm	+4.8mm
Vertical skeletal			
FMA (MP-FH)	26.0°	31.5°	32.6°
MP-SN	33.0°	41.9°	42.4°
Palatal-mandibular angle	28.0°	32.2°	32.5°
Palatal-occlusal plane	10.0°	6.1°	8.7°
Mandibular plane-Occlusal plane (PP-OP)	17.4°	26.1°	23.8°
Maxillary-occlusal plane (MxOP-N perp)	95.6°	95.4°	98.7°
Anterior dental			
U1 protrusion (U1-APo)	6.0mm	7.7mm	6.1mm
L1 protrusion (L1-APo)	1.0mm	2.6mm	2.3mm
U1-Palatal plane	110.0°	109.0°	106.0°
U1-Occlusal plane	57.5°	64.9°	65.3°
L1-Occlusal plane	72.0°	59.8°	60.0°
IMPA	95.0°	94.1°	96.2°

considered. We evaluated the possibility of using lingual appliances, but the marked lingual inclination of the lower right second molar and the close contact between the buccal surface of the lower right second molar and the lingual surface of the upper right second molar would have hindered lingual bracket placement on these teeth. A lingual bracket on the upper right second molar would likely have been sheared off due to premature contact with the opposing arch. An alternative was to bond lingual brackets to all teeth except the upper and lower right second molars, where buccal tubes could be placed using the so-called "crossover technique."[14] Despite this viable option, the patient preferred an appliance that would be less invasive and more comfortable than a full lingual setup.

We therefore proposed an esthetic approach using clear aligner therapy. We recognized that the unilateral scissor bite would be more difficult to resolve because the posterior section of the aligner

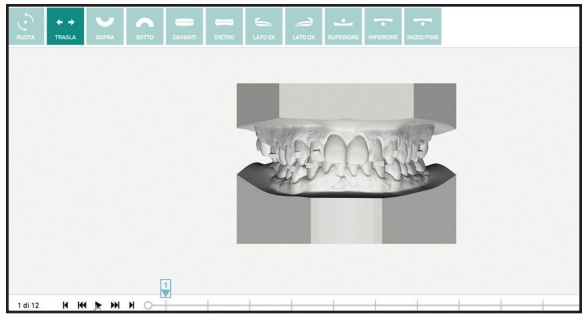
is more elastic, and it is therefore less suitable for delivering the orthodontic forces and moments necessary to resolve such a complex problem.

Treatment Progress

The patient was advised to have all four third molars extracted before orthodontic treatment.

Digital models were then obtained from a CS 2600* intraoral scanner, and a digital setup was performed. The first phase of treatment involved a series of 12 individualized F22** clear aligners per arch (Fig. 2). In the upper arch, grip points

*Carestream Dental LLC, Atlanta, GA; www.carestreamdental.com.
**Sweden & Martina, Due Carrare, Italy; www.f22aligner.com.



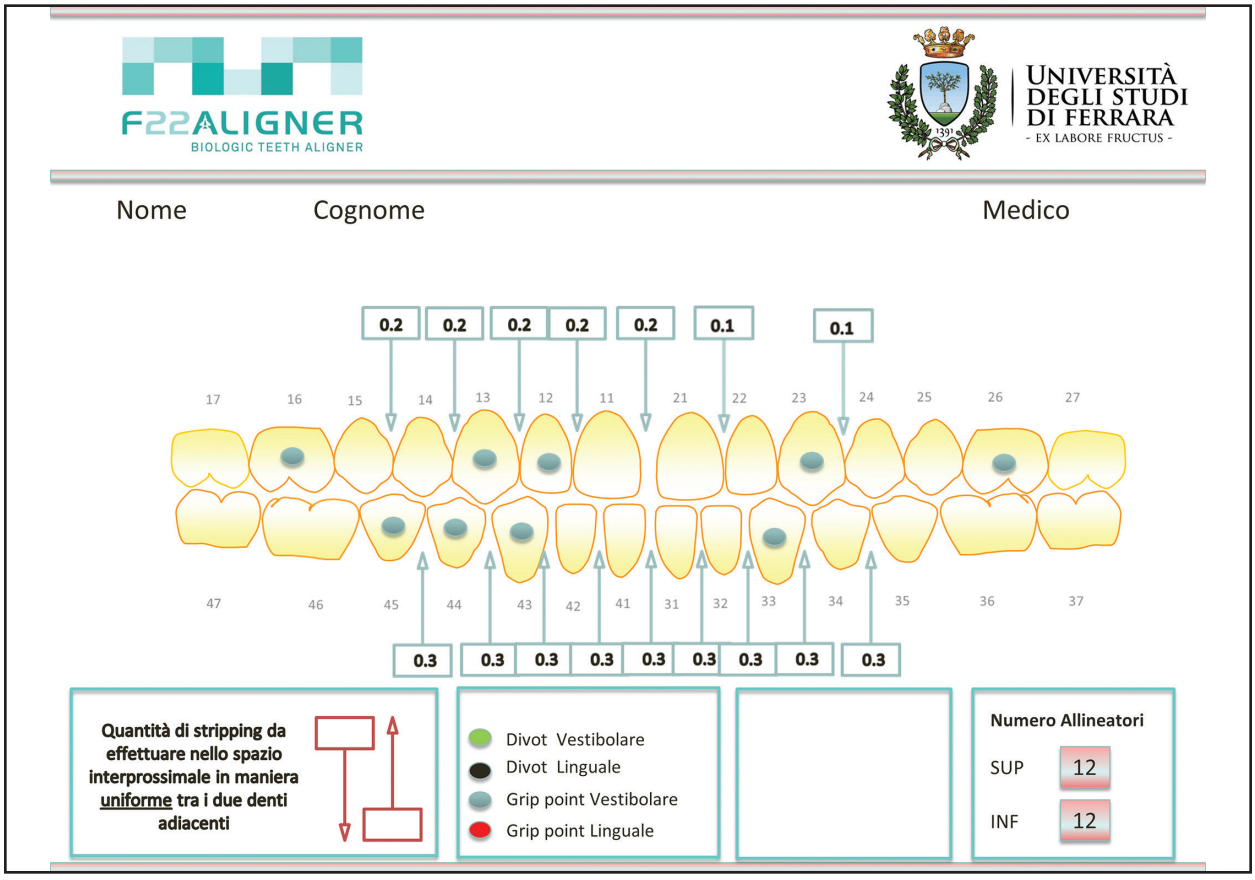


Fig. 2 Virtual setup for F22 aligners.**

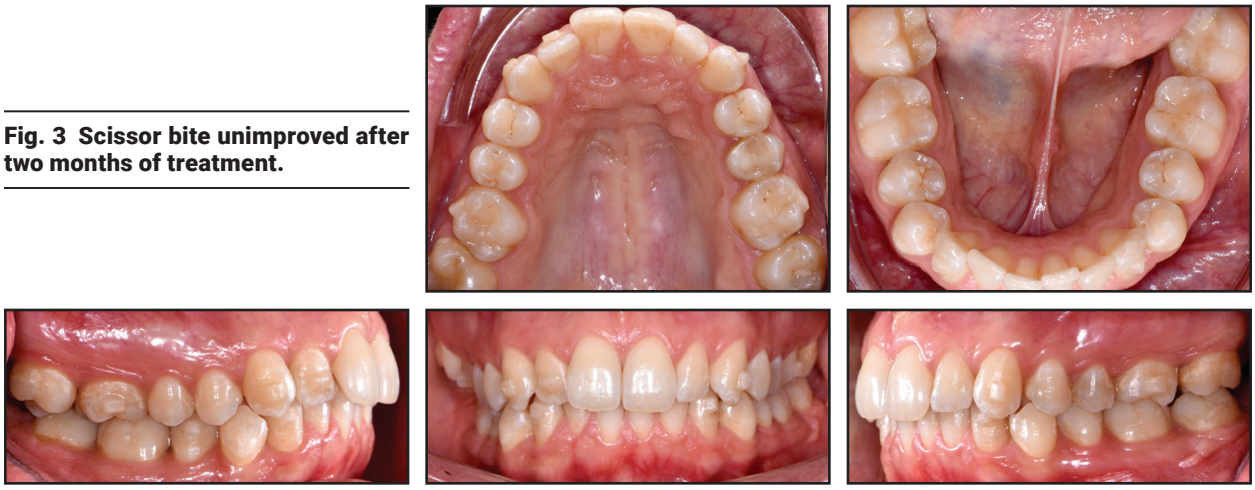


Fig. 3 Scissor bite unimproved after two months of treatment.

were positioned on the right first molar (8.8° distal rotation), left first molar (11.7° distal rotation), right canine (8.1° mesial rotation), left canine (15.9° mesial rotation), and right lateral incisor (.6mm extrusion). In the lower arch, grip points were placed at the left canine (10.6° mesial rotation), right canine (7.5° distal rotation), right first premolar (16.1° mesial rotation), and right second premolar (18.1° mesial rotation). The patient was instructed to wear each pair of aligners 22 hours per day for 15 days, removing them only for meals and brushing.

The patient was seen monthly to check progress and to perform the interproximal reduction (IPR) needed to facilitate the rotation and extrusion movements and resolve the crowding. The amount of IPR prescribed in the upper arch was .2mm from the mesial contact of the right second premolar to the mesial contact of the right central incisor, and .1mm at the contact points between the left central and lateral incisors and the left canine and first premolar. In the lower arch, .3mm of IPR was prescribed from the mesial contact of the left second premolar to the mesial contact of the right second premolar.

After two months of treatment, the scissor bite had not improved, and the patient complained of difficulty in fitting the aligners over the posterior regions of both arches (Fig. 3). With the patient's consent, we decided to cut off the remaining aligner trays on the right side in both arches and to end the first phase of therapy, postponing the correction of the scissor bite to the refinement stage. The patient was instructed to wear each pair of modified aligners for 10 days. This first treatment phase lasted four months and 20 days (Fig. 4). The crowding and malalignment were resolved, gingival exposure in smiling was reduced, and the midlines were partially centered.

The aims of the second phase were to refine the occlusion and the alignment, fully center the midlines, and resolve the right posterior scissor bite. To improve the predictability and efficiency of the scissor-bite correction, a hybrid approach was planned using aligners with fixed buccal sectional appliances, orthodontic miniscrews, and criss-cross elastics. Brackets*** were bonded to the upper right first and second molars and the lower right first and second molars, and .016" × .022" nickel titanium wires† were placed (Fig. 5). A 1.5mm × 8mm orthodontic miniscrew‡ was manually inserted into the buccal interradicular space between the lower right second premolar and first molar. An .017" × .025" stainless steel sectional wire† was attached from the screw head to the buccal surface of the lower right first molar to obtain indirect anchorage for buccal uprighting of the lower right second molar. Temporary bite turbos were built with light-cured flowable resin on the occlusal surfaces of the mandibular first molars

Fig. 4 After four months and 20 days of treatment (end of first phase).

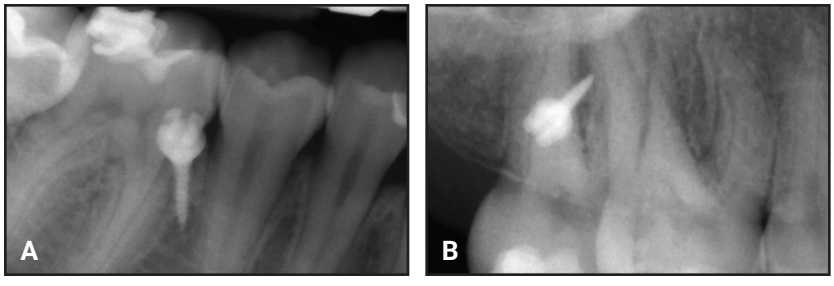


Fig. 5 A. Miniscrew‡ inserted in interradicular space between right second premolar and first molar. B. Miniscrew inserted in interradicular space between upper right first and second molars.

***Legend LP tubes, GC America, Inc., Alsip, IL; www.gcamerica.com.
†GC Orthodontics Europe GmbH, Breckerfeld, Germany; www.gcorthodontics.eu.
‡Spider Screw K1 short neck, registered trademark of HDC SRL, Thiene, Italy. Distributed by Ortho Technology, Inc., Lutz, FL; www.orthotechnology.com.

to facilitate scissor-bite correction.

After the sectional appliances were placed, new intraoral scans were taken and a refinement setup was performed, involving eight trays in each arch. Before the refinement aligners were delivered, a 1.5mm × 8mm palatal miniscrew was inserted in the interradicular space between the upper right first and second molars, and metal buttons were bonded to the palatal surfaces of the upper right second molar and the lower right second molar. An elastic chain was connected directly between the miniscrew and the palatal button on the upper right second molar to exert an intrusive force for the scissor-bite correction (Fig. 6). A criss-cross elastic was applied between the hook on the buccal tube of the upper right second molar and the lingual button on the lower right second molar.

The refinement aligners were delivered to the patient, who was instructed to wear each pair for 20 days to allow scissor-bite resolution without unwanted extrusion of the other teeth due to temporary bite-raising, which might have worsened the patient's facial divergence. The combination of buccal sectional appliances, miniscrews, and criss-cross elastics generated sufficient intrusion forces and moments to enable correction of the scissor bite within about five months (Fig. 7).

A month later, .019" × .025" nickel titanium orthodontic archwires were placed in the upper and lower arches, while the criss-cross elastics continued to be worn. The refinement stage lasted five months and 10 days. The miniscrews were then removed, and removable retainers were delivered.

Treatment Results

After a total 10 months of treatment, the objectives had been achieved (Fig. 8). Both the lip competence and the anterior dental display in smiling were improved. The Class I molar and canine relationships were preserved, the anterior crowding and malalignment were corrected, the midlines were fully centered, and satisfactory overjet and

Fig. 6 A. Intrusion of upper right second molar with elastic chain between lingual button and miniscrew. B. Criss-cross elastic placed between buccal tube hook on upper right second molar and lingual button on lower right second molar.

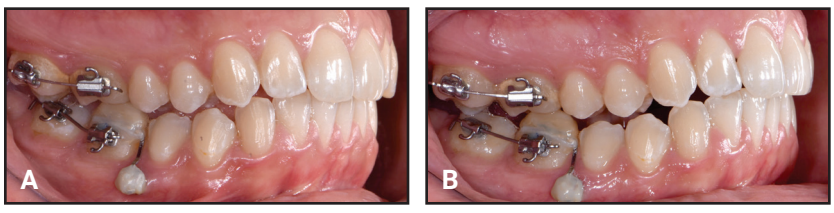


Fig. 7 A. Beginning of refinement stage, five months after start of treatment. B. One month later, with .019" × .025" nickel titanium sectional archwires placed in both arches and criss-cross elastics continued.

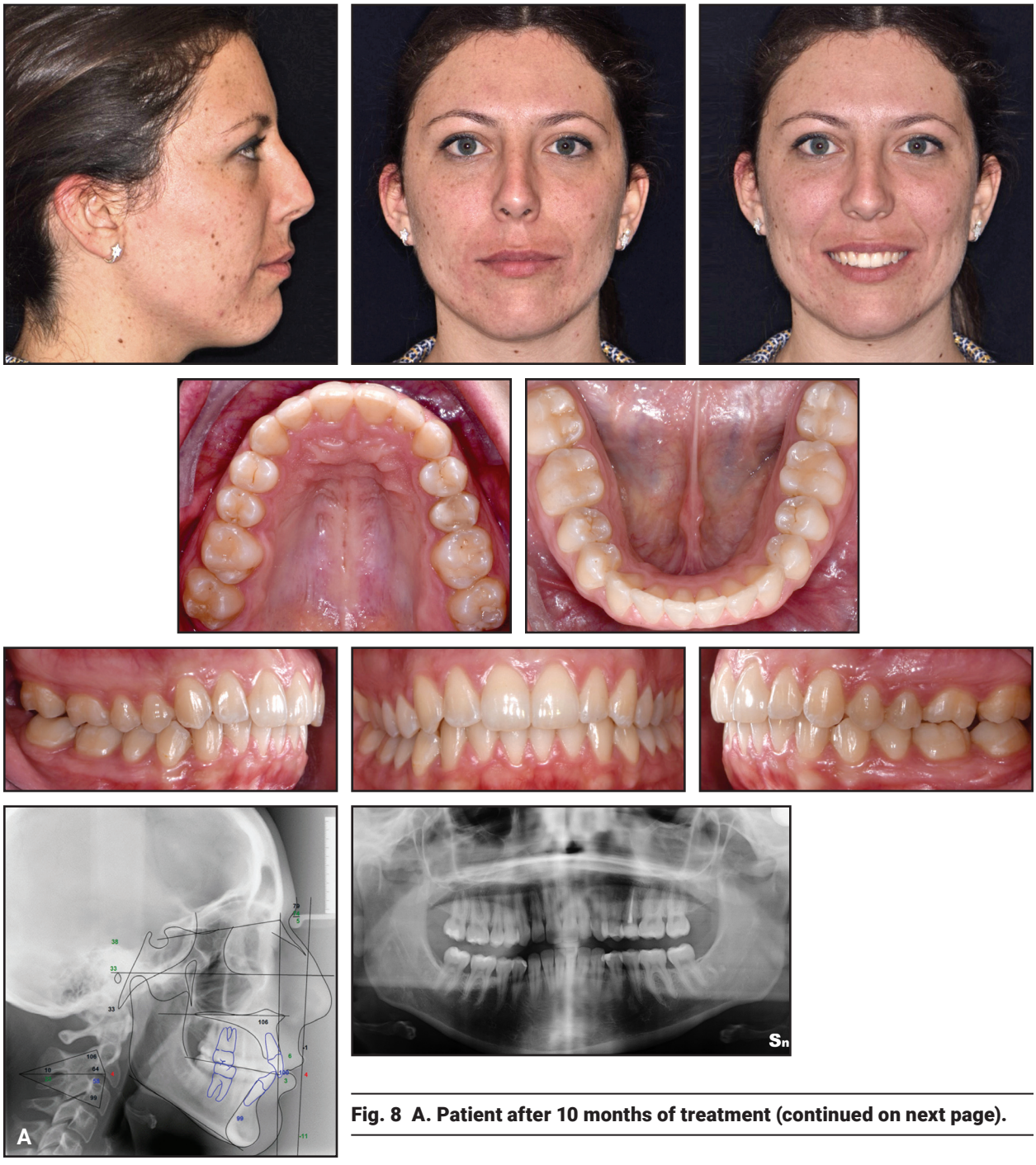


Fig. 8 A. Patient after 10 months of treatment (continued on next page).

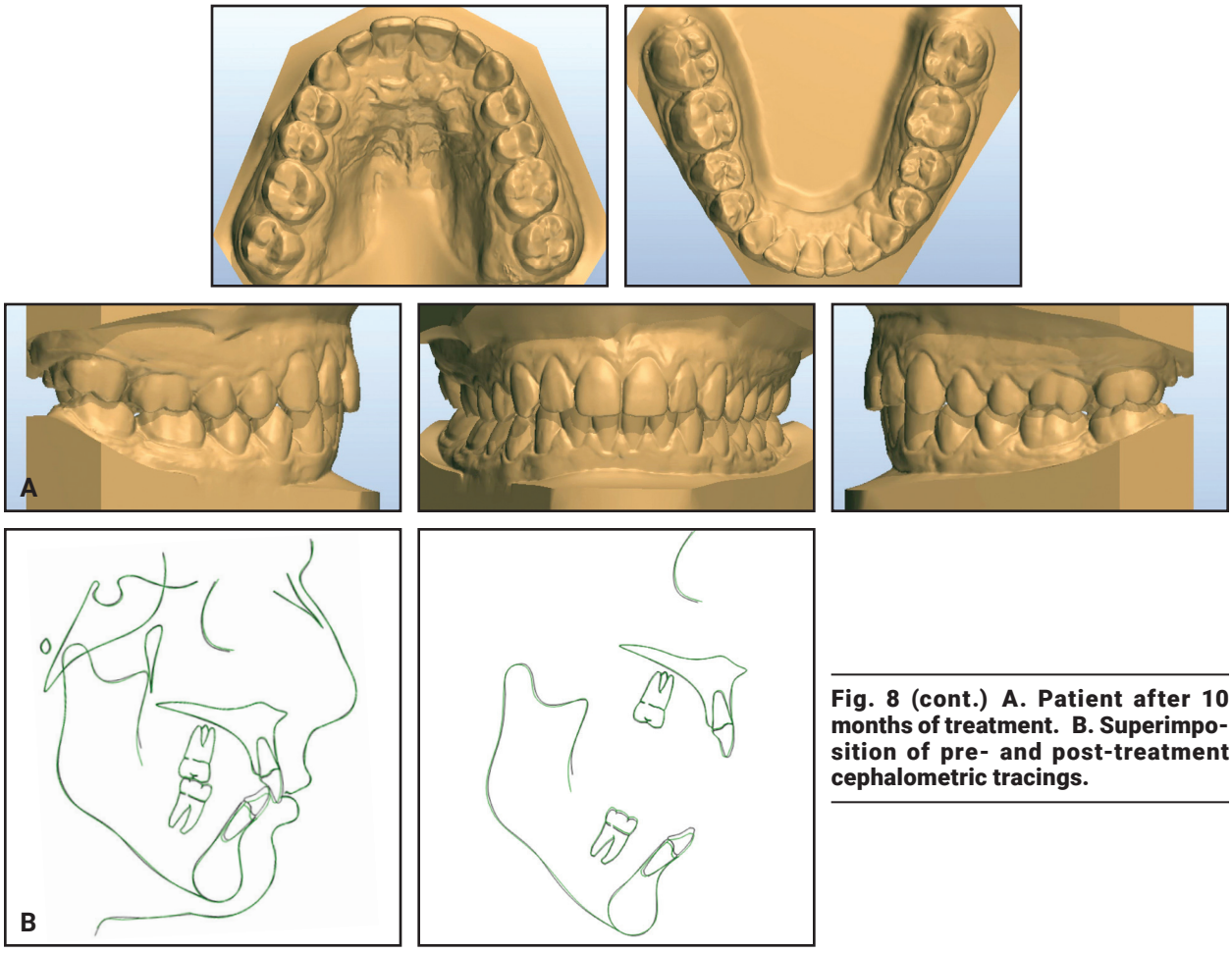


Fig. 8 (cont.) A. Patient after 10 months of treatment. B. Superimposition of pre- and post-treatment cephalometric tracings.

overbite were attained. The scissor bite on the right side was resolved.

The post-treatment panoramic radiograph showed good root parallelism with no signs of root resorption or bone defects. Cephalometric analysis confirmed retroclination of the upper anterior teeth and slight intrusion and proclination of the lower teeth (Table 1). The skeletal divergence did not worsen, and a proper vertical facial relationship was maintained.

Discussion

This report shows how a complex case with a posterior scissor bite can be treated by means of a hybrid aligner approach involving aligners and other auxiliaries. Correction of the scissor bite was imperative not only because of its potential to compromise periodontal health, but also because the patient complained of traumatic biting of the inner right cheek. It was impossible to use full lingual appliances, and the patient declined a combination of lingual brackets with buccal tubes on the upper and lower right second molars.[14] We therefore attempted to correct the malocclusion using clear aligner therapy, even though there was little chance of completely resolving the scissor bite. In fact, after two months, we decided to cut off the remaining aligners distal to the first molars to complete the alignment of both arches.

Before digital impressions were taken for the refinement stage, we planned to correct the scissor bite using sectional appliances with miniscrew anchorage. Combined with criss-cross elastics and the favorable mechanical and esthetic properties of the F22 aligners,[4] this created the system of forces and moments required to resolve the scissor bite without compromising the patient's periodontal health.[15]

This case report is similar to that presented by Tamamura and colleagues, in which a scissor bite at the second molars was corrected using an upper lingual appliance and a lower labial appliance, with skeletal anchorage in the upper arch.[16] Unlike those authors, however, we used skeletal anchorage in both arches, along with criss-cross elastics.

In the second phase of our treatment, the occlusion and the anterior alignment were improved by clear aligner therapy while the scissor bite was corrected by the fixed component. Comparison of pre- and post-treatment cephalometric tracings showed that only dentoalveolar effects were obtained, including retroclination of the upper anterior segment and intrusion and proclination of the lower anterior teeth (Fig. 8B). The superimpositions demonstrated proper control of the patient's skeletal divergence.

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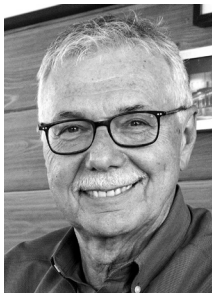
The Golden Age of Orthodontics: Already Ended or Just Beginning?

LEON KLEMPNER, DDS

I'm an orthodontist, just like you. The only difference is that I practiced at a different time.

Dr. Klempner is a retired orthodontist and CEO of People & Practice, a digital marketing consultancy exclusively for orthodontists. For more information, call 888-866-DOCS, go to www.pplpractice.com, or e-mail leon@pplpractice.com.



I went out and started my own practice from scratch, somewhat through trial and error, but also by drawing on my education and the mentors available within the orthodontic community. My practice grew over the years. I opened a satellite office, brought on a partner, and, at the age of 65—after more than 40 years of practicing orthodontics—I sold that business. After retiring from private practice, I became CEO of a digital marketing consultancy for orthodontists that my daughter Amy and I started in 2011.

I've been blessed. I love our profession and, yes, I'm as concerned as you are about the future of our specialty. I've heard the chatter. Younger orthodontists tell me how lucky I was to practice in the "Golden Age" of our profession. Looking back, I suppose I did have a much easier time, because change came more slowly than it does now. I also remember thinking as a resident, however, how lucky my instructors were because they practiced in what I thought of as the Golden Age. I presumed the era of pinching bands and placing dumbbell separators between lower incisors had been the best time to be an orthodontist.

The Golden Age seems to be perpetually in our rearview mirror. In reality, change is always happening. Progress is always being made. I actually believe we are just on the verge of a new Golden Age of orthodontics. You see, it's not just the change—and COVID-19 has only accelerated this evolution in the orthodontic industry—but how you react to the change that will determine whether your practice is entering or exiting a Golden Age of its own.

Let me give you a few examples from my own practice over the years. When I began my career, there was no orthodontic insurance. When it became more widespread, I was one of the last to accept it as partial payment. It was a philosophical decision, because I believed the relationship should be between the patient and the insurance company. As more and more orthodontists began accepting insurance and my practice growth leveled off, however, I had to reevaluate my position. During the gas and housing crisis in the early 1980s, I also reevaluated my financial arrangements; I no longer required a 25% down payment to get treatment started.

At any point, I could have thrown up my hands, lamenting the changes in our industry. Instead, I made adjustments to adapt to the changing business environment. Sometimes they were painful. But in the end, they worked out, and I learned something: whether I liked the change or not, I had to adapt to survive.

Change is happening again. And as I said, it is coming at a much faster pace than ever before.

10 Things to Do Today

In light of the rapidly changing business climate, our clients often ask, "What would you do?" I believe we can adjust the way we run our practices *without* compromising our principles and can continue to serve our patients well.

What would I do now? Here are 10 things that come to mind if I were still practicing:

1. Adjust my hours. People are busier than ever. Often, both parents are working. Kids are scheduled down to the last minute with activities. Take a page from the banks, because not even bankers have "banker's hours" anymore. I would definitely add evening and/or weekend hours to make it more convenient for families to make appointments.

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2. Make it affordable. The biggest barriers to entry for most families are the initial payment and monthly options. If you're not doing so already, accept insurance as partial payment. Extend payments beyond treatment time, six to 12 months if necessary. If there is a second child and the family has a good payment history, be flexible and forgo the initial payment. Remember that affordability is more important than your total fee. Various reports, including the biennial JCO Orthodontic Practice Studies, have shown that delinquency rates are extremely low in orthodontics.

3. Be more transparent. I'd give people all the information they need to make a decision at the first visit. Most people want to know how long, how much, and which appliances are appropriate. If I really weren't sure, I'd give them my best approximation and take records. Nowadays, for many families, time is as valuable or even more valuable than money. Don't waste their time just because you think bringing them back three times before starting treatment will raise your conversion rate. It doesn't. It just annoys people.

4. Speak their language. If I were practicing today,

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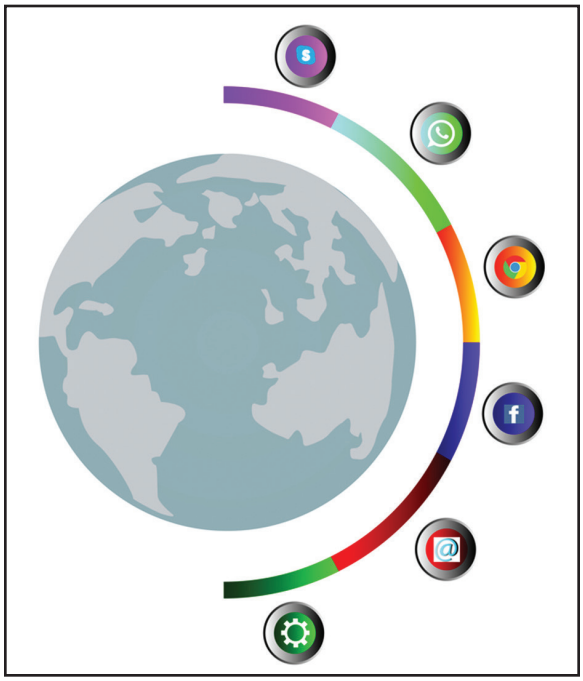
I would adapt my communication and treatment to appeal to "digital natives." Give patients the ability to take a few photos of their teeth and send those in as an initial contact tool. (By the way, this does not replace the records and consultation; it merely offers another way of attracting new patients who are curious about whether they would be aligner candidates, for example. Think of it as your conversation starter.)

5. *Learn to treat more with plastic*. I'd take courses with experienced clear aligner clinicians and learn to treat more cases, without compromising the results I could achieve with plastic. I'd learn how to convert more aligner cases by performing hybrid treatment. Aligner companies spend more than $300 million a year in advertising; you can piggyback on that awareness.

6. *Embrace technology*. It may seem like science fiction, but it's not. Artificial intelligence (AI) is being embedded in almost every new piece of software. I'd begin by learning more about the new AI tools that enable fewer visits with enhanced orthodontic oversight and improved patient communication. I would explore digital printers as a way to lower overhead costs, making simple cases less expensive. Look into remote monitoring platforms that will allow you to manage treatment virtually. Again, time is valuable—for both your patients and your practice.

7. *Take back limited treatment*. I'd discuss all treatment options with new patients, including options of corrective jaw surgery as well as limited treatment, and give my professional recommendation. I'd share what I would do if it were my spouse or child being treated. Recognize, however, that after the case presentation, it's their decision. If they want only limited treatment, and it can be done safely, we should be the ones doing it.

8. *Use social media*. I'd let my patients advertise for me. There are so many strategies you can employ these days that enable your patients to become your best advocates. Online reviews, contests that are open to friends and family (not just patients), and engaging content can incentivize patients to share your practice's brand with their social media networks.



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9. Leverage digital advertising. I wouldn't wait for the legal process to limit my direct-to-consumer (DTC) competition or expect the AAO Consumer Awareness Program to grow my practice. Right now, I'd be educating my community. If you don't have a blog page on your website, start one.

Even that is not enough. Who will read it? I'd use the sophisticated advertising platforms on Facebook* and Instagram* to drive the best prospective patients to my blog content. Digital advertising is smart—it can target multiple data points, including geolocation, age, family status, and a number of other specific criteria. My digital marketing strategy would convey the many benefits of visiting my orthodontic office, comparing my experience and my expertise with DTC alternatives.

10. Lean into DTC. I'd be looking for opportunities to discuss DTC aligners with my patients at every opportunity. My staff would be well trained on this topic. I'd also make sure I had content on my website addressing DTC options, and I'd have a stack of the AAO consumer alert flyers (www.aaoinfo.org/wp-content/uploads/2019/03/AAO-Consumer-Alert-DIY-2019-flier-hl.pdf) to hand out whenever the topic was raised. I would not shy away from the conversation; I would lean right into it. I'd make sure the people in my community really knew the value of seeing an orthodontic specialist. My messaging would promote the benefits of taking x-rays before initiating tooth movement. I'd make sure they knew *why* I require that they be periodically evaluated during orthodontic treatment, instead of just giving them all the aligners without any monitoring. Don't assume people know this already.

How many times have you heard people refer to their general dentists as being orthodontists because they offer aligners? Don't blame them. You may be surprised to learn that many prospective new patients in your local community don't know as much as you think about orthodontics. It's up to us to educate the public on why orthodontists are specialists.

Conclusion

I believe the decision as to whether we are leaving or entering the Golden Age is really a choice that is entirely up to each individual orthodontist. This is what I would do; the more important question is what will *you* do? ■

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PEARLS

Our office is always running out of plastic orthodontic elastic placers. This beautifully illustrated Pearl teaches how to make one chairside in a pinch, using only .036" stainless steel wire and plastic tubing.

NEAL D. KRAVITZ, DMD, MS
Associate Editor for Pearls

An Efficient and Ergonomic Device for Easy Elastic Wear

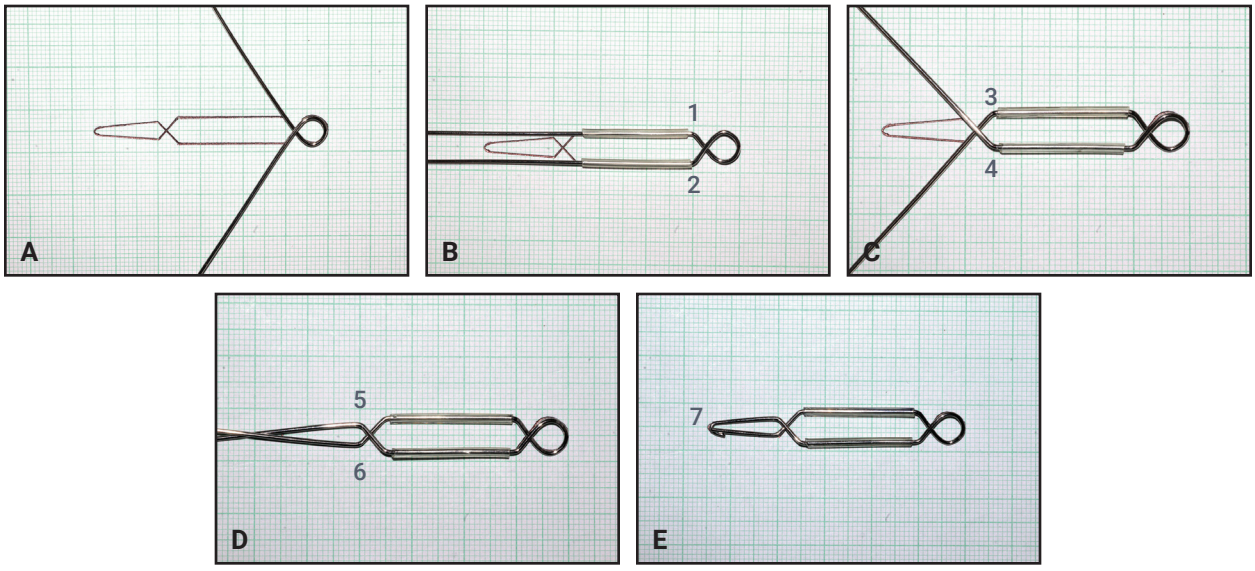
Various types of elastics are prescribed for correction of molar relationships or crossbites, or for occlusal settling. This has long been an integral part of orthodontic treatment that requires patient cooperation. Patients may have difficulty attaching the elastics properly with only their fingers, however, especially if they are not provided with disposable elastic placers. To improve patient compliance and ease of placement, we have devised the SEAT (simple elastic applicator tool).

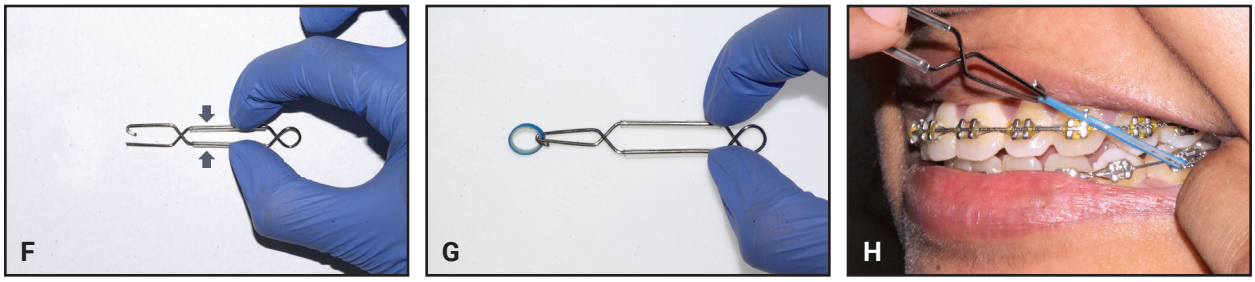
Fabrication

1. Cut a 6-7" length of .9mm or .036" stainless steel wire (A). Using a universal plier, bend a helix about 6mm in diameter at the midpoint of the wire.
2. Add bends at points 1 and 2 as shown (B), making the two arms parallel to each other. Plastic sleeves can be placed over the arms to improve the grip of the device.
3. Bend the wire at points 3 and 4 (C), so that the arms cross over each other. These bends give the device a reverse-action property.
4. Bend the wire again at points 5 and 6, making the two arms converge slightly toward each other (D).
5. Make a U-bend in one of the arms at point 7 to form a hook (E). Cut off the excess wire from the hook arm and from the other arm as shown.

Instructions for Use

Press the upper and lower arms of the SEAT together (F) to separate the arms for elastic insertion. Place the elastic over the hook, then engage the straight arm around the hook to secure the elastic (G). After intraoral placement of the elastic (H), press the upper and lower arms together again





to release the elastic from the SEAT.

This tool offers several advantages. Because of its reverse-action design, it will not release the elastic until desired. The .036" stainless steel wire is rigid enough to withstand deformation forces, but easy to adjust if necessary. The SEAT is quick and simple for the orthodontist to fabricate from inexpensive materials. The design makes wearing elastics much easier for the patient, which in turn will ensure ideal compliance and treatment finishing. Finally, it serves as a motivating factor by giving the patient a sense of involvement and responsibility for treatment.

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THE CUTTING EDGE

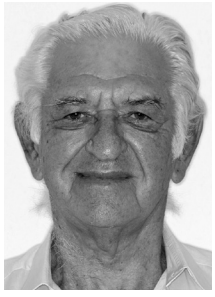
This column is compiled by JCO Technology Editor Marc S. Lemchen, DMD. To help keep our readers on The Cutting Edge, Dr. Lemchen will spotlight a particular area of orthodontic technology every few months. Your suggestions for future subjects or authors are welcome.

Imagine reviewing with a parent a cone-beam computed tomography (CBCT) image that shows an impacted canine impinging on the root of a lateral incisor. Most of us would explain the risks of the lateral incisor root being damaged, perhaps by showing other examples of lateral incisor resorption. Now imagine being able to virtually remove the patient's lateral incisor from the CBCT image and get a single three-dimensional image of the lateral incisor that can be rotated 360°, showing the damage to the root that has already occurred. Clearly, a picture that is worth a thousand words.

Over the past 10 years, we have seen our profession increasingly impacted by the application of artificial intelligence (AI), which helps us perform tasks that would be time-consuming—or in some cases impossible—for an individual to accomplish manually.

The following article describes the use of AI to segment individual teeth from a CBCT scan. The file is first converted from Digital Imaging and Communication in Medicine (DICOM) data to standard tessellation language (STL), like the information we get from our optical scanners. This conversion allows the program to use

Dr. Lewit Borohovitz



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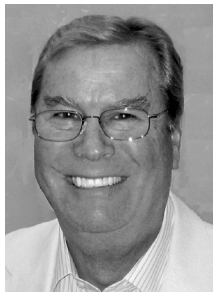

Dr. Redmond

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AI algorithms to virtually "extract" individual teeth for closer examination. We now can clearly see, instead of inferring, the amount of resorption that has resulted from an erupting canine contacting a lateral incisor root.

Nowhere is visualization more helpful than when we are trying to communicate the rationale for treatment, or for a particular treatment plan, to a patient or parent. We take for granted how digital imaging and panoramic and 3D radiographs have facilitated our doctor-to-patient communication over the past 40 years. Think of how easily patients can visualize their teeth on panoramic radiographs, as opposed to a full-mouth series.

We can expect to see more and more applications of AI in our daily lives and in the orthodontic profession. AI will certainly affect the efficiency, accuracy, and quality of our orthodontic results. The application described in this article is another step forward in using AI to improve our treatment plans, treatment outcomes, and patient and parent communication.

MSL

The Diagnostic Advantage of a CBCT-Derived Segmented STL Rendition of the Teeth and Jaws Using an AI Algorithm

CHEN LEWIT BOROHOVITZ, DMD
ZEEV ABRAHAM, BDS, MS
W. RONALD REDMOND, DDS, MS

An accurate diagnosis is the key to a successful orthodontic treatment plan and, consequently, a successful treatment outcome. In today's profession, this cannot be achieved without appropriate imaging.[1]

The goal of imaging in medicine and dentistry, including orthodontics, is to display the patient's "anatomic truth." For many years, two-dimensional radiographs were used to evaluate the patient's 3D status.[2] The use of 2D x-rays to analyze 3D structures has well-known limitations, however, including magnification, geometric distortion, superimposition of adjacent structures, projective displacement, rotational errors, and linear projective transformation.[3,4]

Since its introduction to dentistry in 1998, CBCT has changed the diagnostic approach in both dentistry and orthodontics, providing accurate high-resolution 3D imaging from compact and affordable equipment. In addition, it exposes the patient to a significantly lower radiation dose compared with conventional CT.[5,6]

Digital Process

CBCT is best described as "volumetric imaging." An x-ray source and detector rotate in a cylindrical or spherical path around the center of the region of interest, with a single rotational sweep of 180-720° creating the field of view. Several hundred 2D images are generated in a procedure that takes 10-40 seconds. These images are processed by the computer to create rectangular cubes called voxels, which are .076-.4mm in size and equal in width, thickness, and height. Each voxel represents a shade of gray, depending on its x-ray absorption. Typically, one scan contains more than 100 million voxels. After the creation of a volumetric database from these voxels, different cross-sections can be produced in all planes

of space (sagittal, coronal, and axial), in addition to curved cross-sections (such as panoramic images) and volume renderings (such as cephalometric images).[6-9]

The 3D medical imaging data produced by the CBCT are stored and transmitted in the form of DICOM files. These files contain the raw data that become the basis for further manipulation.[10] The DICOM file can display a series of 2D cross-sections in three planes of space—the most common rendition presented to the examining doctor. The DICOM file can also be segmented, allowing teeth to be removed or hidden so that underlying structures can be exposed. Additionally, the DICOM file can generate a 3D rotating picture of the field of view, including crowns, roots, and bone. The process of distinguishing root from bone is problematic, however, because the two structures are similar in density. Proprietary software programs are available to aid in this procedure, but they are labor-intensive, requiring substantial operator experience and time.[11] Even with the required expertise, the full length and anatomy of roots are often compromised or inaccurate. The pathway of the mandibular nerve can be drawn only manually, after examining a large number of 2D slices of the canal track.

To create a user-friendly 3D landscape of the DICOM data, the file should be converted to STL format. STL files, which are used for 3D printing of medical and industrial products, can be viewed on any computer with a standard operating system such as Microsoft Windows.* Automatic STL conversion and segmentation can also be performed from a CBCT DICOM file of the teeth and jaws using an artificial intelligence (AI) program such as CephX,** Anatomage,*** or Imaging Plus.†

AI capabilities have improved significantly since the 1980s and are now becoming important constituents of many medical applications. AI excels at recognizing complex patterns in imaging data, allowing accurate segmentation. In dental radiology, AI can identify the different tissues in a 3D DICOM package obtained from a CBCT scan and automatically convert it to a segmented STL image within minutes.[12] In orthodontic diagnosis, since all objects are segmented, the user can see different aspects and easily visualize various "what if" scenarios. For example, "What would the anatomy look like if a tooth were removed?" "Is there a hidden pathology beneath one of the structures?" "What is the spatial relationship between objects?" "Could the 3D interactive model offer better understanding simply by delivering the same information in a new package?"

These AI capabilities are based on deep learning mechanisms,[12-14] whereby input is received and the output is learned based on a large, labeled data set that is examined by the AI algorithm at the input level. The data set then undergoes more precise labeling,[14] and the AI algorithm is taught to recognize it. Finally, the algorithm's recognition capabilities are fine-tuned by human intervention ("teaching") until optimal automatic recognition levels are achieved.

A 3D convolutional neural network is the most common machine-learning method of image recognition and classification.[12-14] Besides its uses in medicine and dentistry, it can be applied to such tasks as identification of objects, faces, and traffic signs and for computer vision in self-driving cars. Convolutional neural networks, like neural networks, are made up of perceptrons with learnable weights and biases. Each perceptron receives several inputs, weighs them, and passes the weighted sum through an activation function; it responds with an output, which, in turn, may serve as an input for another perceptron, and so on. In this manner, convolutional neural networks can mimic the decision-making tasks performed by our own central nervous systems.

The following two cases, both treated in the Tel Aviv University Department of Orthodontics, demonstrate how the AI capabilities of DICOM-to-STL conversion can have a significant effect on orthodontic treatment planning.

*Registered trademark of Microsoft Corporation, Redmond, WA; www.microsoft.com.
**Trademark of CephX by Orca Dental AI, Las Vegas, NV; www.cephx.com.
***Anatomage, Inc., Santa Clara, CA; www.anatomage.com.
†Dolphin Imaging and Management Solutions, Chatsworth, CA; www.dolphinimaging.com.

Case 1

A 13-year-old male presented with a mild dental Class II malocclusion, a bilateral crossbite (upper right first premolar through second molar to lower right first premolar through second molar, and upper left second premolar to lower left second premolar), and a functional shift of the mandible to the right (Fig. 1). Clinical examination indicated a Class I skeletal pattern, maxillary constriction, and 9mm of crowding in the upper arch, with a lack of space for the canines; the lower arch showed moderate crowding (5mm). The left maxillary canine had partially erupted in an ectopic position, buccal to the upper left lateral incisor. The upper lateral incisors were buccodistally tipped, and the upper right canine was not palpable buccally or palatally.

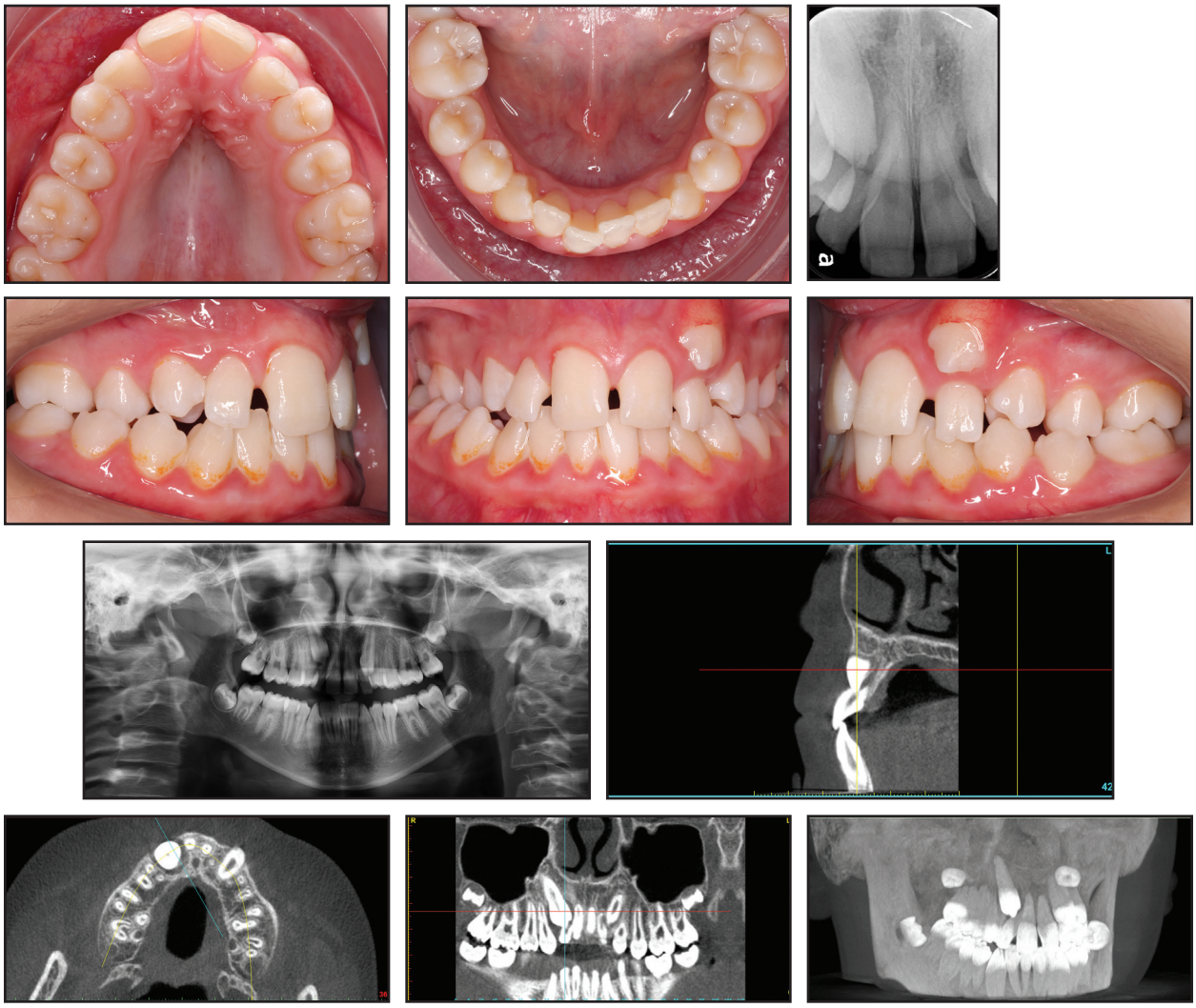

Fig. 1 Case 1. 13-year-old male with mild dental Class II malocclusion, Class I skeletal pattern, and upper and lower crowding before treatment. (Position of upper right canine and integrity of upper lateral incisor roots not apparent on standard x-ray images.)

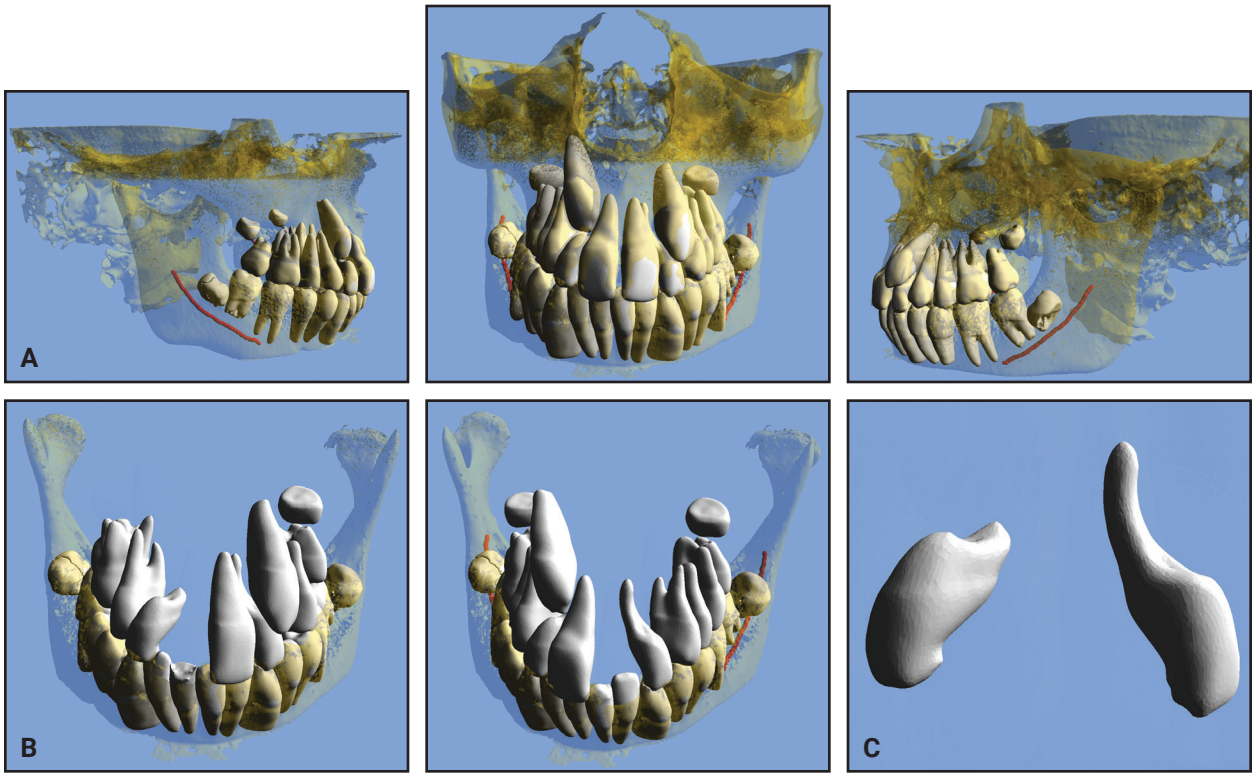

Fig. 2 Case 1. A. Pretreatment three-dimensional views from STL files. B. Views after virtual extraction of adjacent teeth and maxillary bone, showing severe resorption of lateral incisors. C. Upper lateral incisors after all other structures virtually hidden (images courtesy of CephX by Orca Dental AI).

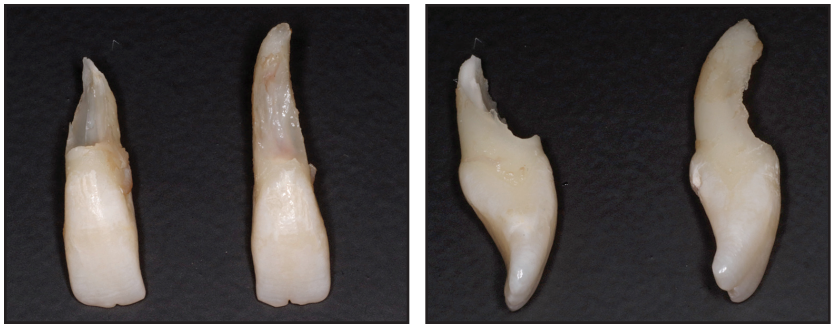

Fig. 3 Case 1. Actual extracted upper lateral incisors.

The initial evaluation would likely have led to a nonextraction treatment plan including maxillary expansion and some form of arch development to resolve the crowding in both arches and gain enough space for the canines to erupt. There was, however, a radiographic suggestion of root resorption involving both upper lateral incisors. Because the panoramic and periapical x-rays could not clearly confirm the position of the upper right canine nor the integrity of the upper lateral incisor roots, the patient was sent for a CBCT scan.

The DICOM file of the scan was uploaded to the CephX web viewer for automated AI conversion to STL. A 3D segmented model of the teeth and jaws could then be viewed, and the canines and central incisors could be virtually extracted for better visualization of the lateral incisors (Fig. 2).

Upon review of the 3D STL interactive models, it was clear that the resorption of the upper lateral incisors was more severe than initially suspected. The treatment plan was therefore revised to include extraction of the two upper lateral incisors and possibly the two lower second premolars (to be determined after the maxillary archform had been established). The extracted lateral incisors showed a similar morphology to those in the STL viewer (Fig. 3).

The STL web viewer of Case 1, which uses the proprietary CephX STL AI algorithm, is available at https://bit.ly/2Yjum5S. (This system is compatible with any smartphone with sufficient memory, but it was taken from a broad field of view and may take close to a minute to download.) To see how the 3D manipulation provides a vastly improved view of the maxillary lateral incisors, select Show/Hide under the View menu on the upper toolbar, then click on any relevant teeth and bony structures to toggle between shown and hidden. Close the Show/Hide menu by clicking Done.

Case 2

A 12-year-old female presented with a submerged lower right second deciduous molar and an impacted permanent lower right second premolar (Fig. 4). She was referred by a general dentist after complaining of pain in the lower right region, but she had no prior medical history. Clinical evaluation found a Class I skeletal pattern, a dental deviation of the lower midline to the right, and a posterior open bite on the right due to submergence and probable ankylosis of the lower right second deciduous molar. Neither the second decidous molar nor the lower right second premolar was visible clinically.

Radiographic examination revealed the positions of the submerged deciduous molar and the impacted permanent premolar, indicating their proximity to the inferior alveolar nerve canal and the lower border of the mandible, as well as the second premolar's position relative to the adjacent first molar. A CBCT was requested for further

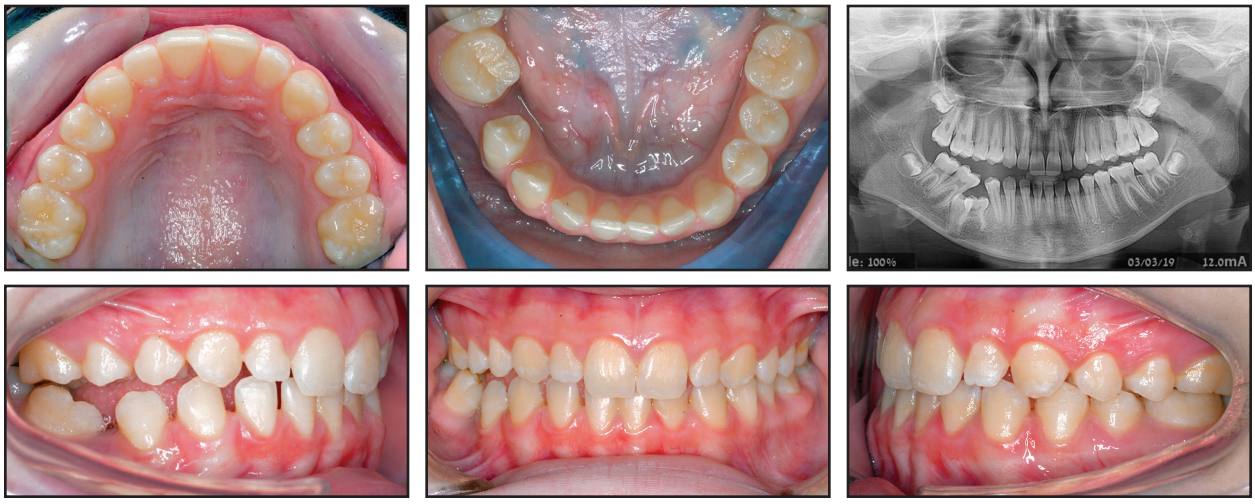

Fig. 4 Case 2. 12-year-old female patient with Class I skeletal pattern, impacted permanent lower right second premolar, and posterior open bite on right side due to submergence and probable ankylosis of lower right second deciduous molar. Note position of lower right second deciduous molar and lower right second premolar in relation to inferior alveolar nerve and lower border of mandible (continued on next page).

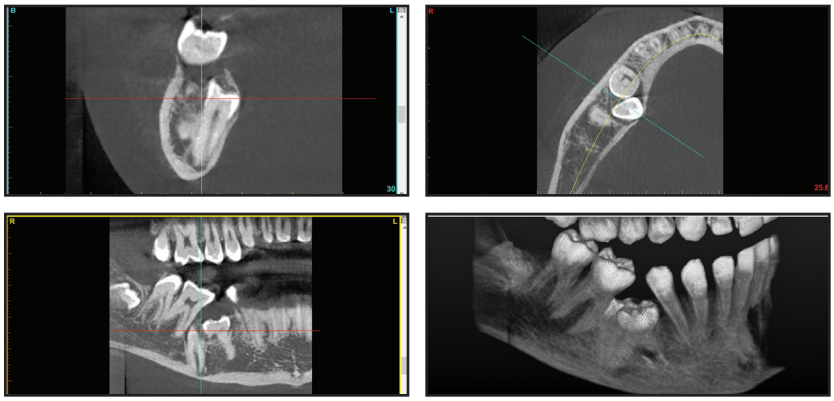

Fig. 4 (cont.) Case 2. 12-year-old female patient with Class I skeletal pattern, impacted permanent lower right second premolar, and posterior open bite on right side due to submergence and probable ankylosis of lower right second deciduous molar. Note position of lower right second deciduous molar and lower right second premolar in relation to inferior alveolar nerve and lower border of mandible.

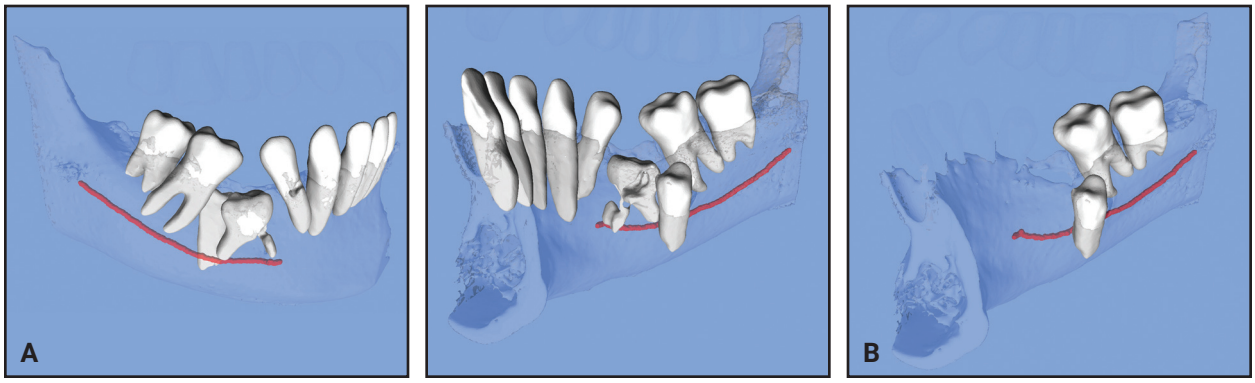

Fig. 5 Case 2. A. Pretreatment 3D views from STL files. B. View after virtual extraction of lower right second deciduous molar and section from lower left lateral incisor through lower right first premolar. Note proximity of inferior alveolar nerve (red) to lower right second premolar root (images courtesy of CephX by Orca Dental AI).

investigation of this anatomical proximity and for surgical access planning.

An STL file was automatically converted from the DICOM file using CephX AI algorithms. The segmented model was virtually manipulated for better depiction of the 3D relationships between the objects (Fig. 5). Considering the proximity of the lower right second deciduous molar to the inferior alveolar nerve and the root of the first molar, it was evident that to avoid damaging those structures, the first vector of force on the lower right second premolar should be lingual and mesial. The STL model also demonstrated a severe mesiolingual rotation of the impacted lower right second premolar, which was not apparent in conventional imaging.

Use the link https://bit.ly/3bHczd8 for 3D manipulation of the STL segmented model with the web viewer, following the same procedure as with Case 1.

Discussion

These cases substantiate the importance of 3D visualization in making an accurate diagnosis. Segmented STL models were instantly converted from standard DICOM data using an AI program.

In the first case, virtual removal of tooth material in the maxillary anterior region revealed severe lateral incisor root resorption that affected our treatment plan, changing it from a nonextraction approach to a two- or four-tooth

extraction case. Had we relied solely on axial 2D slices of the CBCT scan, we might have debated whether to extract the maxillary lateral incisors. Impacted canines are often associated with root resorption that progresses rapidly and thus tends to be diagnosed late.[15] It has long been acknowledged that 2D radiographs are insufficient for appraisal of the root damage related to ectopic canines,[16] mainly because the resorption is commonly located in the middle third of the root (either buccally or palatally), and also because of radiographic superimposition of the adjacent canine.[17] Since lateral incisor root resorption can now be easily recognized in CBCT images, it has been found to be even more common than previously assumed, with an estimated prevalence of 48% in cases involving ectopically erupting canines.[18] Given the ongoing debate regarding the cost-effectiveness of CBCT scans for orthodontic patients, according to the "as low as reasonably achievable" (ALARA) principle,[6,19] the use of CBCT is most commonly recommended for impacted teeth.[5,20,21]

The second case demonstrates not only the importance of determining the force application vectors in three dimensions, as previously described,[8,22] but also the capacity of AI to readily identify the inferior alveolar nerve—an otherwise arduous manual task for a technician. The ability to manipulate the STL model in all directions and view the relationship between the inferior alveolar nerve and a severely impacted premolar is another major advantage of CBCT in cases of mandibular impactions.[23] Because orthodontic forces exerting pressure on the inferior alveolar nerve have been reported to cause temporary paresthesia of the lower lip,[24,25] an accurate analysis of the relationship between impacted teeth and the inferior alveolar nerve is particularly important.

Conclusion

The orthodontic cases presented in this article demonstrate how technological advances have provided invaluable tools for management of impactions. The combination of CBCT and AI conversion of DICOM files to STL models now enables rotational 3D viewing of the teeth, roots, bones, and mandibular nerves, opening new dimensions in treatment planning. In addition, the ability to hide or virtually extract overlying and obstructing teeth has dramatically improved the orthodontist's perspective and exposed previously hidden problems.

ACKNOWLEDGMENT: We thank Dr. Nearchos Panayi (past graduate of the Tel Aviv University International Orthodontic Program) for his assistance in obtaining high-quality images of the STL and DICOM files for this article.

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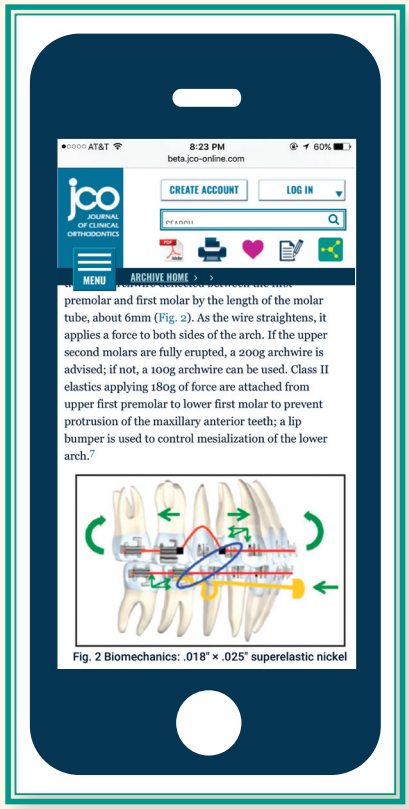

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Learning Objectives

After completion of this exercise, the participant will be able to:

1. Discuss the diagnostic and mechanical principles involved in early orthodontic treatment.
2. Compare a hybrid approach using sectional fixed appliances with other methods of clear aligner treatment.
3. Fabricate an orthodontic elastic placer for patient home use.
4. Describe the diagnostic advantages of three-dimensional segmented STL renditions of the teeth and jaws.

Article 1

Kennedy, D.B. and Sinclair, P.M.: *Master Clinician: David B. Kennedy, BDS, MSD, FRCD(C)* (pp. 327-341)

1. Lower force levels are required to achieve skeletal expansion for patients in the early mixed dentition because:
   a) any crossbite is likely to be unilateral
   b) the suture is still immature
   c) the nasal base is wider
   d) all of the above
2. Palatally displaced ectopic canines are more prevalent in all of the following groups except:
   a) females
   b) patients with small or missing lateral incisors
   c) patients who have a history of trauma to the deciduous incisors
   d) patients who have a family history of ectopic canines
3. There is a more of a tendency for lower second permanent molar impaction when the angle between the lower first and second permanent molars is:
   a) greater than 24°
   b) less than 24°
   c) less than the angle between the upper first and second molars
   d) not improved by placement of a lower lingual arch
4. Serial extraction treatment is appropriate in a patient with a:
   a) protrusive dentition
   b) full face
   c) shallow overbite or open bite
   d) any of the above

Article 2

Palone, M.; Cervinara, F.; Casella, S.; Siciliani, G.; and Lombardo, L.: *Resolution of a Complex Malocclusion Using a Hybrid Aligner Approach* (pp. 343-353)

5. The incidence of scissor bite in children is reportedly:
   a) 1.1%
   b) 5.1%
   c) 8.8%
   d) 11.1%
6. In this case, the first phase of clear aligner treatment was ended because the:
   a) scissor bite had been corrected
   b) scissor bite had not been corrected
   c) patient had worn all 12 sets of aligners as prescribed
   d) required interproximal reduction had not yet been performed

7. The second phase of treatment involved all of the following except:
   a) refinement aligners
   b) fixed buccal sectional appliances
   c) a palatal miniplate
   d) criss-cross elastics
8. Post-treatment cephalometric superimpositions demonstrated:
   a) retroclination of the upper anterior segment
   b) intrusion and proclination of the lower anterior segment
   c) vertical control of the patient's skeletal divergence
   d) all of the above

Article 3

Deshpande, S.; Shenoi, S.B.; and Hattarki, R.S.: *An Efficient and Ergonomic Device for Easy Elastic Wear* (pp. 359-360)

9. The authors' SEAT acronym stands for:
   a) systems extension and acceptance team
   b) secure ergonomic application tool
   c) simple elastic applicator tool
   d) stress-free elastic attachment turner
10. The device is fabricated from:
   a) a plastic orthodontic elastic placer
   b) .036" stainless steel wire
   c) .010" stainless steel ligature wire
   d) a 6-7" length of elastomeric chain
11. After placement, the elastic is released by:
   a) pressing the upper and lower arms of the device together
   b) disengaging the straight arm from the hook
   c) hooking the elastic with a finger
   d) pushing the plastic sleeve forward
12. The elastic will not be released until desired because of:
   a) the reciprocal force between the elastic and the hook
   b) the grip of the plastic sleeves
   c) the device's reverse-action property
   d) all of the above

Article 4

Lewit Borohovitz, C.; Abraham, Z.; and Redmond, W.R.: *The Diagnostic Advantage of a CBCT-Derived Segmented STL Rendition of the Teeth and Jaws Using an AI Algorithm* (pp. 361-369)

13. Cone-beam computed tomography (CBCT) is best described as:
   a) three-dimensional slicing
   b) volumetric imaging
   c) magnetic resonance imaging
   d) interventional radiology
14. CBCT generates several hundred two-dimensional scans, which are processed by the computer to create rectangular cubes called:
   a) voxels
   b) pixels
   c) texels
   d) perceptrons
15. To create a user-friendly 3D landscape of the DICOM data produced by a CBCT, the file should be converted to:
   a) high-resolution 3D slices
   b) artificial intelligence software
   c) a digital model
   d) STL format
16. The most common machine-learning method of image recognition and classification is:
   a) volume rendering
   b) DICOM-to-STL conversion
   c) a convolutional neural network
   d) a tensor flow

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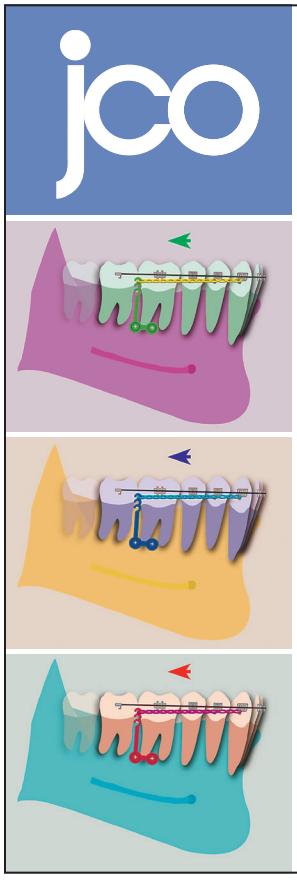

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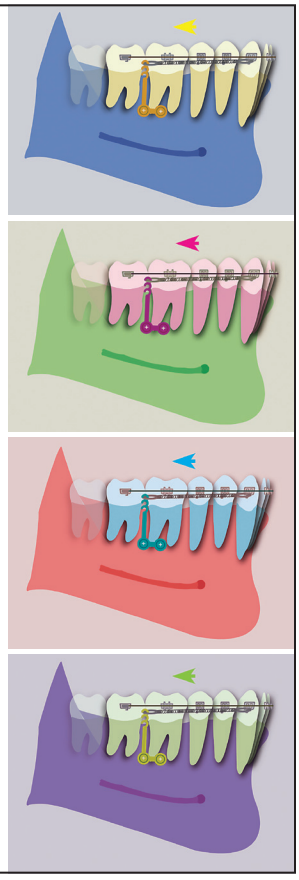

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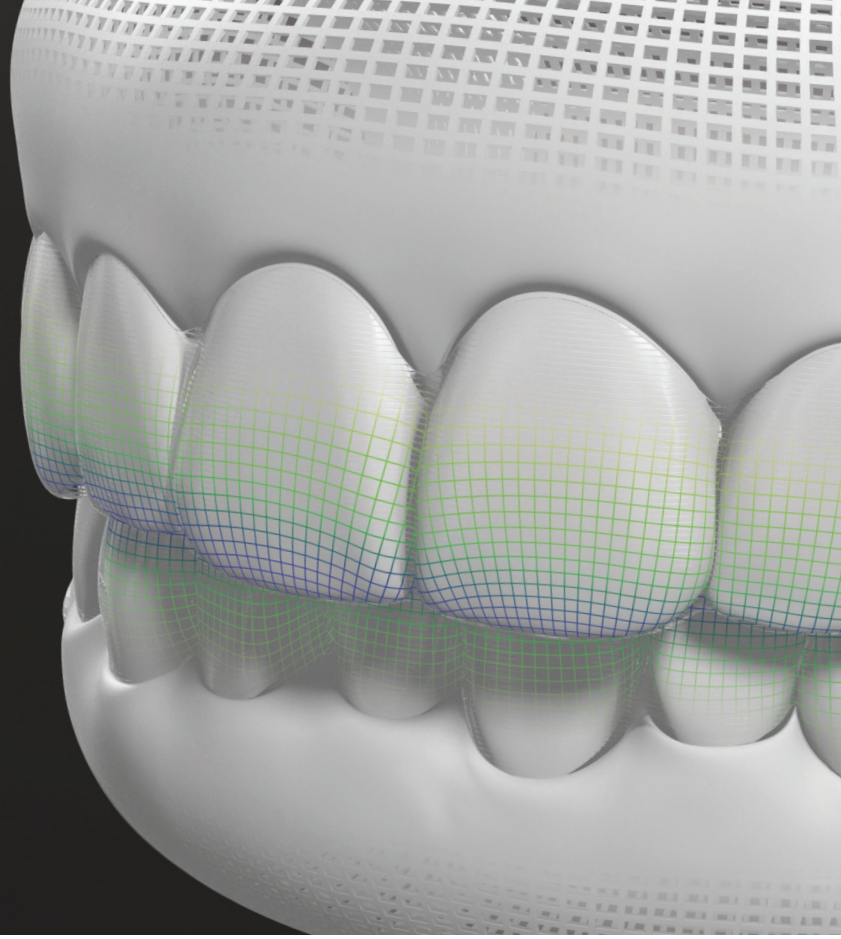
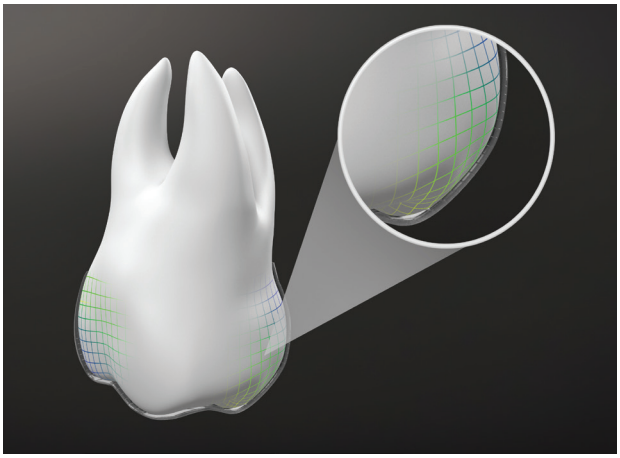
Invisalign® G8 offers more predictable deep-bite correction and posterior arch expansion.



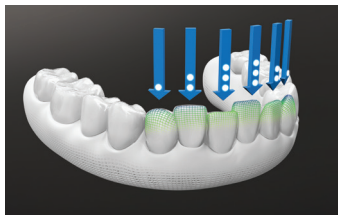
Introducing Invisalign G8 with SmartForce® Aligner Activation.

Invisalign G8 is the only clear aligner system with the advantage of SmartForce aligner activation. This new generation of the Invisalign clear aligner system is designed to further enhance predictability and efficiently deliver improved clinical outcomes for the challenges you encounter most frequently.

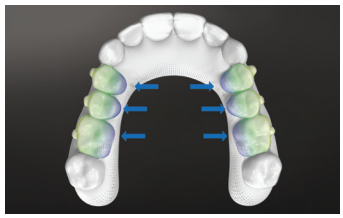


With SmartForce aligner activation, areas on the aligner surfaces are contoured to apply forces to the tooth in the proper direction to **produce the desired movement while minimizing unwanted movements.**

Improvements to predictability in:



Deep bite correction



Posterior arch expansion

Discover more about the latest generation of the Invisalign clear aligner system. Visit **Invisalign.com/G8.**

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Transforming smiles, changing lives.