Bimaxillary Protrusion Treated with Insignia® System Customized Brackets and Archwires

Abstract

Introduction: *Correction of bimaxillary protrusion is challenging, particularly without orthognathic surgery and/or temporary anchorage devices. A viable option is bimaxillary space closure following extraction of premolars in all four quadrants. This time consuming and technically challenging approach is facilitated with a digital custom appliance.*

Diagnosis: *A 12yr 6mo old boy presented with a chief complaint of lip protrusion. The diagnostic evaluation revealed a convex profile (15°), slight skeletal protrusion (ANB 83°, SNB 80°, ANB 3°), steep mandibular plane angle (FMA 33°), bimaxillary lip protrusion (3mm/5mm to the E-Line), flared incisors (18°/92°), excessive overbite (5mm), deep curve of Spee (4mm), and a Discrepancy Index (DI) of 20.*

Treatment: *All four first premolars were extracted and a customized appliance (Insignia® system), with self-ligating brackets and progressive archwires, was constructed by reverse engineering from a digital set-up. Extraction spaces were successfully closed in all four quadrants. There were two minor molar alignment problems and inadequate lingual torque expression on the UL1. All of these discrepancies were attributed to undetected errors in the digital set-up. Active orthodontic treatment was accomplished in 13 appointments over 19 months.*

Outcomes: *Excellent dental alignment and esthetics were documented with a Cast-Radiograph Evaluation (CRE) of 21, and a Pink & White Esthetic Score of 5. Compared to about 36 months for conventional extraction treatment of bimaxillary protrusion, the Insignia® appliance provided an almost 50% decrease in treatment time (19 months). The patient and his parents were pleased with the dental alignment, facial esthetics and relatively short treatment time.*

Conclusion: *The Insignia® digital appliance is very accurate, and precisely aligns the dentition according to the digital set-up, but torque compensations are required for mechanics that significantly move the roots of teeth. With correct treatment planning, the outcomes are enhanced by minimal treatment adjustments, thereby producing fewer therapeutic lag phases due to PDL necrosis. Thus decreased treatment time is due to continuous low force mechanics with few adjustments. (Int J Orthod Implantol 2017;48:50-70)*

Key words:
Insignia® system, customized passive self-ligating bracket, digital set-up, bimaxillary protrusion, extraction of premolars, incisor retraction, bite turbos, early light short elastics, decreased treatment time, lag phase due to PDL necrosis

Introduction

Bimaxillary dentoalveolar protrusion is a common Asian dentofacial anomaly that results in both functional and esthetic problems. Patients with a moderate to severe protrusion are candidates for orthodontics, extractions and orthognathic surgery, to improve the facial profile.[1] Extraction of all four first premolars followed by retraction of the anterior segments with maximal anchorage mechanics is a common treatment

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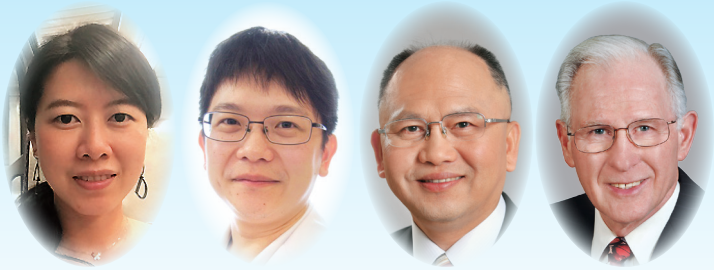

for the correction of bimaxillary protrusion.[2-4] However, the differential anchorage value of posterior segments,[4-5] and variable growth potential of adolescents contribute to the unpredictability of many orthodontic and surgical approaches for correcting protrusion.[6-12]

One-size-fits-all straight wire appliances rarely produce a precisely finished final result without substantial finishing effort: bracket repositioning and detail bends in archwires. Standard pretorqued and preangulated brackets are designed for average teeth and minimal root movement. Thus, substantial clinical compensation

Fig. 1: Pre-treatment facial and intraoral photographs

via bracket repositioning and detailing bends is required for a precise final alignment despite variations in tooth-surface morphology, manual errors in the direct bonding process, and root movement mechanics.[6-12] Using advanced digital technology, the Insignia® System (*Ormco, Glendora, CA*), introduced in 1987 by Dr. Craig Andreiko, involves two components: (*1*) Insignia Approver® a three-dimensional (*3D*) real-time software for virtual treatment planning with torque compensations, and (*2*) a Custom Fixed Appliance consisting of brackets, placement jigs, and archwires. The customized design of the appliance for the specific correction planned greatly decreases detail bends and bracket rebonding, which results in less traumatic mechanics and improved treatment efficiency.[13]

Closing extraction spaces, without producing undesirable side effects, continues to be a challenging process in orthodontics, even with an advanced digital set-up.[14-18] Details in biomechanics must be carefully anticipated to provide appropriate torque compensations. This case report presents an adolescent patient with a bimaxillary protrusion treated with premolar extraction and space closure utilizing a digital Insignia® system appliance. No temporary anchorage devices (*TADs*)[7] were used.

Etiology and Diagnosis

A 12 years 6 month male presented to Beethoven Orthodontic Center in Hsinchu City, Taiwan, with a chief complaint of lip protrusion (*Figs. 1-4, Table 1*). He had a very convex profile (*15°*) and protrusive lips (*3mm/5mm to the E-Line*). There was no contributory medical or dental history. Sagittal skeletal

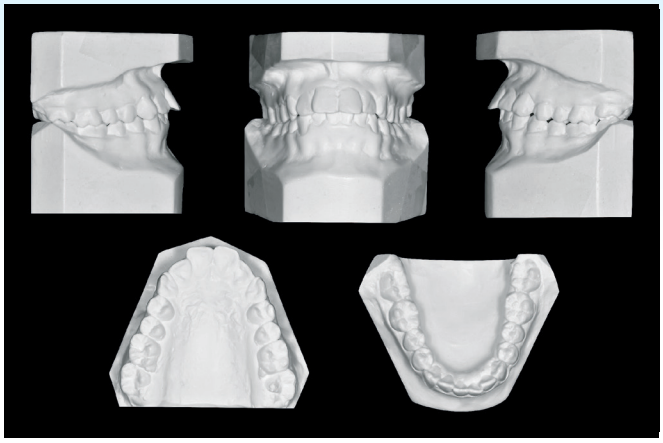

Fig. 2: Pre-treatment study models (casts)

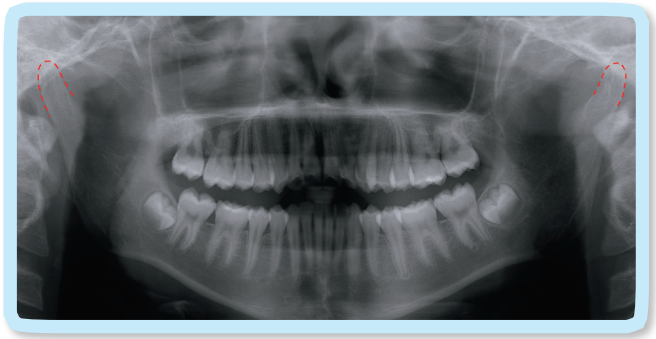

Fig. 3:
Pre-treatment panoramic radiograph shows both condylar heads outlined in red.

Fig. 4: Pre-treatment cephalometric radiograph

relationships (*SNA 83°, SNB 80°, ANB 3°*) were within normal limits (*WNL*), but the mandibular plane was steep (*SN-MP 40°, FMA 33°*). Lower facial height (*%FH 53.6%*) was WNL. There was no significant skeletal asymmetry, nor signs or symptoms of temporomandibular disorder (*TMD*).

An intraoral examination showed that the maxillary dental midline was coincident with the facial midline, but the mandibular midline was 0.5mm to the left. In the absence of a significant skeletal discrepancy, bimaxillary dental protrusion was consistent with the cephalometric analysis of the lips to the E-Line (*3mm/5mm*). The upper incisors were tipped labially (*U1 to NA 7mm, U1 to SN 118°*), as were the mandibular incisors (*L1 to NB 8mm, L1 to MP 92°*). The American Board of Orthodontics (*ABO*) discrepancy index (*DI*) was 20 points, as shown in the supplementary Discrepancy Index (*Worksheet 1*).

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	83°	84°	1°
SNB° (80°)	80°	80°	0°
ANB° (2°)	3°	4°	1°
SN-MP° (32°)	40°	39.5°	0.5°
FMA° (25°)	33°	32.5°	0.5°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	7 mm	0 mm	7 mm
U1 To SN° (104°)	1 8°	103°	15°
L1 To NB mm (4 mm)	8 mm	3.5 mm	4.5 mm
L1 To MP° (90°)	92°	82°	10°
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	3 mm	0 mm	3 mm
E-LINE LL (0 mm)	5 mm	1 mm	4 mm
%FH: Na-ANS-Gn (53%)	53.6%	53.7%	0.1%
Convexity: G-Sn-Pg' (13°)	15°	13°	2°

■ Table 1: Cephalometric summary

Treatment Objectives

The following treatment objectives were determined:

1. Correct lip protrusion.
2. Decrease the inclination of the incisors to the apical base of bone.
3. Establish ideal overjet and overbite.
4. Correct the slight mandibular midline discrepancy.
5. Resolve the crowding in both arches.
6. Establish Class I molar and canine relationships.

Treatment Plan

Extract all first premolars and install the digitally designed (*Insignia*) fixed appliance utilizing Damon Q® passive self-ligating (*PSL*) brackets (*Ormco, Glendora, CA*). All archwires, auxiliaries and elastics were produced by the same company, unless otherwise specified.

Maximally retract the anterior segments to resolve dental protrusion. Correct the curve of Spee as well as the axial inclination of the incisors. If further retraction is required, install bilateral infrazygomatic crest (*IZC*) bone screws to serve as anchorage to further retract both arches. Detail and seat the final occlusion with vertical elastics as needed.

Digital Set-Up

(1) Vertical:

- Upper: *Extrude incisors 1mm*
- Lower: *Intrude incisors 2mm, and correct the curve of Spee*
- Anterior overbite: *Set to 1.5mm (interlabial surface dimension)*

(2) Extract upper and lower first premolars.

(3) A/P movement and space closure:

- UR6, LR6, UL6: *Move 3mm mesially*
- LL6: *Move 4mm mesially*
- Close Extraction Spaces: *Equal and opposite (50%-50%) movement of the anteriors and posteriors (Fig. 5)*

(4) Incisor Crown Torque:

- Upper: *Decrease 9 degrees*
- Lower: *Increase 3 degrees*

* **Note**: Closing extraction spaces decreases the axial inclination of the anterior teeth, so both upper and lower incisors require ~5° more positive torque. Upper incisor crown torque was reduced from 118° (*pre-treatment*) to 109° (*standard 104°+over-correction 5°*). The lower incisor torque was increased from 92° (*pre-treatment*) to 95° (*standard 90°+over-correction 5°*).

(5) Midline correction:

- Move the lower midline 0.5mm to the right to coincide with the upper midline (*Fig. 5*).

(6) Archwire Plane:

- Set to the center of the upper and lower central incisors.

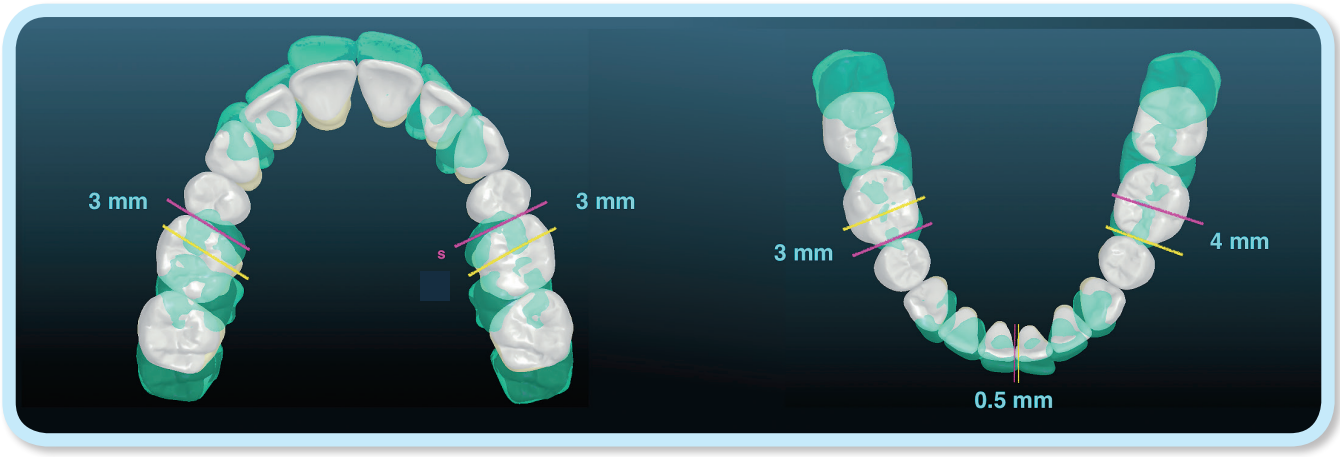

Fig. 5:
Digital set-up prescribes the relative movement in the occlusal plane, including incisal retraction and space closure. White teeth are the desired post-treatment alignment. Green teeth are the pre-treatment dentition. The yellow lines mark the pre-treatment mesial surfaces of the first molars and lower midline. Pink lines are the post-treatment mesial surfaces of the first molars and lower midline.

Right buccal segment: Move tooth UR6 and LR6 3mm mesially.

Left buccal segment: Move teeth UL6 3mm mesially, and LL6 4mm mesially. Close all spaces using 50%-50% movement of anteriors and posteriors. Move the lower midline 0.5mm to the right.

Treatment Progress

Two months following extraction of all four first premolars, all teeth were bonded with an Insignia® digitally-designed 0.022-in custom fixed appliance with Damon Q® self-ligating brackets on all permanent teeth. All treatment and sequencing details are shown in Table 2 and Figs. 6-10. All fixed appliances were removed after 19 months of active treatment.

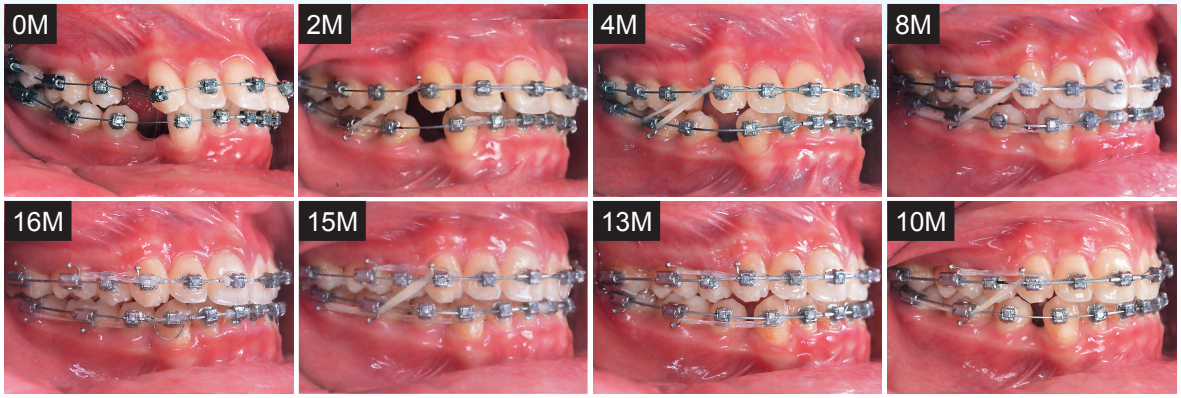

Fig. 6:
A series of right buccal view photographs shows progress from the start of treatment at zero months (0M) to sixteen months (16M) in clockwise order.

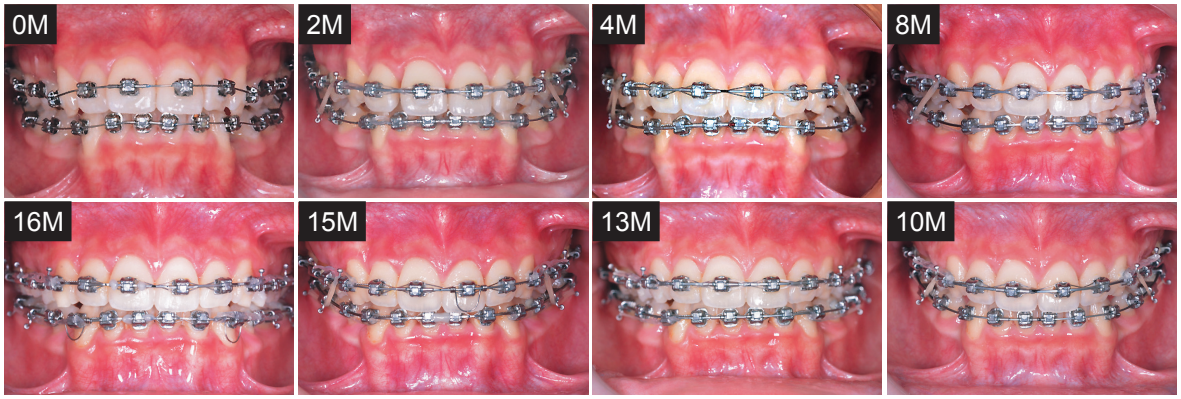

Fig. 7:
A series of frontal view photographs shows progress from the start of treatment at zero months (0M) to sixteen months (16M) in clockwise order.

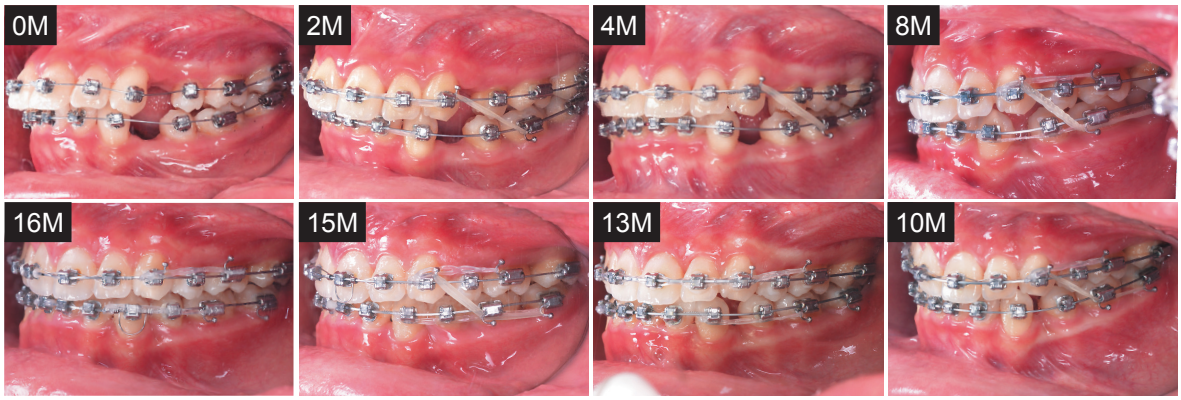

Fig. 8:
A series of left buccal view photographs shows progress from the start of treatment at zero months (0M) to sixteen months (16M) in clockwise order.

Fig. 9:
A series of upper occlusal view photographs shows progress from the start of treatment at zero months (0M) to sixteen months (16M) in clockwise order.

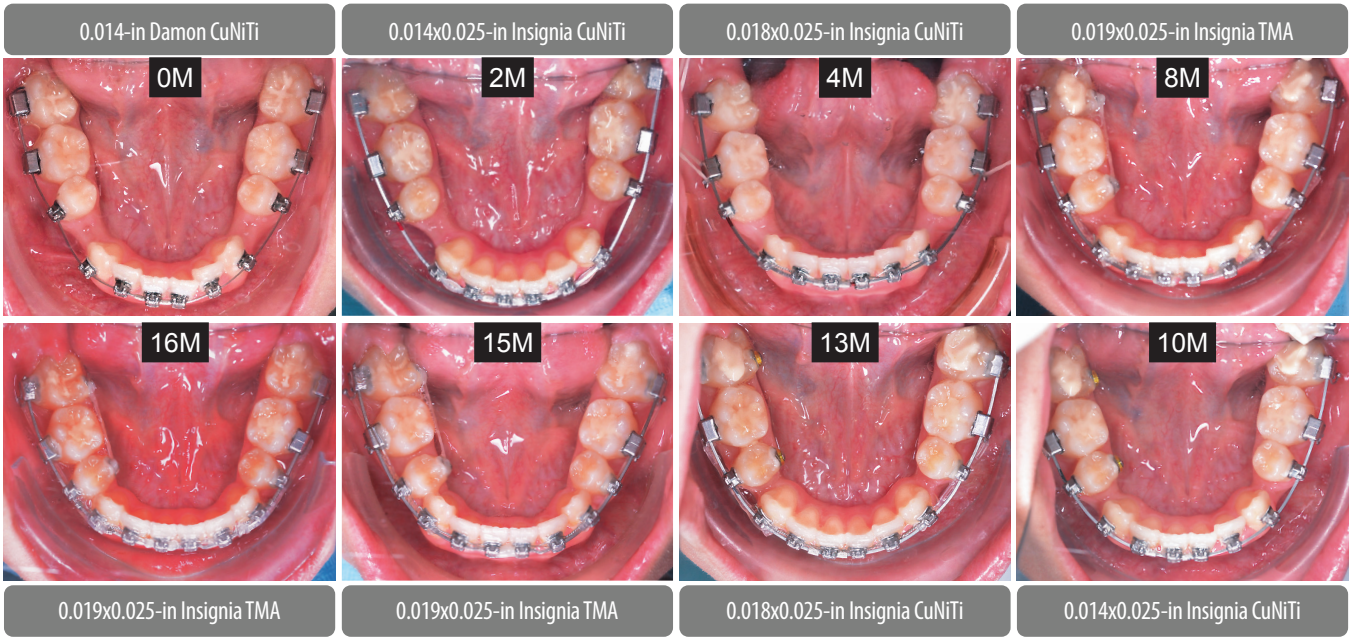

Fig. 10:
A series of lower occlusal view photographs shows progress from the start of treatment at zero months (0M) to sixteen months (16M) in clockwise order.

Appointment	Archwire	Notes
1 (*0 mo*)	U/L: 0.014-in Damon CuNiTi	• Disarticulation with posterior bite-turbos constructed with Fuji II® Type II Glass Ionomer cement (*GC America, Alsip IL*) on the occlusal surfaces of the L7s.
2 (*1 mo*)	U/L: 0.018-in Damon CuNiTi	
3 (*2 mo*)	U/L: 0.014x0.025-in Insignia CuNiTi	• Start early light short Class II elastics (*Quail, 3/16-in, 2-oz*) from U3s to L6s to retract maxillary anteriors (*Figs. 6-8, 2M*).
4 (*4 mo*)	U/L: 0.018x0.025-in Insignia CuNiTi	• Maxillary anterior teeth were tied together with an 0.010-in stainless steel ligature wire (*Figs. 7-4M, 9-4M*), and retracted with Class II elastics (*Fox, 1/4-in, 3.5-oz*) from U3s to L6s.
5 (*6 mo*)		• Rebonded the UR2 bracket to a more mesial position for mesial-in correction.
6 (*8 mo*)	U/L: 0.019x0.025-in Insignia TMA	• All the extraction spaces were closed with pre-stretched power chains. • Class II elastics (*Fox, 1/4-in, 3.5-oz*) were used from U3s to L6s and L7s to add a more horizontal vector to retract the upper anteriors and to protract the lower posteriors. • Lingual buttons were applied on LR5 and LR7. Power chains protracted the LR7 (*Fig. 10-8M*).
7 (*10 mo*)	U/L: 0.019x0.025-in Insignia TMA	• Rebonded the LL2 bracket to a more mesial position for mesial-in correction (*Fig. 10-10M*).
8 (*13 mo*)	U/L: 0.019x0.025-in Insignia TMA	
9 (*14 mo*)	U/L: 0.014x0.025-in Insignia TMA	• Rebonded the UR6 bracket to a more mesial position for mesial-in correction.
10 (*15 mo*)		• The incisal edges of UL1 were not well aligned with the UR1 because of insufficient lingual crown torque. A torquing spring (*auxiliary*) was used to correct the problem (*Fig. 7-15M*). • First order in-and-out bends were also applied to the LL2 and LR2 to correct the mesial-in rotations (*Fig. 10-15M*).
11 (*16 mo*)	U: 0.019x0.025-in Insignia TMA L: 0.019x0.025-in Insignia TMA	• First order in-and-out bends were applied to the UR2 and all 3s to correct the mesial-in rotations. • Third order bend (*twist bend: -10°*) was also applied on UL1 to enhance the lingual crown torque. • Two torquing springs were used at LR3 and LL3 to decrease buccal root torque (*Fig. 7-16M*).
12 (*18 mo*)		• The Class II elastics (*Fox, 1/4-in, 3.5-oz*) were changed to triangle intermaxillay elastic (*Chipmunk, 1/8-in, 3.5-oz*) from UR5 to LR5 and LR6 to settle the right occlusion.
13 (*19 mo*)		• All appliances were removed. Anterior fixed retainers were bonded on all mandibular canines and incisors (*3-3*). Removable clear overlay retainers were delivered for both arches, and the patient was instructed to wear them full time for the first 6 months and nights only thereafter. Instructions were provided for home hygiene and maintenance of the retainers.

■ Table. 2: Treatment Sequence.

Treatment Results

The patient was treated to the desired result and the post-treatment records show remarkably improved facial esthetics due to the harmonious relationship of the upper and lower lips. Overjet was corrected to 0mm and the overbite was reduced from 5 to 1.5mm. Bilateral Class I canine and molar relationships were achieved (*Figs. 11 and 12*). The post-treatment panoramic radiograph shows complete space closure with acceptable root parallelism and no significant periodontal bone loss or root resorption (*Fig. 13*).

The cephalometric analysis of tracings superimposed on the anterior cranial base (*ACB*) revealed substantial vertical and anterior growth. Substantial anterior growth of the maxilla produced a 1° increase in the SNA

Fig. 11: Post-treatment facial and intraoral photographs

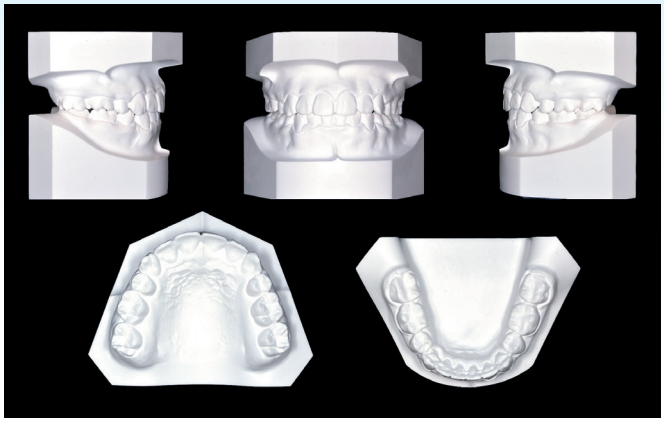

Fig. 12: Post-treatment study models (casts)

Fig. 13:
Post-treatment panoramic radiograph shows both condylar heads outlined in red.

Fig. 14: Post-treatment cephalometric radiograph

and ANB angles to 84° and 4°, respectively. Extensive incisor retraction (*7.0mm/4.5mm*), resulting in a 2° decrease in facial convexity to an ideal 13° (*Figs. 14-15 and Table 1*).

Clockwise rotation of the occlusal plane was related to correction of the deep curve of Spee. Despite substantial retraction of the upper and lower incisors (*7.0mm/4.5mm respectively*), torque control of the maxillary incisors was near ideal (*U1-SN 103°*), but the lower incisors were tipped distally about 8° (*L1 to MP 82°*). A portion of this problem reflected an error in the initial digital set-up (*Fig. 16*), but the major aspect of the discrepancy was compensation associated with space closure mechanics. Additional incisor retraction was required to offset protrusive maxillary growth (*Fig. 15*). Torque compensations were required to optimize overbite and overjet. Despite the protrusive growth pattern, space closure and dental compensations produced excellent facial esthetics (*Fig. 11*), which was the patient's chief complaint.

The ABO Cast Radiograph Evaluation (*CRE*) score was 21 points (*Worksheet 2*). Significant CRE discrepancies occurred relative to the UR6, which is thought to be due to rotations that were not detected prior to approving the digital set-up (*Fig. 16*). The dental esthetics were excellent as documented by the Pink and White dental esthetic index of 5 (*Worksheet 3*). Post-treatment clinical evaluation revealed no significant signs or symptoms of TMD, tooth mobility, loss of vitality, generalized root resorption, or periodontal compromise.

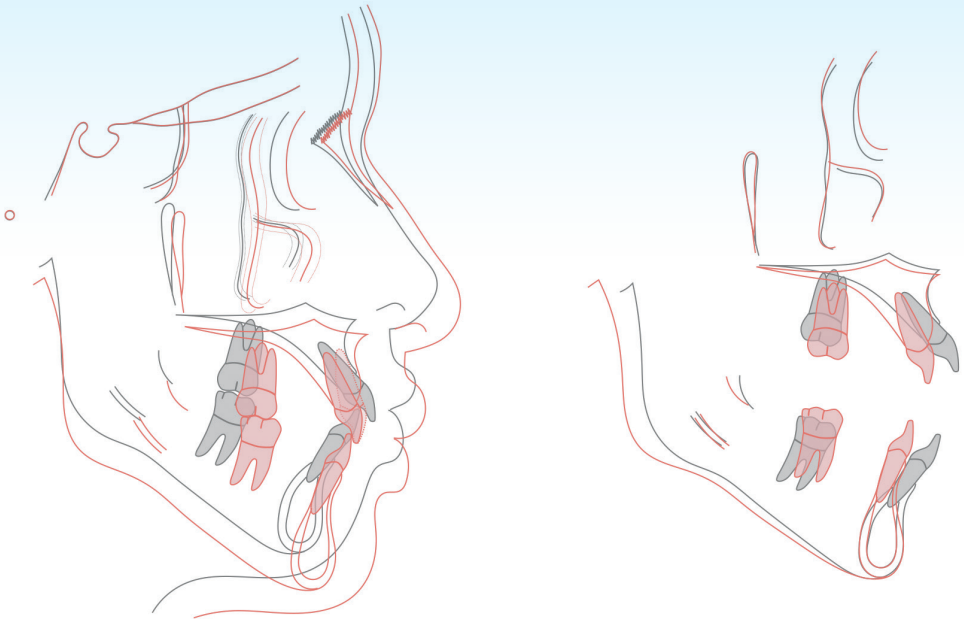

Fig. 15:
Superimposed cephalometric tracings show the dento-facial changes during treatment. Black line and gray-shaded teeth are the pre-treatment tracing, and the red line and pink shaded teeth are the post-treatment tracing. The red dotted maxillary incisor is the post-treatment position of UL central incisor with a labially positioned root. The tracings superimposed on the anterior cranial base (left) show the significant facial growth that occurred during treatment. The superimposed maxillary (upper right) and mandibular (lower right) tracing show the retraction and extrusion of the dentition in both arches. The combination of incisal retraction and anterior displacement of the E-Line resulted in decreased lip protrusion. See text for details.

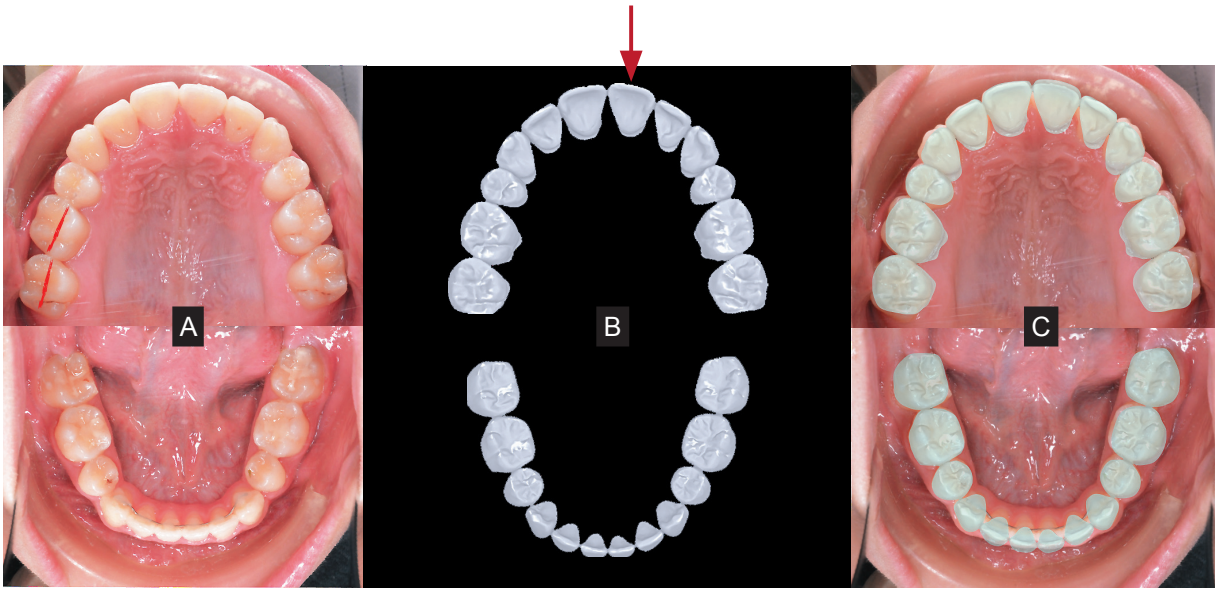

Fig. 16:
The actual treatment results (A) are compared with the digital set-up (B), and both occlusal views (A & B) are superimposed to show any discrepancies (C). The red lines in A show minor rotational problems. Note that the upper left dental central incisor (red arrow in B) is slightly out of alignment consistent with the more labial root position shown in Figure 15. See text for details.

Discussion

Bimaxillary Dentoalveolar Protrusion

Major Principles of Treatment: The goals for correction of bimaxillary protrusion include retraction and decreased axial inclination of both the maxillary and mandibular incisors. Space closure of premolar extraction spaces typically results in a decrease in the soft tissue prominence of the lips and facial convexity. Extraction of four first premolars followed by the retraction of the anterior segments in both arches is an evidence-based approach for correcting incisor protrusion, excessive axial inclination (*proclination*), and protrusive lips.[2,3]

Incisor Retraction: For Class I bimaxillary protrusions, the amount of incisor retraction is expected to be about the same for both arches. However, the anchorage value for the upper molars is less than in the lower arch because of the deceased bone density in the maxilla compared to the mandible.[4] Also the PDL distraction of the leading roots of lower molars forms dense cortical bone that the trailing roots must resorb.[5] Therefore, maximum anchorage of maxillary molars is usually required. Bills, Handelman and BeGole[2] studied the effects of orthodontic correction with maximum anchorage in 48 ethnically diverse bimaxillary protrusion patients. They reported the mean retraction of upper and lower incisors was 5.2 and 3.2mm, respectively. Chen et al.[6] compared the treatment outcomes of self-ligating brackets with micro-implant and headgear anchorages in 31 adults with bimaxillary protrusion; upper incisor retraction was 8.37mm using micro-implant anchorage, and 6.63mm with headgear anchorage.

The current patient was fitted with customized passive self-ligating brackets, and the upper incisors were retracted about 7mm without additional mechanical supplements such as molar bands, transpalatal arch bars, extra-oral headgear, or temporary anchorage devices. The Insignia® system reverse engineers the bracket slot for each tooth to facilitate initial alignment and leveling. Precisely placed custom brackets accelerate alignment to a full-sized rectangular archwire and require few if any detailing adjustments. This efficient approach decreases treatment time and anchorage loss because it controls repetitive PDL necrosis.[13]

Digital Orthodontics: Accuracy, Effectiveness, and Efficiency

The Insignia® System provides a precise virtual set-up of the desired final alignment. However, it is critical for the clinician to carefully examine the digital set-up, and provide torque compensations based on root movement anticipated. Once the clinician has approved the final set-up in 3D, bracket customization and placement are reverse-engineered back to the pre-treatment malocclusion.[13] The use of patient-specific brackets, indirect bonding transfer devices (*jigs*), and customized archwires decrease chairside time and treatment duration to more efficiently produce the desired final alignment.[14-17]

Weber et al.[14] provided comprehensive treatment for 35 patients with the Insignia® system and compared them with 11 conventionally treated cases, in terms of the quality of the result and treatment time. The Insignia® patients were treated to a significantly

lower (*better*) American Board of Orthodontics (*ABO*) Cast-Radiograph Evaluation (*CRE*) score, and the mean treatment time was significantly shorter (*14.23 months vs. 22.91 months, respectively*).

Closing extraction spaces is challenging clinical mechanics. Figures 11-15 document the successful closure of four first bicuspid extraction spaces with a total of 13 visits over 19 months. The final alignment of the dentition in 3D corresponded well with the virtual set-up (*Fig. 16*), except for a few minor discrepancies for the following teeth: UR6, UL1, UL3, and lower incisors. These finishing details are similar to a previous report by Brent, Cristopher and Thorsten.[18] Although the present result (*Figs. 11-15*) required some bracket repositioning and wire-bending during the finishing stage, the clinicians felt the effort involved was considerably less than for most conventionally treated patients, and the the treatment duration was ~50% less. The current patient and his family were well satisfied with the treatment results, and appreciated the benefits of the digital orthodontic appliance because the treatment time was shorter than they expected (*~36 months*).

Three Keys for Correcting Bimaxillary Protrusion with Insignia®

Customized brackets, reverse engineered from a digital set-up, are powerful technology that is very exacting. However, the clinician must visualize the treatment process to anticipate specific compensations to optimize the efficiency of the treatment process.

Key1: Anterior torque compensation

The Insignia® system supplies the interactive software and virtual set-up for clinicians to predict the treatment results so that mechanics "*begin with the end in sight.*" However, there are biologic and physical factors that can affect the axial inclinations of the anterior teeth during and after space closure. Compensations are required to achieve an actual treatment outcome that is comparable to the virtual set-up:

(1) **Extraction Spaces**: The axial inclination of the incisors in both arches requires anchorage (*mesial movement of the buccal segments*) for lingual tipping of the crowns of the teeth or torquing of the roots. Anchorage value of adjacent teeth and resistance to space closure are affected by the size and location of the spaces in each arch. Extraction patterns to reduce bimaxillary protrusion may involve first (*4*) and second (*5*) premolars in the upper (*U*) and lower (*L*) arches. For Class I patients, with no anchorage support for the upper arch (*TADs, headgear*), it is unwise to extract four first premolars (*U4s and L4s*) because more rapid loss of maxillary anchorage during space closure usually results in a Class II molar relationship, which requires additional mechanics and treatment time; U4s and L5s is a preferable approach. If maximal retraction is required, and there is supplemental posterior maxillary anchorage, all four 4s is preferable. Physiologic rationale must be applied for a realistic Insignia® treatment plan. Maxillary premolar spaces

close at a high rate (*1-2mm/mo*) because the buccal segments are susceptible to rapid anchorage loss.[4,19,20] Overbite may be adequate anchorage to close maxillary posterior spaces by protracting the buccal segments.[19] However, mandibular posterior segments have much greater anchorage value than maxillary posterior segments.[5] Relatively rapid mesial movement (*~0.8mm/mo*) is noted for the first 8 months of space closure, but then slows dramatically to ~0.33mm/mo, as the trailing roots engage the dense cortical bone produced by PDL distraction of the leading roots.[5]

(2) **Differential Space Closure Mechanics and Anchorage Selection**: Frictionless (*closing loop mechanics*) or friction-prone (*sliding mechanics*) is an important consideration. Anchorage supplementation with TADs or headgear, and the type of elastics (*Class II or Class III*) planned, are all determining factors for differential anterior torque compensations. If TADs are used to support posterior anchorage, additional torque compensation is required because the incisors will be retracted further. Overall, the torque supplement for the incisor brackets in the digital set-up is directly related to the amount of retraction (*root movement*) planned.

(3) **Original Pattern of Malocclusion**: The amount of incisal torque is inversely related to crowding, but directly related to lingual tipping of the incisors and the depth of the curve of Spee. Torque compensations for mechanics that tend to tip incisors are essential for achieving ideal treatment results.

For treatment planning of the present patient (*Fig. 5*), the digital set-up was supplemented with 3° of lingual root torque. But the final inclination of the lower anteriors was inadequate due to the anterior growth of the jaws and the correction of the deep curve of Spee. In retrospect, a torque supplement of ~10° was warranted because the extraction space was anterior in the mandible (*L4s extracted*), mandibular molars have very high anchorage value,[5] and the curve of Spee was deep (*4mm*) (*Fig. 17*). Excessively retracted lower incisors were an unexpected sequelae that was compensated with torquing auxiliaries during finishing; however, the latter should not be used for more than 3 months. Torquing springs are superior to third order bends in customized wires because insertion of adjusted wires into a custom bracket system can be unpredictable and ineffective.[21]

In retrospect, the root axes between the upper central incisors were not parallel in the original set-up, which is difficult to detect with 2D radiograph and the crown images in the occlusal view of the virtual set-up (*Figs. 18-A&B*). Digital alignment technology is improved with a 3D parametric model to detect the shape and volume of dental roots.[22] In early 2017, TruRoot™ data was introduced for the Insignia® system, which combines CBCT imaging with intraoral scanner or impression data to simulate the actual crown and root anatomy, allowing clinicians to better visualize and predict tooth movement and alignment (*Fig. 18-C*). Unfortunately, this new technology was not available when the current patient was treated.

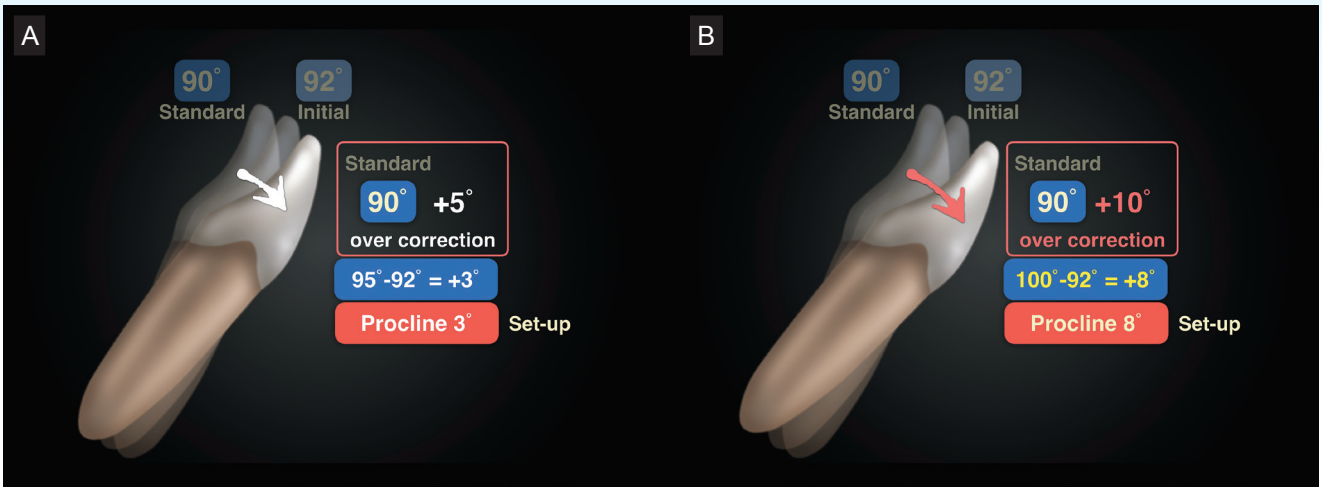

Fig. 17:

Incisor torque compensations are a critical treatment planning consideration that supplements the digital set-up: A. The original set-up for torque over-correction was 5°. B. The specific mechanics required for this growing patient that required first premolar extractions was an addition 5°. Thus, the overall torque over-correction was 10°. The additional torque control was needed because of the anterior positioning of the extraction space and less proclined incisors. See text for details.

Fig. 18:

A. Apical view of the upper digital set-up is rarely used in the pre-treatment planning, but it may be useful for specifying the torque compensation if a discrepancy is not apparent in the occlusal view. The red arrow shows correct torque for the UR1, compared to what appears to be a minor discrepancy on the adjacent central incisor (UL1). B. An intraoral photograph shows the post-treatment torque discrepancies between the maxillary central incisors, and the UL1 root is more prominent (white arrow). C. With additional data from panoramic radiography, CBCT (ex: i-CAT), intraoral scanner, and/or an impression, a 3D images of each root can be constructed. (Illustration C from Dr. Angle Lee's presentation: Increasing Simulation Accuracy of Insignia by CBCT. CC429, newtonsa0301, YouTube™)

Key2: Disarticulation and Early Light Class II elastics

Bite turbos (*occlusal prematurities used to increase the intermaxillary space*) are very useful early in treatment for opening a deep overbite, as well as for leveling a deep curve of Spee to prevent interferences with lower brackets.[23,24] Advantages of bonded bite turbos are: (*1*) no patient cooperation is required, (*2*) it is a full-time alteration of the occlusion, and (*3*) they are easy to bond and remove. Bite turbos are constructed with glass ionomer cement, composite resins or self-curing acrylic resins. To solve Class II occlusions with excessive overjet, early light short elastics can be used in the initial leveling and alignment stage to simultaneously retract the anterior segment, decrease incisor proclination and correct the overjet.

Key3: Archwire selection for space closure

Space closure with a stock Damon Q® bracket appliance usually requires bending a reverse curve of Spee in a lower archwire made with a material such as an 0.016x0.025-in stainless steel (*Fig. 19*). Appropriate treatment planning during the digital set-up eliminates wire bending with the Insignia® system. Following the recommended wire sequence, either an 0.019x0.025-in stainless steel or 0.019x0.025-in Insignia® TMA wire can be used for optimal space closure without bending a reverse curve of Spee.[13] Use of a full-size archwire is designed to prevent tipping when closing spaces (*Fig. 20*).

After all the extraction spaces have been closed, full-sized 0.021x0.025-in CuNiTi or TMA wires are

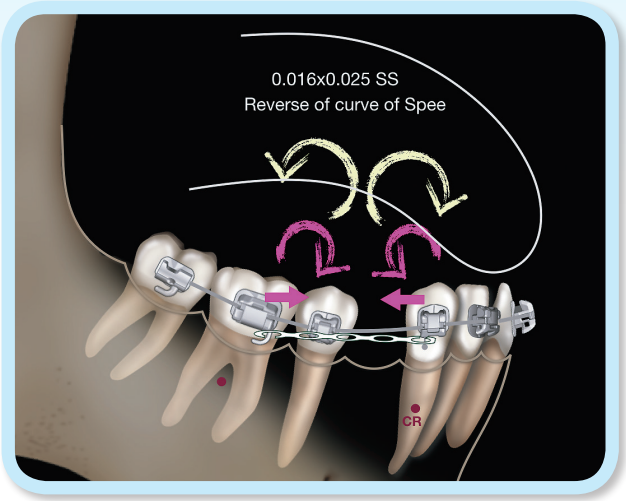

Fig. 19:
An 0.016x0.025-in stainless steel (SS) archwire with a reverse curve of Spee is an ideal configuration for space closure in the lower arch. Note that the moments (magenta equal and opposite curved arrows) produced by the space closure forces (magenta arrows) are offset by the equal and opposite moments (yellow circular arrows) due to the reverse curve of Spee.

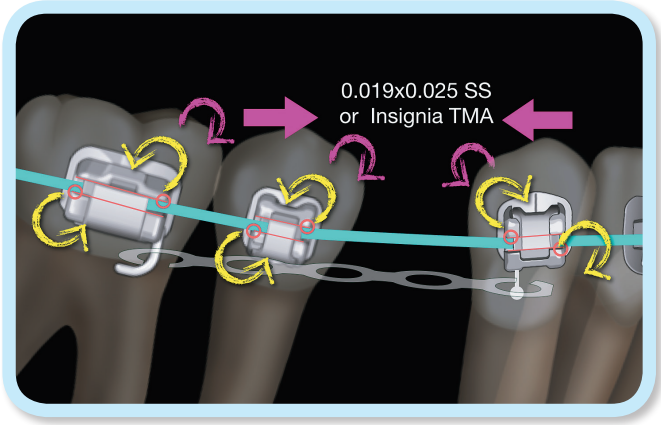

Fig. 20:
A large rectangular archwire (green line) such as an 0.019x0.025-in stainless steel (SS) or Insignia® TMA more completely fills the bracket slots resulting in more predictable space closure. This configuration decreases the play between the bracket and the wire. Space closure force (magenta arrows) produces equal and opposite moments (magenta curve arrows) to translate rather than tip the teeth. During space closure, the load is transferred from the archwire to the brackets by equal and opposite moments (couples) that are produced at the ends of each bracket (yellow curved arrows).

recommended to adjust the final rotation, tip, and torque for all teeth. However for the current patient, only a 0.019x0.025-in TMA wire was used in the finishing stage. To compensate for the unexpected growth response, detailing bends and torque springs were required during the last month. A subsequent full-size archwire would have been helpful for avoiding some of the finishing problems.

Soft Tissue Evaluations and Changes

Facial esthetics with regard to orthodontic treatment mainly focuses on profile convexity (*G-Sn-Pg'*) and lip protrusion relative to the nose-chin plane (*Rickett's E-Line*).[25] Ideal facial convexity is a G-Sn-Pg' angle of 13 degrees (*Table 1*). However, protrusive lips to the E-Line are unfavorable for all variations of facial divergence, particularly for males.[26]

Several factors[7,8] are associated with correcting lip protrusion:

1. Incisal edge retraction
2. Pre-treatment thickness of soft tissue at the subnasale (*lip-nose junction*), lips and mental (*chin*) areas because thinner tissue tends to retract more.
3. Nasal and chin growth during treatment is favorable because lips appear flatter as the the E-Line is positioned more anteriorly.

The current successful treatment for bimaxillary lip protrusion and convex profile was attributed to incisal retraction, as well as to favorable (*anterior*) growth of the nose and chin to anteriorly reposition the E-lIne. Accurate diagnosis, a well planned treatment sequence, and a favorable extraction pattern produced a favorable "*start-to-finish*" outcome that was highly predictable.

Conclusions

1. Extraction of all four first premolars and symmetrical space closure result in maximal incisor and lip retraction for resolving bimaxillary dentoalveolar protrusion.
2. Space closure in all four quadrants is challenging clinical mechanics.
3. The Insignia® system is a well designed digital appliance that features a virtual treatment plan, customized brackets, and sequenced archwires.
4. Anchorage is preserved so that incisors are retracted and aligned into a favorable finished occlusion, without using TAD supplemented anchorage.
5. The 3 keys to success with digitally engineered mechanics are precise estimation of anterior torque compensations, use of auxiliaries as prescribed, and careful adherence to the recommended archwire sequence.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 20

OVERJET

0 mm. (edge-to-edge)	=	1 pt.
1 – 3 mm.	=	0 pts.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	3 pts.
7.1 – 9 mm.	=	4 pts.
> 9 mm.	=	5 pts.

Negative OJ (x-bite) 1 pt. per mm. per tooth =

Total = 2

OVERBITE

0 – 3 mm.	=	0 pts.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	3 pts.
Impinging (100%)	=	5 pts.

Total = 2

ANTERIOR OPEN BITE

0 mm. (edge-to-edge), 1 pt. per tooth
then 1 pt. per additional full mm. per tooth

Total = 0

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 0

CROWDING (only one arch)

1 – 3 mm.	=	1 pt.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	4 pts.
> 7 mm.	=	7 pts.

Total = 2

OCCLUSION

Class I to end on	=	0 pts.
End on Class II or III	=	2 pts. per side _____ pts.
Full Class II or III	=	4 pts. per side _____ pts.
Beyond Class II or III	=	1 pt. per mm. additional _____ pts.

Total = 2

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 0

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = 4 pts.

Each degree < -2° _____ x 1 pt. = _____

Each degree > 6° _____ x 1 pt. = _____

SN-MP

≥ 38° = 2 pts.

Each degree > 38° _____ x 2 pts. = _____

≤ 26° = 1 pt.

Each degree < 26° _____ x 1 pt. = _____

1 to MP ≥ 99° = 1 pt.

Each degree > 99° _____ x 1 pt. = _____

Total = 4

OTHER (See Instructions)

Supernumerary teeth	_____ x 1 pt. =	_____
Ankylosis of perm. teeth	_____ x 2 pts. =	_____
Anomalous morphology	_____ x 2 pts. =	_____
Impaction (except 3rd molars)	_____ x 2 pts. =	_____
Midline discrepancy (≥3mm)	@ 2 pts. =	_____
Missing teeth (except 3rd molars)	_____ x 1 pts. =	_____
Missing teeth, congenital	_____ x 2 pts. =	_____
Spacing (4 or more, per arch)	_____ x 2 pts. =	_____
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	_____
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	4 x 2 pts. =	8

Identify: Close 4 extracted spaces without severe crowding + Deep curve of Spee

Total = 8

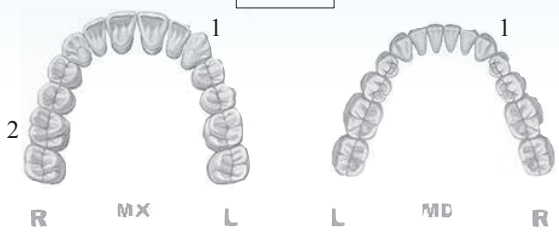
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 21

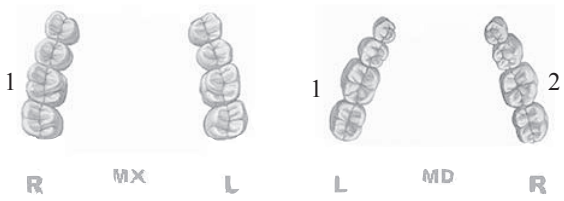
Alignment/Rotations

4



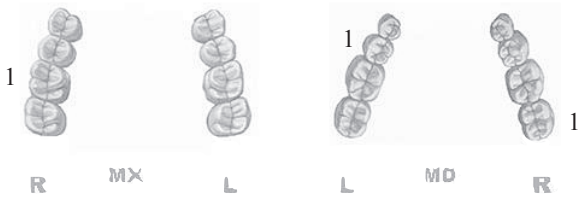
Marginal Ridges

4



Buccolingual Inclination

3

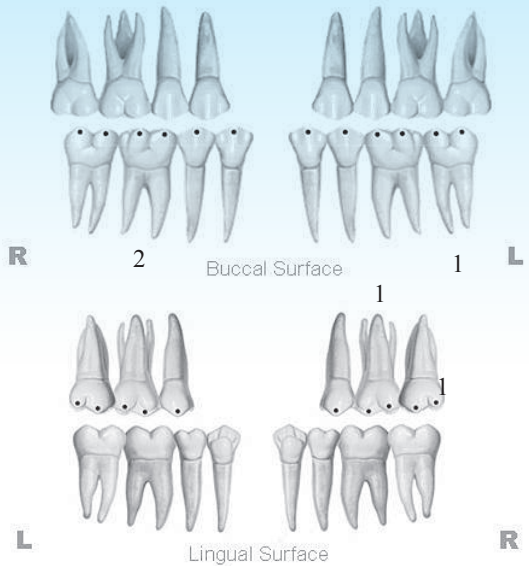


Overjet

3

Occlusal Contacts

4

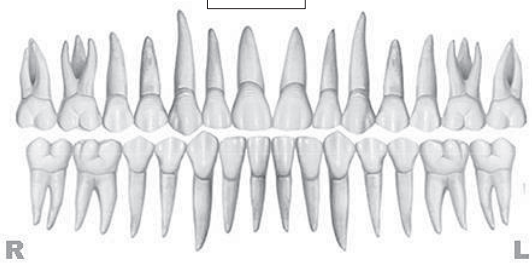


Occlusal Relationships

1

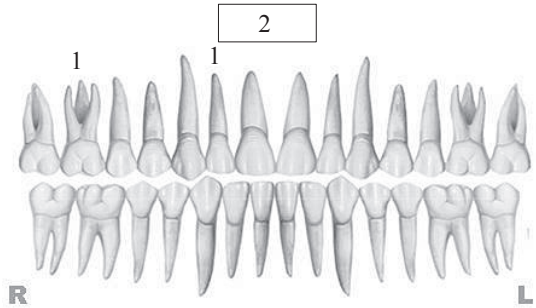
Interproximal Contacts

0



Root Angulation

2



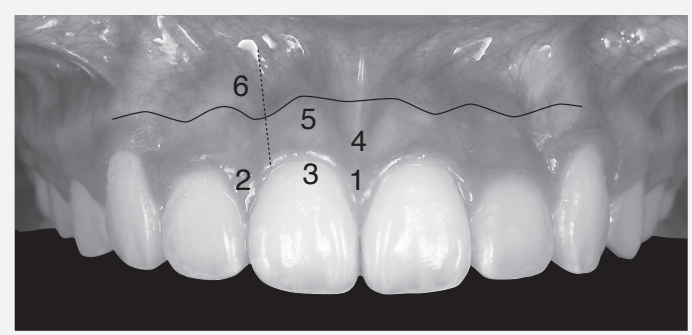
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 5

1. Pink Esthetic Score

Total = 3

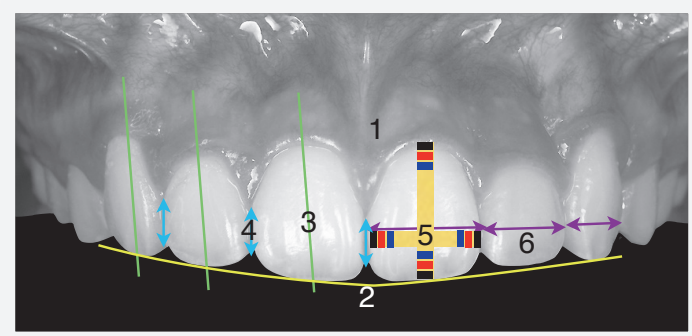


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

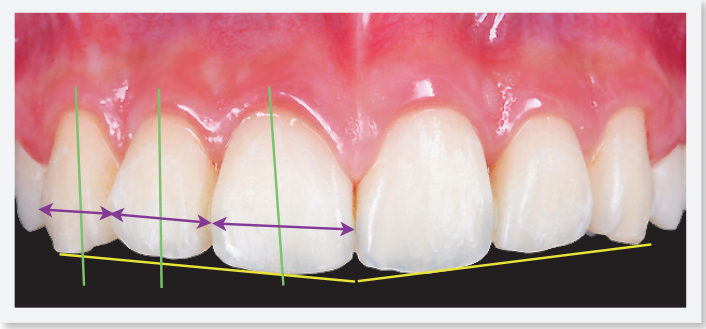
1. M & D Papilla	(0)	1	2
2. Keratinized Gingiva	(0)	1	2
3. Curvature of Gingival Margin	(0)	1	2
4. Level of Gingival Margin	(0)	1	2
5. Root Convexity (Torque)	0	(1)	2
6. Scar Formation	0	1	(2)

2. White Esthetic Score (for Micro-esthetics)

Total = 2



1. Midline	0	1	2
2. Incisor Curve	0	1	2
3. Axial Inclination (5°, 8°, 10°)	0	1	2
4. Contact Area (50%, 40%, 30%)	0	1	2
5. Tooth Proportion (1:0.8)	0	1	2
6. Tooth to Tooth Proportion	0	1	2



1. Midline	(0)	1	2
2. Incisor Curve	(0)	1	2
3. Axial Inclination (5°, 8°, 10°)	0	(1)	2
4. Contact Area (50%, 40%, 30%)	(0)	1	2
5. Tooth Proportion (1:0.8)	(0)	1	2
6. Tooth to Tooth Proportion	0	(1)	2