Severe Malocclusion with Openbite, Incompetent Lips and Gummy Smile (DI 29) Treated in 16 Months with Clear Aligners to a Board Quality Result (CRE 18)

Abstract

History: *A 30-year-old male presented with chief complaint (CC) of openbite, occasional TMJ pain, a shift when biting, and "gummy smile" (excessive gingival exposure). Modified Palmer nomenclature for this report is upper (U), lower (L), right (R), left (L), and teeth are 1-8 from the midline.*

Diagnosis: *Facial analysis revealed: decreased facial profile (10.5°), increased lower facial height (LFH)(58.9%), bimaxillary protrusion tendency (SNA 83°, SNB 82.5°), lip incompetence, excessive upper lip elevation when smiling, mandibular deviation to the right, occlusal plane canted up 4° on the right, slightly protrusive mandible, incompetent lips, gummy smile, and dark buccal corridors. Compared to the facial midline, the upper midline was 2mm right, and the lower midline was 4mm right.*

Dental evaluation showed: *Class I occlusion except for a 2-3mm Class II UR3, ~3mm of crowding was noted in each arch, upper incisors tipped lingually (SN 100°), lower incisors tipped labially (MP 93.5°), 2mm $C_R \rightarrow C_O$ shift anterior and to the right due to a crossbite of a LL5, and 1-2mm loss of alveolar bone height between the LR3 and LR4.*

Etiology: *Probable etiology, for this acquired asymmetric malocclusion with increased LFH, was deemed a juvenile airway obstruction that resulted in a low tongue posture, interincisal tongue position, and posterior rotation of the mandible. Facial deviation to the right reflects a habitual sleeping pattern on the left side.*

Treatment: *An iTero Element® intraoral scanner and ClinCheck® treatment planning system were used to specify 31 Invisalign® aligners (Align Technology, Inc, San Jose, CA, USA) to: 1. expand, align and level both arches, 2. resolve the right canine Class II relationship, 3. correct incisor axial inclinations, 4. close the openbite by extruding lateral incisors, and 5. reduce the gummy smile by retracting incisors to correct incompetent lips. Phase 1 was 19 aligners for initial alignment and Phase 2 was 12 aligners to detail and finish. This complex malocclusion was treated in 16 months, and the patient was trained in lip seal exercises, natural lip elevation, and varied sleep positions.*

Outcomes: *A severe complex malocclusion with an American Board of Orthodontics (ABO) Discrepancy Index (DI) of 29 was treated to an excellent result, as documented by an ABO Cast-Radiograph Evaluation (CRE) score of 18, and a Pink and White (P&W) dental esthetic score of 1. Comprehensive analysis revealed an improved facial profile, competent lips, and more natural smile line, but there was no change in facial deviation and cant of the occlusal plane. The patient's CC (TMJ pain, bite shift and gummy smile) was resolved to his satisfaction.*

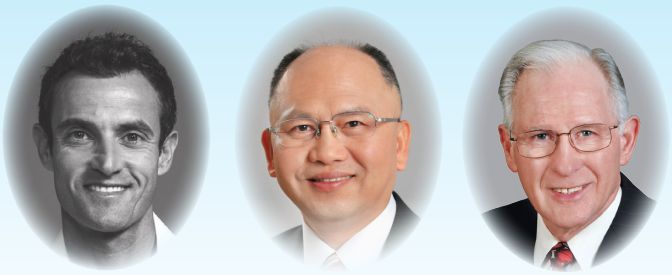
Conclusions: *This is the first comprehensive case report of a severe, complex malocclusion (DI 29) treated with clear aligners to a board quality result (CRE 18, P&W 1). (Int J Orthod Implantol 2017;48:74-94)*

Key words:
Invisalign, aligner treatment, anterior openbite, gummy smile, intermittent TMJ pain, incisor retraction, competent lips, lower face deviation, function shift

Dr. Diego Peydro Herrero,
Director, Clínica Dental Peydro, Valencia, Spain
Director of Master COIP. International Master Class in Invisalign Technique
Master Class of Beethoven Invisalign International Course (Left)

Dr. Chris Chang,
Founder, Beethoven Orthodontic Center
Publisher, International Journal of Orthodontics & Implantology (Center)

Dr. W. Eugene Roberts,
Editor-in-chief, International Journal of Orthodontics & Implantology (Right)



Background

As stated in the abstract, this journal (*IJOI*) utilizes a modified Palmer notation: upper arch (*U*), and lower arch (*L*), right side (*R*), and left side. Teeth in each quadrant (*UR, UL, LR, LL*) are numbered 1-8 from the midline. The supplier for this case report (*Align Technology, San Jose, CA*) uses a different method: UR, UL, LR, LL quadrants are numbered 1-4, respectively. The quadrant number is then separated by a period from the tooth number 1-8. Comparing both methods (*IJOI and Align*), the maxillary central incisors are UR1 (*1.1*) and UL1 (*2.1*).

Fig. 1: Pre-treatment photographs

History

A 30-year-old male presented with chief complaints of openbite, occasional TMJ pain, a shift when biting, and excessive gingival exposure (*gummy smile*).

Pre-Treatment Evaluation

Clinical examination showed bilateral Class I molars and left canines, but the right canines were 2mm Class II (*Fig. 1*). Facial analysis (*Fig. 1*) revealed a relatively flat facial profile, incompetent lips, and slightly protrusive mandible. A gummy smile with dark buccal corridors was associated with inadequate transverse development of the maxillary arch. The patient complained of intermittent pain in both temporomandibular joints (*TMJs*), but the contours of the mandibular condyle were within normal limits (*WNL*), based on the panoramic and cephalometric radiographs (*Fig. 2*). There was a 2mm

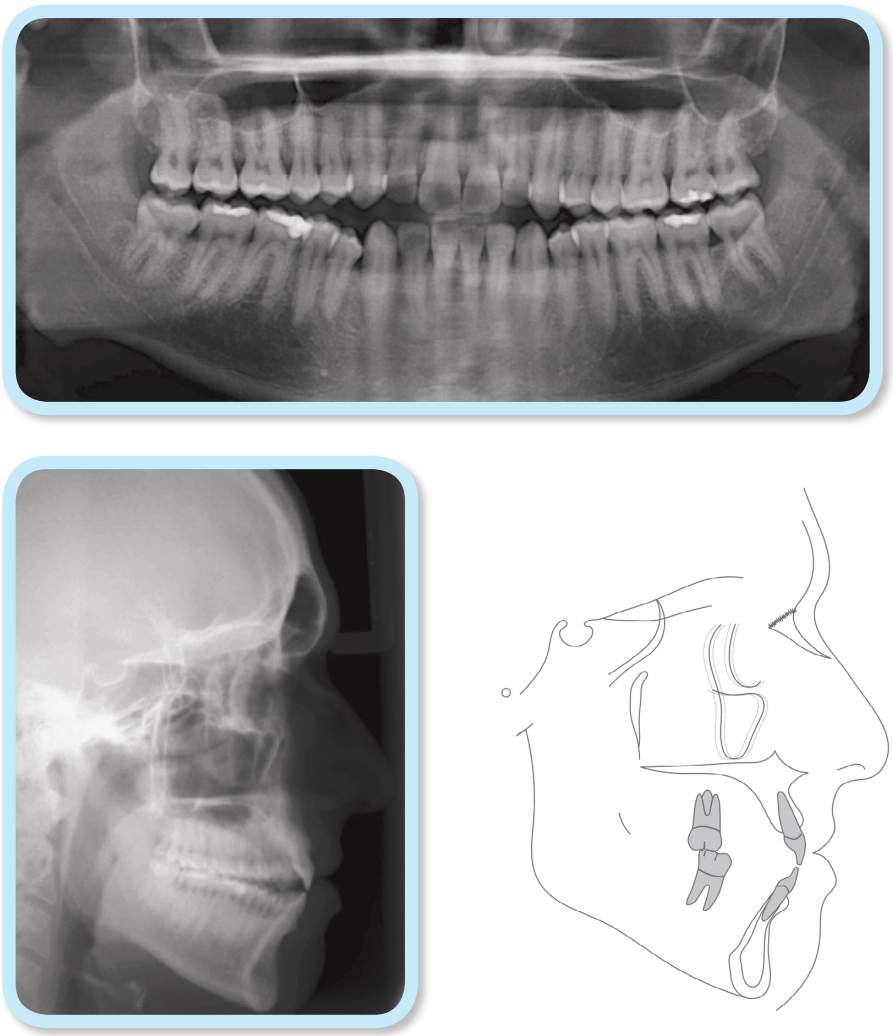


Fig. 2:
Pre-treatment radiographs are: 1. Panoramic view (upper), 2. Lateral cephalogram (lower left), 3. Tracing of the lateral cephalometric radiograph with the central incisors and first molars shaded in gray (lower right).

$C_R \rightarrow C_O$ shift anteriorly and to the right, which was associated with end-on incisal occlusion and LL5 crossbite.

Cephalometrics revealed decreased facial convexity (*10.5°*), increased facial height (*58.9%*), slight bimaxillary protrusion (*SNA 83°, SNB 82.5°*), normal intermaxillary relationship (*ANB 2.5°*), and a mandibular plane angle (*SN 32.5°, MPA 25.5°*) that was WNL. The frontal view (*Fig. 1*) showed lower face deviation, and an occlusal plane cant to the right. A more detailed analysis in maximum interception (C_O) revealed the chin point was 5mm deviated to the right, occlusal plane was canted 4° up on the right, maxillary midline was 2mm to the right of the facial midline, and the mandibular midline was 4mm to the right of the facial midline (*2mm intermaxillary midline discrepancy*). There was crowding in both dental arches (*-3mm/-3mm*), decreased axial inclination of the maxillary incisors (*100°*), lower incisor axial inclination (*SN 93.5°*) WNL, end-to-end incisal occlusion (*no overjet*), and an asymmetric openbite of 1-4mm from UR5-UL4. The panoramic radiograph (*Fig. 2*) documented all permanent teeth were normally erupted, and bone height was WNL except for a 1-2mm loss of alveolar bone height between the LR3 and LR4.

For the current malocclusion (*Figs. 1-2*) the ABO Discrepancy Index (*DI*) was 29 as shown in the subsequent worksheet. According to the ABO evaluation criteria, this malocclusion is classified as severe (*DI>20 points*).[1]

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	83°	82.5°	2.5°
SNB° (80°)	80°	79°	1°
ANB° (2°)	3°	2.5°	0.5°
SN-MP° (32°)	32.5°	31.5°	1°
FMA° (25°)	25.5°	24.5°	1°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	3 mm	2 mm	1 mm
U1 To SN° (104°)	100°	108°	8°
L1 To NB mm (4 mm)	7 mm	5 mm	2 mm
L1 To MP° (90°)	93.5°	83°	0.5°
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	-8 mm	-9 mm	1 mm
E-LINE LL (0 mm)	-2 mm	-3 mm	1 mm
%FH: Na-ANS-Gn (53%)	58.9%	58.2%	0.7%
Convexity: G-Sn-Pg' (13°)	10.5°	14°	3.5°

■ Table 1: Cephalometric summary

Etiology

The etiology of openbite malocclusion[2] in conjunction with long-face syndrome[3] is controversial, but current evidence increasingly favors environmental factors, such as low tongue position producing an acquired malocclusion (*Fig. 2*). The latter may be related to a history of oropharyngeal airway problems, and/or habitual sleep position.[4] Posturing the tip of the tongue between the incisors to contact the lower lip is associated with openbite and decreased maxillary width.[5,6] Tongue thrust is a compensation to (*not the cause of*) openbite malocclusion.[6] Based on the

current history and records (*Figs. 1-3*), the probable etiology of the current openbite malocclusion was a juvenile airway problem[4] that resulted in an interdental tongue posture.[7] Airway problems may resolve in adults because of lymphoid tissue atrophy in late adolescence,[4] although the openbite persists as an aberrant tongue posture habit. If both the openbite and its proximal etiology (*low tongue posture and lip incompetence*) are corrected, the outcome has a good prognosis.[5,6]

Gummy smile (*excessive gingival display*) is an undesirable esthetic characteristic as perceived by the observer (*usually the patient and/or family*).[8] A careful evaluation is indicated to determine if the problem can be managed to the observer's satisfaction with conservative (*orthodontic*) and/or surgical treatment. However, smile analysis is a dynamic process which is best evaluated in a personal interview or with a video image.[9] A single photograph may be flawed by excessive (*unnatural*) lip elevation. The etiology of the gummy smile for the present patient (*Fig. 1*) was deemed: 1. protrusive maxilla (*SNA 83°*), 2. incompetent lips, and 3. excessive lip elevation.

Treatment Objectives

The priority was to develop a treatment plan that addressed the etiology of the acquired malocclusion (*Figs. 1-3*). The openbite was due to low tongue posture, which was manifest as openbite associated with decreased maxillary width. Gummy smile was related to a protrusive maxilla, incompetent lips

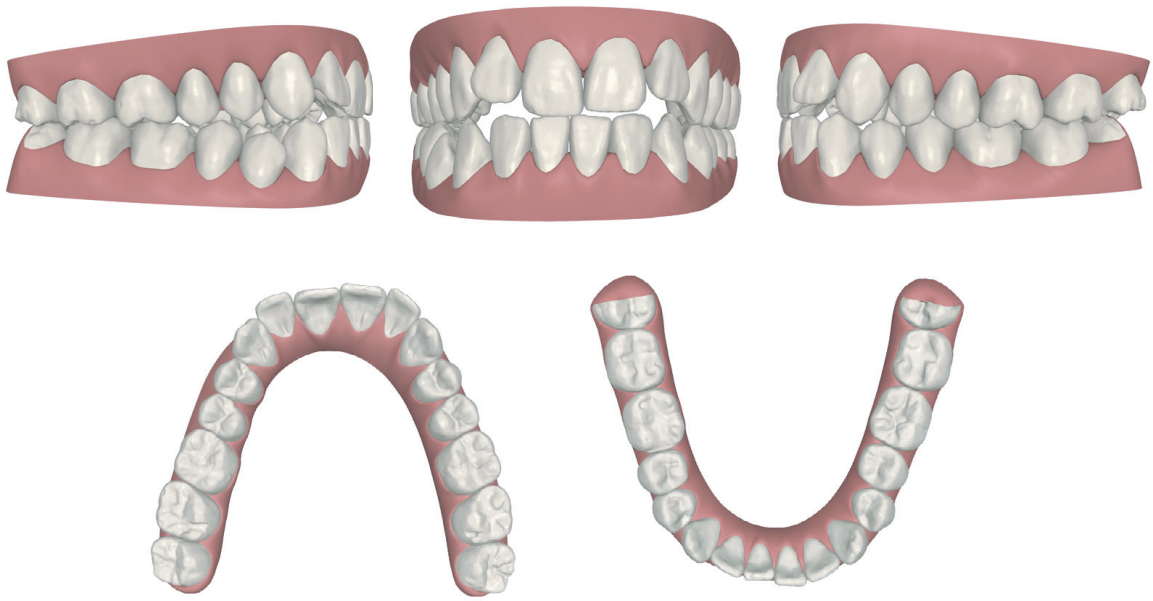


Fig. 3: Pre-treatment images of the dentition were captured by an iTero® intraoral scanner.

and excessive lip elevation. Clear aligners were the therapeutic choice for the patient and the clinician. The treatment objectives were:

1. Level and align the dentition in both arches to correct the openbite.
2. Expand both arches to correct tongue posture and retract the upper and lower incisors.
3. Resolve the right Class II canine relationship.
4. Train the patient to posture the tongue in the roof of the mouth.
5. Increase axial inclination of the upper incisors.
6. Decrease axial inclination of the lower incisors.
7. Correct the gummy smile by correcting lip incompetence, and lip elevation training.
8. Reenforce training of the patient (*in front of a mirror*) to maintain lips in contact, position the tongue in the roof of the mouth, and smile with more natural lip elevation.

Maxilla (*all three planes*):

- A - P: *Retract*
- Vertical: *Maintain*
- Transversal: *Maintain*

Mandible (*all three planes*):

- A - P: *Retract*
- Vertical: *Decrease*
- Transversal: *Maintain*

Maxillary Dentition:

- A - P: *Retract Incisors, maintain molars by expanding the maxillary arch*
- Vertical: *Extrude*
- Transversal: *Expand*

Mandibular Dentition:

- A - P: *Retract Incisors, maintain molars by expanding the maxillary arch*
- Vertical: *Extrude*
- Transversal: *Expand*

Facial Esthetics:

- Retract both anterior segments to correct lip incompetence
- Correct gummy smile: *Lip competence and more natural elevation of the upper lip*
- Eliminate dark buccal corridors

Treatment Plan

An iTero Element® intraoral scanner (*Align Tech, Inc, San Jose, CA, USA*) was used to digitize a 3D dataset of the dentition and supporting tissues (*Fig. 3*). A dedicated treatment planning system (*Invisalign® by Align Technology, Inc, San Jose, CA, USA*) planned the

correction: 1. align and level both dental arches, 2. extrude the lateral incisors, canines and premolars to close the openbite, 3. retract both anterior segments by expanding the arches, 4. resolve the right canine Class II relationship, as well as 5. detail and finish the 3D alignment of the entire dentition.

Two stages of treatment (*Figs. 4 and 5*) were specified by the software to achieve a final occlusion similar to the digital set-up (*Fig. 6*). Aligner tooth movement requirements were determined by 3D superimposition of the original malocclusion (*Fig. 3*) on the desired result (*Fig. 6*). The original treatment plan proposed on ClinCheck® (*Fig. 7*) was unacceptable because of: 1. an emphasis on extrusion of maxillary central rather than lateral incisors to close the openbite, and 2. inadequate expansion of both arches to retract the upper and lower anterior segments. The clinician (*DPH*) entered seven modifications on ClinCheck® to produce the appropriate treatment sequence, including placing extrusive attachments on the

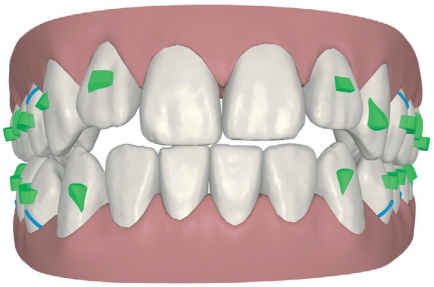


Fig. 5:
Prior to delivering Aligner 10, horizontal beveled attachments are bonded on both maxillary lateral incisors to apply extrusive loads.

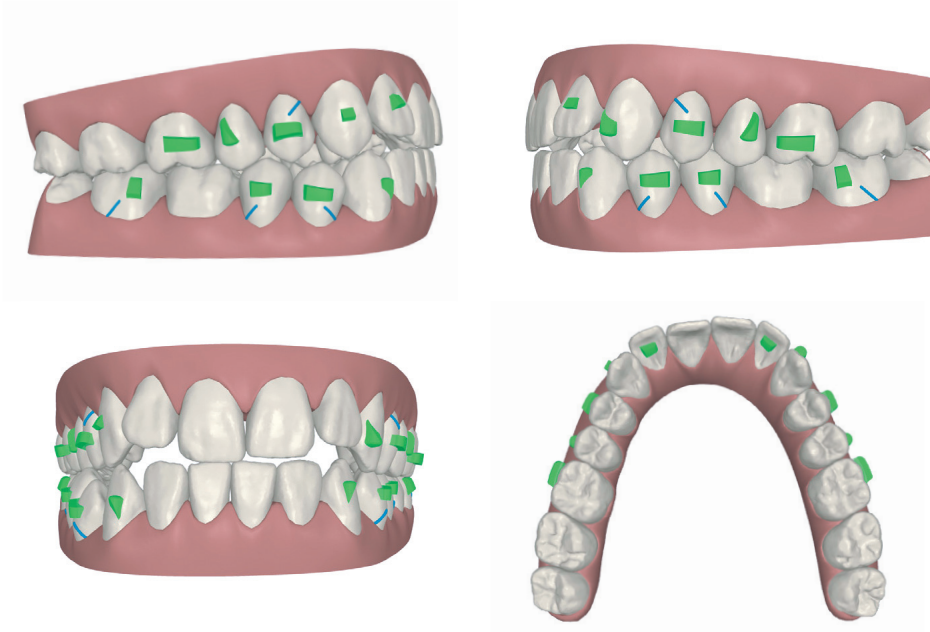


Fig. 4:
At the second appointment, 20 days into treatment, the initial set of attachments (green) are bonded on the teeth with composite resin. See text for details.

Fig. 6:
Images of the digital set-up show the final planned occlusion after leveling, alignment, and expansion of the arches. See text for details.

maxillary lateral incisors and removing them from the central incisors (*Fig. 8*). This clinician-directed treatment plan was subsequently approved on ClinCheck® prior to designing the iterative series of aligners to reposition the teeth in a step-by-step pattern. Attachments were required on some teeth to apply forces and/or couples to affect tooth movement. The aligner specifications, listed on the left side of the treatment-sequence table (*Fig. 8*), were used to calculate the iterations for each step of initial treatment sequence. Overall, a total of 31 aligners were specified for the entire treatment: 19 for the first phase (*initial alignment*), and 12 for the second phase (*detailing and finishing*). All aligners and treatment auxiliaries (*attachments and elastics*) were supplied by Align Technology.

Phase 1 initial Alignment. The clinical objectives for the first phase were to correct the minor crowding and expand the transverse dimension of the dental arches to retract the incisors. Biomechanics rationale is to expand each arch to decrease its sagittal length, and the incisors are simultaneously retracted because they have less anchorage value than the anterior segments. Class II elastics are required because the lower molars have greater anchorage value than upper molars.[10] Nineteen iterations are specified in the treatment plan (*Fig. 8*) to accomplish the initial alignment. An aligner is constructed for each step-by-step application of a therapeutic load to achieve the progressive alignment. For the first phase (*19 aligners*) the patient is instructed to use each aligner for 10 days and then progress to the next aligner. Class II elastics (*3/16-in 6½-oz*) are planned between cuts in the aligners from the upper first premolars (*U4s*) to the lower second molars (*L7s*). In the third month of treatment, a triangle configuration of vertical elastics (*1/8-in 6½-oz*) is applied from the U4s to both lower premolars, during the sleeping hours for the duration of treatment.

Phase 2 Detailing and Finishing. When the initial alignment (*Phase 1*) is completed, perform a progress scan to plan detailing and finishing with an additional 12 aligners. The frequency of aligner progression is increased to every two weeks during the second phase of treatment, and the pattern of elastics wear is continued.

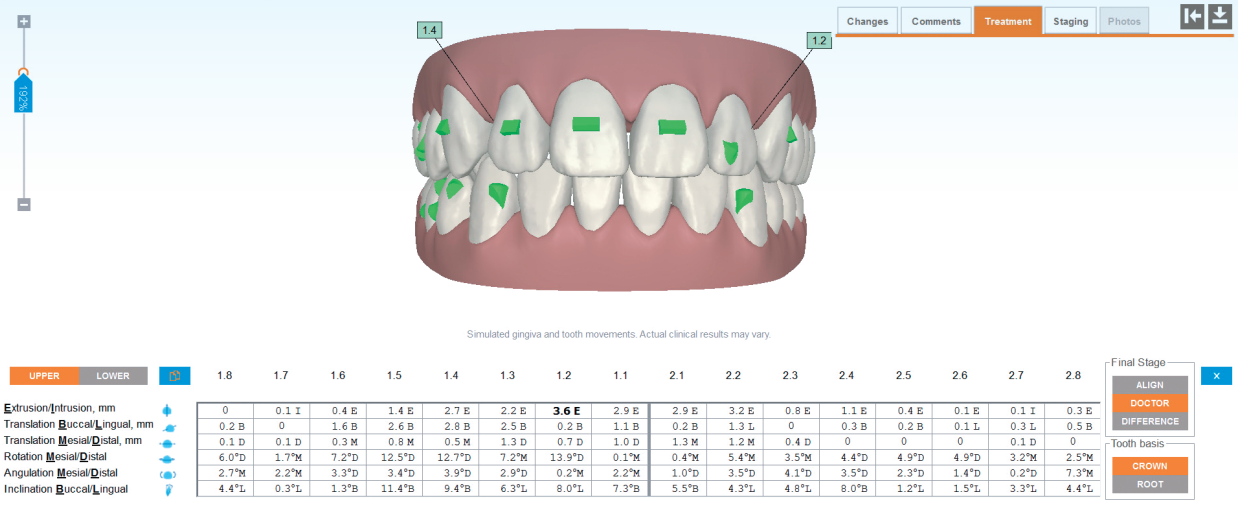


Fig. 7:
A table describes the initial proposal for a progressive sequence and magnitude of loads planned for individual teeth. This treatment plan was not adopted. See text for details.

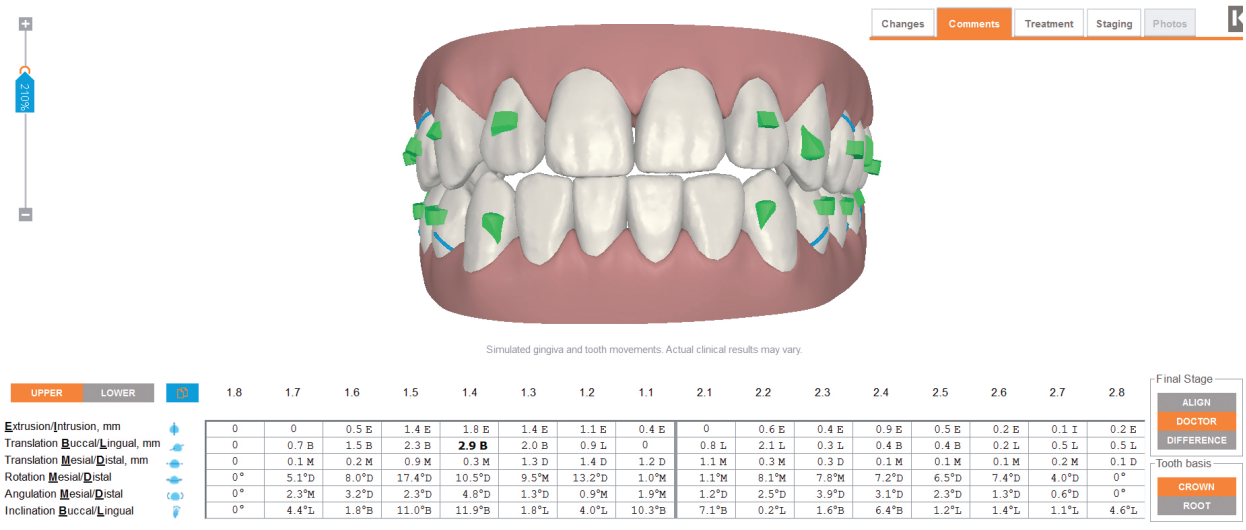


Fig. 8:
Following instructions from the clinician, the treatment plan (Fig. 7) was adjusted with seven modifications to Clincheck® before formulating the definitive treatment plan, as outlined in the table at the bottom. See text for details.

Appliances and Treatment Progress

Phase 1: Treatment at the first appointment began as soon as the first two aligners were delivered. The patient was instructed to consistently wear them 20-22 hours a day, and only remove them for eating and tooth brushing. The initial aligners were worn 10 days each. They were programmed to bring about expansion and proclination, but not extrusion or rotation movements, because the latter required placing attachments (*Figs. 4 and 8*). The second clinical appointment was planned for 20 days into treatment, when the attachments were bonded on the selected teeth using at the composite Tetric EvoCeram (*Ivoclar Vivadent, Inc. NY, USA*):

UPPER MAXILLA (*per tooth*) :

- 1.6 Horizontal gingival beveled 4mm
- 1.5 Optimized (*to achieve and hold ideal position*)
- 1.4 Horizontal gingival beveled 4mm
- 1.3 Optimized for extrusion
- 1.2 Horizontal attachment 3mm on the palatal surface
- 1.2 Optimized for extrusion (*bonded in aligner 10*)
- 2.6 Horizontal gingival beveled 4mm
- 2.5 Optimized
- 2.4 Horizontal gingival beveled 4mm
- 2.3 Optimized for rotation
- 2.2 Optimized for extrusion (*bonded in aligner 10*)

MANDIBLE (*per tooth*) :

- 3.7 Vertical 3mm
- 3.5 Horizontal gingival beveled 3mm
- 3.4 Horizontal gingival beveled 4mm
- 3.3 Optimized for rotation
- 4.7 Vertical 3mm
- 4.5 Horizontal gingival beveled 3mm
- 4.4 Horizontal gingival beveled 4mm
- 4.3 Optimized for rotation

After placing the attachments, aligners 3-9 were delivered, with instructions to wear each aligner for 10 days and then progress to the next. Aligners 3-9 were designed primarily for expansion and anterior tipping of the incisors, in addition to rotational corrections of the canines, premolars and molars. It was also necessary to correct upper lateral incisor rotations before commencing extrusion. Interproximal reduction (*IPR*) in the lower arch was also performed at this appointment. Each contact point from the distal of the LR3 to distal of the LL3 were reduced an average of 0.3mm per surface to provide lower anterior space (*12x0.3=3.6mm*) to align the incisors, reduce lower incisor axial inclination, and increase lingual root torque.

Aligner 10 was programmed with extrusive attachments on the maxillary lateral incisors (*Fig. 5*) to complete rotation and extrude UR2 and UL2 to the level of the adjacent central incisors. A 1mm

space was created between the central and lateral incisors, as the arch expanded, to provide space for alignment of the maxillary anterior segment with the openbite closed. When the patient wore aligners 10-15, he was instructed to use the following elastics at night:

- 3/16-in 8-oz Class II elastics worn from the first premolars to a button bonded in the second lower molars bilaterally
- 1/8-in 6½-oz elastics attached through cuts in the aligners from the first premolars to both lower premolars

Starting with aligner 10, the patient was instructed to progress to the next aligner in the series every two weeks. The programmed mechanics involved continued maxillary expansion and increased upper central incisor torque to establish a normal overbite and overjet relationship. Aligners 10-19 were designed to extrude lateral incisors 2mm, expand the maxilla, improve interdigitation with nine months of treatment. As the buccal segment, interdigitation and overbite relationships were corrected the mandible was postured 1-2mm more posteriorly and superiorly to decrease LFH, correct lip competence, and improve the gummy smile. The planned initial alignment was achieved during Phase 1.

Phase 2: A new scan was performed to design the second phase of 12 aligners for final detailing. The same elastics wear was continued during the sleeping hours. After the 6 month finishing phase, active treatment was completed. Occlusal adjustments and esthetic detailing were performed to ensure stability, eliminate occlusal interferences, and improve the shape of incisors and canines. After 15 months of treatment, all attachments were removed, and the last set of aligners was worn passively for three months to stabilize the final alignment.

Treatment Results

Compared to the pre-treatment records (*Figs. 1-3*), the post-treatment facial photographs (*Fig. 9*) and cephalometric documentation (*Fig. 10*) show that the profile and smile esthetics were markedly improved with 15 months of clear aligner treatment. Dental alignment (*Fig. 1*) is near ideal as originally specified by the digital set up (*Fig. 6*). The panoramic radiograph (*Fig. 10*) reveals that axial inclinations of the dentition are not ideal but quite acceptable for 15 months of treatment. More ideal axial inclinations (*second order alignement*) was not warranted because it would require a much longer treatment time with minimal additional benefit.

Pre-treatment and post-treatment cephalometric tracings (*Fig. 11*) were revealing. Superimposition on the anterior cranial base showed the incisors were retracted about 3-4mm in each arch. The axial inclinations of the incisors was improved: maxillary incisors were increased to 108°, and mandibular incisors were decreased to 93°. The alignment of the dentition resulted in interdigitation that was consistent with a 1-2mm more distal and superior position to the mandible. The latter was probably related to the TMJ symptoms the patient reported prior to treatment, because those pre-treatment problems were no longer evident after the functional shift was corrected. Before and after treatment tracings superimposed on the maxilla and

mandible revealed stabilization of the molars while the anterior segments were retracted 1-3mm in the sagittal plane. The anterior segments were extruded 1-2mm in each arch to close the openbite (*Fig. 11*).

Despite the severe openbite, crowding, and midline deviation, this severe malocclusion (*DI 29*) was corrected to a Class I molar and canine relationship. Intermaxillary second and third order alignment was WNL (*Fig. 6*). Overjet and overbite were near ideal. C_R and C_O were coincident. Signs and symptoms of TMJ disfunction were resolved. The dental result was excellent as documented by a ABO Cast-Radiograph Evaluation (*CRE*) score of 18, and a Pink & White (*P&W*) dental esthetic score of 1. For scoring details refer to the worksheets at the end of this report.

Maxilla (*all three planes*):

- A - P: *Retracted*
- Vertical: *Maintained*
- Transversal: *Maintained*

Mandible (*all three planes*):

- A - P: *Retracted*
- Vertical: *Maintained*
- Transversal: *Maintained*

Fig. 9:
Post-treatment intraoral and facial photographs document the final outcome in the same order as the pre-treatment Figure 1. See text for details.

Maxillary Dentition:

- A - P: *Retracted*
- Vertical: *Slight extrusion*
- Transversal: *Expansion*

Mandibular Dentition:

- A - P: *Retracted*
- Vertical: *Maintained*
- Transversal: *Expansion*

Retention

The patient used the last set of aligners for three months as the initial retainers. After the post-treatment settling, new impressions were made to fabricate clear overlay retainers with ESSIX® thermoplastic (*Dentsply International Raintree Essix, Sarasota, FL USA*). The new retainers were delivered and the patient was instructed to wear them at night (*sleeping hours*).

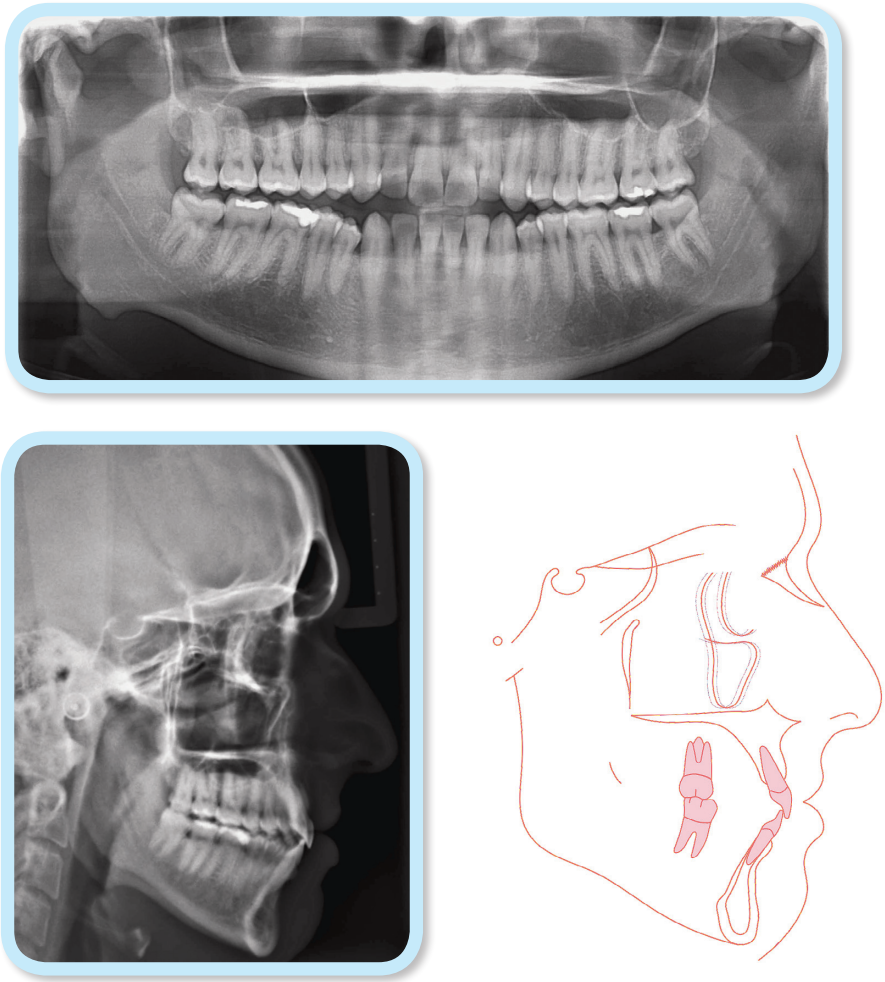


Fig. 10:
Post-treatment radiographs are: 1. Panoramic view (upper), 2. Lateral cephalogram (lower left), 3. Tracing of the lateral cephalometric radiograph, with the central incisors and first molars shaded in red (lower right).

Discussion

Invisalign® technicians proposed a treatment plan that focused on closing the openbite primarily by extruding the upper incisors (*Fig. 7*), but that plan failed to address all of the treatment objectives. It is important to understand that technicians are experts at moving teeth with aligners but they are not doctors. It's important for the clinician to carefully evaluate the treatment plan relative to the overall objectives. Technicians are essential, for planning tooth movement to accomplish each phase of treatment, but the orthodontist is ultimately responsible for making sure the plan that is approved addresses all of the treatment objectives.

Biomechanics of progressive aligner loads must be carefully considered when treating complex malocclusions. Differential arch expansion was effective for resolving the $C_R \rightarrow C_O$ shift due to cusp interference associated with crossbite. In the absence of severe crowding, expansion of both arches results in retraction of the incisors, because molars have more osseous anchorage compared to incisors. Since lower molars have more anchorage value than upper molars,[10] crowding must be carefully managed relative to the original interdigitation of the buccal segments in each arch. IPR and intermaxillary elastics are the principal adjustments for differential mechanics to manage asymmetries or anchorage discrepancies. The treatment plan (*Fig. 8*) was carefully coordinated with the auxiliaries (*IPR and elastics*) to achieve an excellent outcome (*Figs. 9-11*).

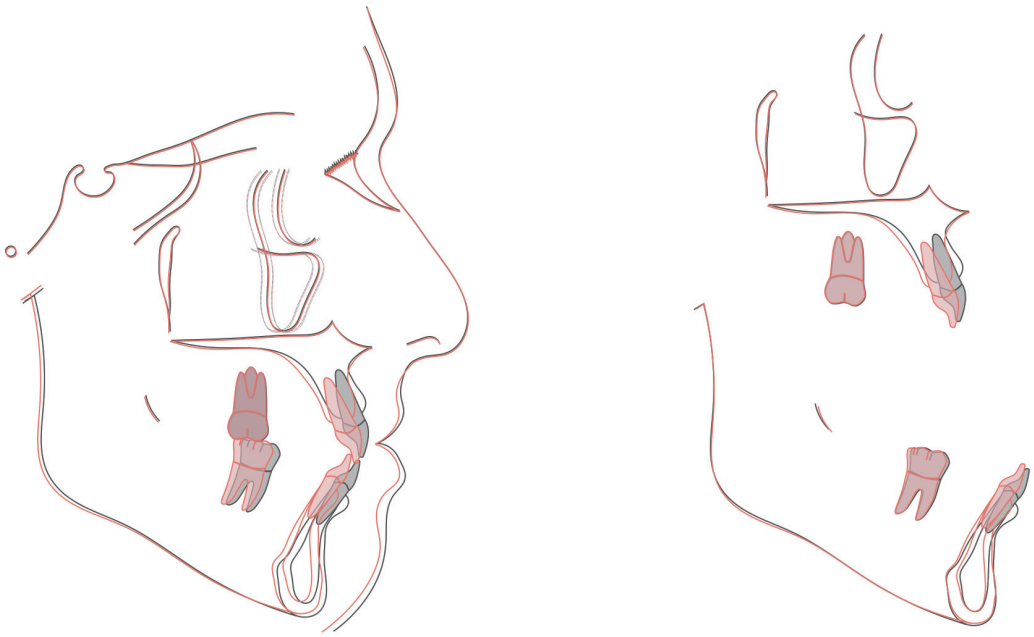


Fig. 11:
Cephalometric tracings from before (black) and after (red) treatment are superimposed to show the dentofacial changes during treatment. The anterior cranial base superimposition is on the left. Maxillary and mandibular superimpositions are upper right and lower right, respectively.

Although the patient was told third molar extractions might be necessary because they are distally positioned in the ramus area, at the end of treatment they remained asymptomatic and therefore retained. However, longterm monitoring for operculum inflammation is recommended as part of the retention recall evaluations.

Numerous reports in the literature advocate clear aligners for treatment of openbite,[11-15] transverse deficiencies,[16] smile discrepancies,[17] and a variety of other malocclusions.[18-20] To the authors' knowledge the current case is the most severe malocclusion (*DI 29*) treated with clear aligners to be reported in the literature. This appears to be the first ABO style case report for aligner treatment that is documented with dental alignment (*CRE 18*) and esthetics (*P&W 1*) scores. Furthermore, comprehensive analysis of the excellent case records document correction of the dental midlines, facial profile, lip incompetence, gummy smile, $C_R \rightarrow C_O$ discrepancy, and TMJ problems. The current results, for non-extraction aligner treatment of a complex malocclusion (*DI 29*), are impressive. Malocclusions with a combination of openbite,[21,22] facial asymmetry,[23,24] and midline discrepancy[24-26] are challenging problems with conventional mechanics, orthognathic surgery and/or prosthodontics.

The efficient correction, of a complex malocclusion (*Figs. 1-3*) in 15 months with 31 clear aligners, required rigorous planning: detailed history, thorough diagnosis, careful assessment of the etiology, and a comprehensive treatment plan focused on reversing the etiology. Fixed mechanics can exacerbate openbite problems because they tend to extrude posterior teeth during alignment. All lateral loads tend to extrude teeth because the tapered form of an alveolus creates an inclined plane effect.[10] Clear aligners are superior mechanics for conservative correction of anterior openbite because two layers of aligner material overlay occlusal contacts in the posterior intermaxillary space. Thus, the success of aligner therapy for correction of openbite is usually predicable.[11,15,19] Double overlays of aligner plastic deliver intrusive force to both arches, which intrudes or at least maintains the vertical dimension of occlusion (*VDO*) (*Fig. 10*).[11,15,19]

Anterior openbite correction is a longterm stability problem. Many anterior openbite patients relapse after conservative fixed appliance and/or surgical treatment[28-30] probably due to recurrent airway and/or low tongue posture problems, that result in recurrent inter-incisor tongue posture.[6,7] Axial loads on the molars, using a maxillary intrusion splint, improved stability for openbite malocclusions treated with fixed appliances, supplemented with temporary anchorage devices (*TADs*).[31] Following this principle, the longterm retention strategy for the current patient is based on controlling the VDO with routine lip contact (*competence*) during the waking hours, and delivering axial loads to the posterior segments, via clear overlay retainers at night.

Clear aligner therapy is practiced by both general

practitioners and orthodontic specialists, but clinical expertise and perceptions relative to the applied technology vary greatly.[32,33] Positioners[34] can play an important role in the functional finishing of the occlusion and developing of lip competence. In addition, aligners may be a better option for periodontally compromised patients.[35] Clear aligners were the first routine application of computer aided design and manufacturing (*CAD-CAM*) engineering to the clinical practice of orthodontics (*~1997*). However, to date there are no case reports in the literature utilizing an ABO style analysis to assess aligner therapy relative to: 1. classification of the complexity (*severity*) of the malocclusion with a discrepancy index (*DI*), and/or 2. scoring the outcome with a cast-radiograph evaluation (*CRE*).[1] For fixed appliances, the DI is a documented index for predicting the clinical effort required to resolve a malocclusion,[36-38] and the CRE is established tool for assessing and improving clinical outcomes.[36,39-43] Comparative studies for aligner therapy are overdue.

The present case report documents the effectiveness of clear aligner therapy for treating a severe malocclusion (*Figs. 1-3*) to a board quality result (*Figs. 9-11*). This opens a new era for the serious consideration of aligners for the management of challenging malocclusions, but the lack of appropriate clinical data on discrepancies and outcomes is a deterrent. If aligners are to evolve into a competitive method, for resolving a broad range of malocclusions in orthodontic practice, clinical studies are needed to determine the range of discrepancies that clear aligners can resolve to a board quality result, presently defined as a CRE ≤ 26 points.

Conclusions

- Invisalign® clear aligners are capable of managing a severe malocclusion with openbite, incompetent lips, gummy smile and TMD (*DI 29*) to a board quality result (*CRE 18*).
- Successful management of complex malocclusions requires careful planning: detailed history, thorough diagnosis, assessment of the etiology of the problem(s), and a comprehensive treatment plan that focuses on reversing the etiology.
- The Invisalign® team provides a technical service to design a unique sequence of aligner loads, that are coordinated with differential IPR and application of elastics, to achieve the objectives of treatment.
- The clinician is ultimately responsible for approving the treatment plan using the ClinCheck® software.
- With adequate patient cooperation and an appropriate treatment plan, it is possible to achieve excellent results in terms of occlusion, function, and dentofacial esthetics.
- To evolve as a competitive orthodontic technique for resolving substantial malocclusions (*DI>10*), clinical studies with clear aligners are needed to

determine the range of discrepancies treatable to a board quality result (*CRE≤26 points*).

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 29

OVERJET

0 mm. (edge-to-edge)	=	
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 = 3

Total = 3

OVERBITE

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

Total = 0

ANTERIOR OPEN BITE

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

Total = 10

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 12

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 = 1

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 = 1

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 1

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 = 0

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	1 x 2 pts. =	2

Identify: Incompetent lips

Total = 2

Cast-Radiograph Evaluation

Case # **Patient**

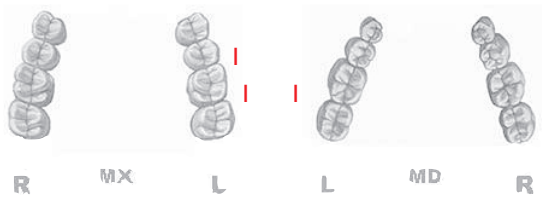
Total Score: 18

Alignment/Rotations

0

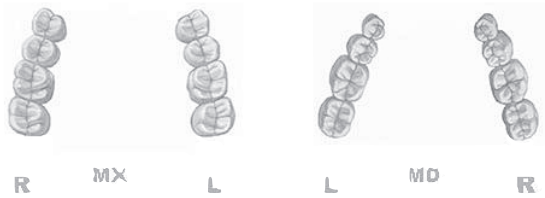
Marginal Ridges

3



Buccolingual Inclination

0

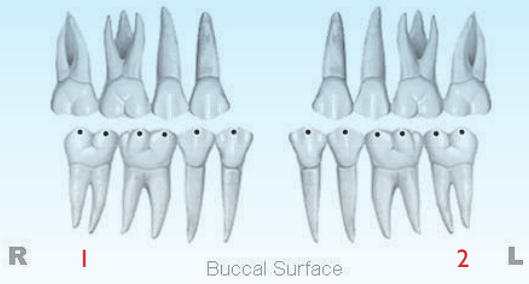


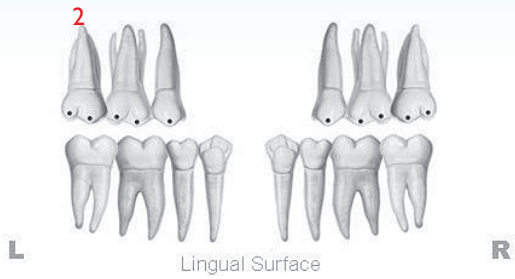
Overjet

7

Occlusal Contacts

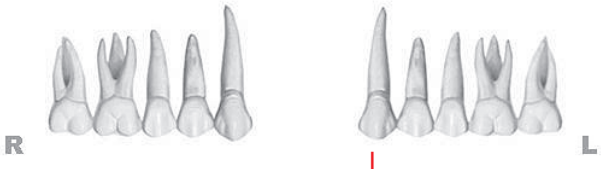
5





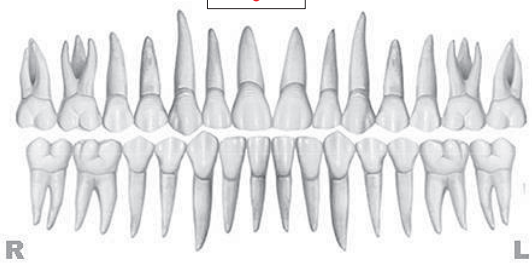
Occlusal Relationships

1



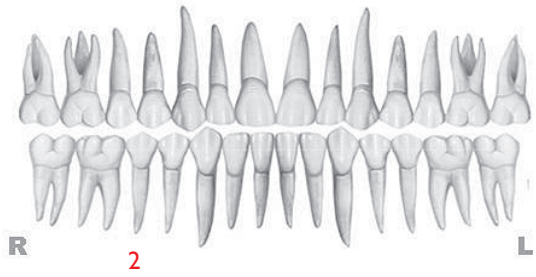
Interproximal Contacts

0



Root Angulation

2



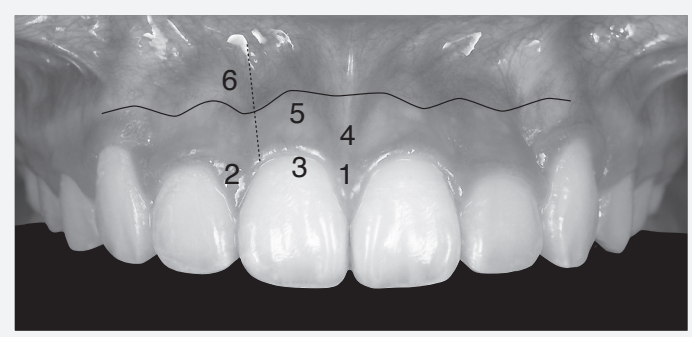
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 1

1. Pink Esthetic Score

Total = 1

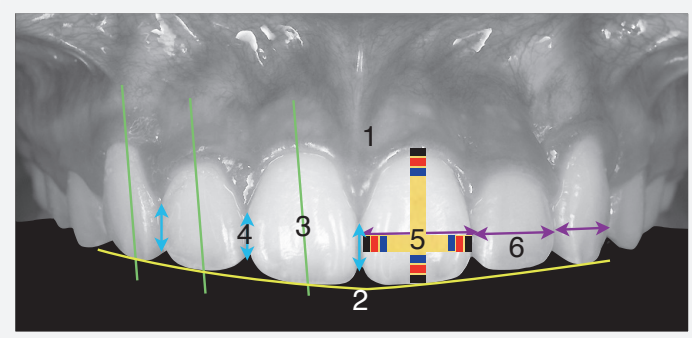


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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 = 0



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