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Team Beethoven gave an orthodontic lecture in a century-old, former priest seminary in Bonn, home to Beethoven on March 30, 2019.

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2019-20
熱愛學矯正

全新的貝多芬高效 Damon 矯正大師系列課程是由國際知名講師張慧男醫師親自規劃及授課，課程特色強調由臨床病例帶動診斷、分析、治療計畫擬定與執行技巧。此外，透過數位影片反覆觀看，課堂助教協助操作，以及診間臨床見習，讓學員在短時間能快速上手，感染「熱愛矯正學，熱愛學矯正」的熱情。

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Damon Master
(Thu) 9:00-5:00 中文授課

The Beethoven Damon Master Program, created by Dr. Chris Chang, is a two-year clinical program. Its hands-on orientation features case study-based diagnosis, analysis, treatment planning andresult evaluation. Combining in-class teaching assistants, after-class video review and chair-side observation, participants will learn to master the essential tips of the Damon System.

Year 1 2019
Module 1 - **4/25**/19' Module 4 - **7/18**
Module 2 - **5/16** Module 5 - **8/22**
Module 3 - **6/20** Module 6 - **6/28-29**（擇一）

Year 2 2019-20
Module 1 - **9/12** Module 4 - **12/12**
Module 2 - **10/17** Module 5 - **1/9**/20'
Module 3 - **11/21**

Damon + .014 Cu NiTi

Excellent Finishing
(Tue) 9:00-12:00 中文授課

Critically reviewing classical literature and contemporary papers and applying lessons learned to clinical work; utilising ABO's DI and CRE standards to turning excellent finishing into attainable goals.

Finishing X
Module 9 - **5/14** Module 11 - **7/23**
Module 10 - **6/25**

Finishing XI
Module 1 - **8/27** Module 6 - **1/14**/20'
Module 2 - **9/10** Module 7 - **2/25**
Module 3 - **10/22** Module 8 - **3/24**
Module 4 - **11/12** Module 9 - **4/14**
Module 5 - **12/10** Module 10 - **5/19**
Module 11 - **6/16**

Damon Clear

Damon, OBS & VISTA International Workshop
English Class

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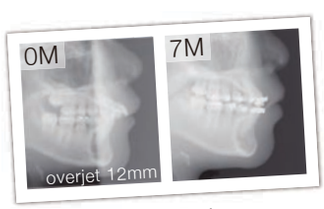
2019
Class 1 - **5/21-24** Class 2 - **12/03-06**

2020
Class 1 - **5/12-15** Class 2 - **12/08-11**



Damon + Bite Turbo +
Early Light Short Elastic

每次上課請依最新一期 JDO 公告為主

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An Unexpected Twist in the Journey
AJO-DO Case Report of the Year Award

I'd like to start off by expressing my utmost gratitude to all of the staff in the Beethoven Group, all of whom have helped make the Beethoven Group that what it is today. Why, you may ask yourselves?

It's actually academic. Surprisingly! I am very proud to inform you that the Beethoven Group has won the award for the best AJO-DO case report of 2019. We were already over the moon that our unique one buccal shelf screw approach had been published in the AJO-DO, so to receive such a distinguished academic award, as a non-academic group, was completely off our radar.

I am a practitioner; I am an Orthodontist. Six years ago a friend of mine received this award and I never even dreamed of being able to receive such an honor. Therefore our case reports have never been written with any intention of receiving an award. The teaching value is the most important. How to serve and treat our patients is always the first concern, later we consider whether or not it can be a candidate for publication. Furthermore, I was requested to produce a video explaining the treatment details, which has become the most viewed on the AJO-DO website.

No case is ever perfect, but we can be well pleased with the results. The publication of this journal is our humble offering of passing on the baton of our analog experience to the younger digital generation, and we sincerely hope that everyone can learn from it. I don't want to make anything perfect; I don't want to suffer from OCD. This has always been the purpose of our journal, to help people not make the same mistakes that we have made. We have our own style, key points and show our mistakes and failures, which is not necessarily particularly academic.

Will it ever happen again? We will continue publishing our reports for educational value and will keep on serving patients and trying to find better ways of helping to improve our profession. We will never do anything just for the sake of an award. I hope that you will all keep on marching with us on our path to glory.

Chris Chang DDS, PhD, Publisher of JDO.

Mutilated Class III Malocclusion with Anterior Crossbite and Autotransplantation of Two Molars

Abstract

***Introduction**: A 20-year-old female presented for orthodontic consultation to evaluate chief complaints of multiple caries, lower arch spacing and a protrusive lower lip.*

***Diagnosis**: Clinical and radiographic examination revealed a straight facial profile (G-Sn-Pg' 3˚), protrusive lower lip, hypermentalis activity, lower dental midline deviated to the left, asymmetric Class III/I subdivision-right malocclusion, wide arches, 6mm of space in the lower arch, and a relatively high mandibular plane angle (SN-MP 45˚). Panoramic radiography revealed a hopeless UR6, missing LL7 and an endodontically-treated LL6 with periapical sclerosis. The Discrepancy Index was 54 points.*

***Treatment**: A passive self-ligating appliance was installed to align the dentition and prepare implant sites. Two teeth (UR6, LL6) were subsequently extracted and the sites were immediately transplanted with the LR7 and UL8, respectively. A mandibular buccal shelf (MBS) bone screw (BS) was placed mesial to the LR8 for anchorage to retract the lower right segment to close space and correct the dental midline. Lower buccal segments were differentially retracted with BS anchorage and Class III elastics to correct the asymmetric Class III interdigitation. Third order correction and finishing were accomplished with rectangular archwires and a root torquing auxiliary. The active treatment time was 38 months.*

***Outcomes**: Excellent dental and periodontal results were achieved. Cast-Radiograph Evaluation was 27 and the Pink & White Esthetic Score was 2. Lip protrusion and incompetence were corrected to the patient's satisfaction. The lower lip was retracted and lower facial height increased. The facial changes reflected an undiagnosed functional shift in occlusion, extruded lower molars, a 2˚ clockwise rotation of the mandibular plane, as well as retraction and extrusion of the lower incisors.*

***Conclusions**: Autogenous molar transplantation is a cost-effective option for correction of a complex, mutilated malocclusion. It is important to carefully assess functional shifts in occlusion particularly if there are wear facets on the teeth. (J Digital Orthod 2019;54:4-23)*

Key words:
Class III, mutilated malocclusion, passive self-ligating appliance, buccal shelf miniscrew, dental transplantation, anterior crossbite, interdisciplinary treatment, midline deviation

History and Etiology

A 20-year-old female presented for orthodontic evaluation with chief complaints: multiple caries, lower arch spacing and a protrusive lower lip. Clinical and cephalometric evaluations showed an intermaxillary discrepancy (*ANB 1˚*) that was due to a slightly protrusive mandible (*SNB 84˚*). The straight facial profile (*G-Sn-Pg' 3˚*) was associated with increased lower facial height (*58.5%*), lower lip protrusion (*0.5mm to the E-Line*), and hypermentalis strain when the lips were closed (*Fig. 1*). This morphologic pattern is commonly referred to as an increase in lower facial height (*LFH*) and/or an excessive vertical dimension of occlusion (*VDO*). An

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Periodontist, Jing-Jong Lin Orthodontic Clinic (Center left)
Dr. John Jin-Jong Lin,
Examiner of JDO,
Director of Jin-Jong Lin Orthodontic Clinic (Center right)
Dr. W. Eugene Roberts,
Editor-in-chief, Journal of Digital Orthodontics (Right)

intraoral examination and study casts revealed canine and molar relationships that were Class III on the right side and Class I on the left (*Class III/I subdivision-right malocclusion*). A -1.5mm negative overjet was associated with an anterior openbite (*1-2mm*), and there was 6mm of spacing in the lower arch (*Fig. 2*). The lower dental midline and chin were both shifted to the left (*Fig. 1*).

Fig. 1: Pre-treatment facial and intraoral photographs

Cephalometric analysis revealed a straight facial pattern (*G-Sn-Pg' 3˚, SNA 85˚, SNB 84˚, ANB 1˚*), with a high mandibular plane angle (*SN-MP 45˚*) (*Fig. 3 & Table 1*). The panoramic radiograph (*Fig. 4*) showed two teeth are missing: UR8 and LL7. The UR6 was severely decayed and the endodontically treated LL6 had a large periapical lesion on the distal root.

Interdisciplinary treatment with bone screw (*BS*) anchorage[1-3] is indicated to correct the deviated midline. Instead of extractions and implant-supported protheses, the patient preferred orthodontic preparation for autotransplantation (*LR7 to replace UR6, and UL8 to replace LL6*), followed by comprehensive orthodontics to align both arches and close space.

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA˚ (82°)	85˚	85˚	0˚
SNB˚ (80°)	84˚	83˚	1˚
ANB˚ (2°)	1˚	2˚	1˚
SN-MP˚ (32°)	45˚	47˚	2˚
FMA˚ (25°)	38˚	40˚	2˚
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	6 mm	4.5 mm	1.5 mm
U1 To SN˚ (104°)	107˚	103˚	4˚
L1 To NB mm (4 mm)	8 mm	6 mm	2 mm
L1 To MP˚ (90°)	80˚	68˚	12˚
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	-4.5 mm	-3 mm	1.5 mm
E-LINE LL (0 mm)	0.5 mm	-0.5 mm	1 mm
Convexity: G-Sn-Pg' (13°)	3˚	4.5˚	1.5˚
%FH: Na-ANS-Gn (53%)	58.5%	59.5%	1%

Table 1: Cephalometric summary

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

Fig. 3: Pre-treatment lateral cephalometric radiograph

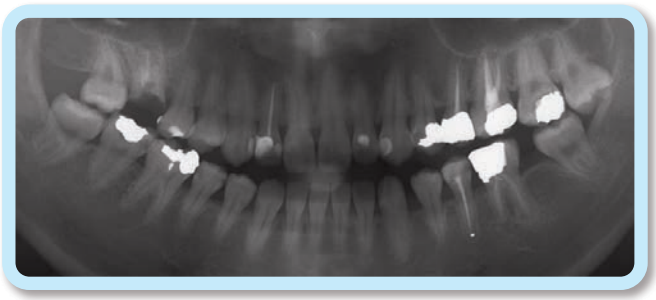

Fig. 4: Pre-treatment panoramic radiograph

Diagnosis

Skeletal:

- Lower face protrusion: *SNA 85˚, SNB 84˚, ANB 1˚*
- Mandibular plane angle was increased: *SN-MP 45˚, FMA 38˚*
- Facial asymmetry: *The chin point is deviated to the left.*

Dental:

- Buccal (*canine and molar*) relationships: *Class III on the right and Class I on the left.*
- Overjet: *-1.5mm, negtive overjet*
- Anteior openbite: *1-2mm*
- Spacing: *6mm in the lower arch*
- Missing teeth: *UR8 and LL7*
- Midlines: *Lower dental midline was shifted to the left.*
- Arch-forms: *Wide arches*

Facial:

- Profile: *Decreased convexity (G-Sn-Pg' 3˚)*
- Nasolabial Angle: *Increased due to retrusive upper lip (-4.5mm to the E-Line).*
- Anterior-Posterior: *Prognathic mandible, maxilla was within normal limits (WNL)*
- Protrusive lower Lip: *0.5mm to the E-Line*
- Hypermentalis Strain: *On lip closure*

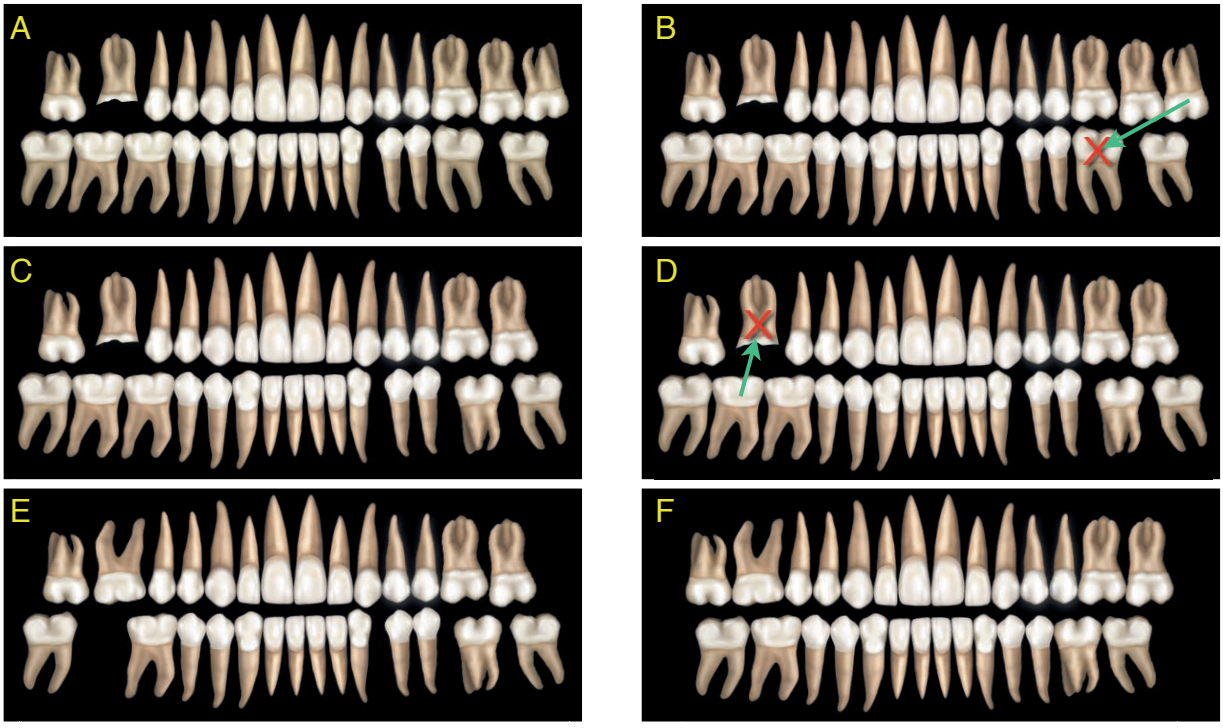

Fig. 5:
A. Pre-treatment mutilated malocclusion. B. Plan for extracting the LL6 and replacing it with an autotransplantation of the UL8. C. After the initial autogenous tooth transplant. D. Plan for replacing the UR6 with autotransplantation of the LR7. E. After the second autogenous tooth transplant. F. Final result after orthodontic alignment.

The American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*) was 54 points as shown in the subsequent Worksheet 1.[4]

Treatment Objectives

1. Level and align both arches.
2. Correct overjet and overbite.
3. Retract the lower lip and control the VDO to relieve mentalis strain.
4. Maintain the maxilla and mandible in all three planes.
5. Maxillary and mandibular dentition:
   a. Orthodontic alignment for autotransplantation: LR7 → UR6, UL8 → LL6
   b. Optimal intermaxillary alignment
   c. Close interproximal spaces
   d. Ideal overjet and overbite
   e. Class I canine and molar relationships
6. Facial esthetics: Retract the protrusive lower lip and establish lip competence

Treatment Alternatives

Interdisciplinary options were orthodontics, implants, prostheses and autotransplants. After a thorough discussion, the patient preferred a camouflage treatment plan: periodontal treatment, restorative replacement of amalgam restorations, presurgical orthodontic preparation, autotransplantation, and comprehensive orthodontics for optimal alignment and space closure.

Treatment Progress

Since the patient had multiple carious lesions and poorly restored teeth, it was important to stabilize dental health. A periodontist was consulted for a complete evaluation of periodontal health and to plan the autogenous transplants. Oral hygiene, scaling and root planning were performed. Then the patient was referred for restorative dentistry to restore caries and reconstruct poorly restored teeth (*Fig. 6*). After 11 months of general dental care, a

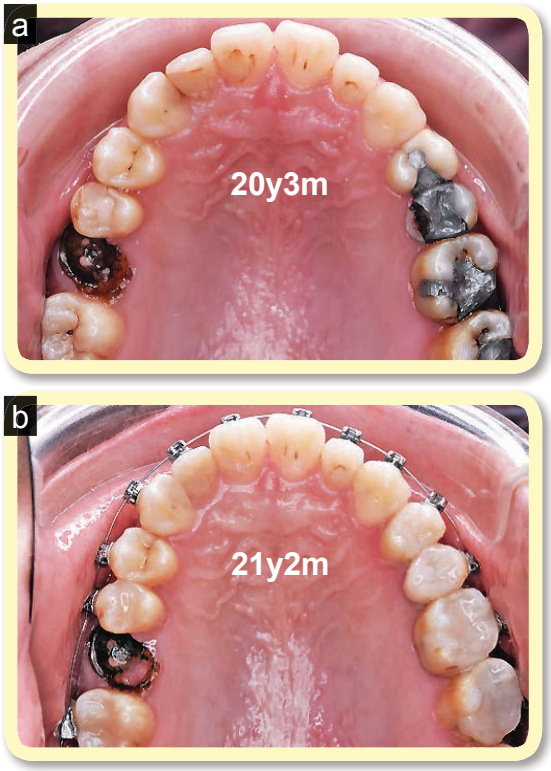

Fig. 6:
a. Pre-treatment view (20y3m) of the maxillary arch showing multiple teeth on the left restored with amalgam. b. Post-treatment view (21y2m) after the amalgam restorations were replaced with composite resin.

full fixed 0.022-in slot Damon Q® bracket system (*Ormco, Brea, CA*) was installed. Archwires, elastics and auxiliaries were provided by the same supplier. All brackets were standard torque (*Fig. 7*), and the initial archwires were 0.014-in CuNiTi for both arches. The entire dentition was bonded including UL8, LL6 and LR7. Orthodontic alignment was used to mobilize teeth in order to reduce extraction trauma and maintain intact PDL tissue on teeth to be transplanted (*Fig. 8*).[5] Orthodontic stimulation widens the PDL by stimulating alveolar bone resorption and increasing periodontal vascularity. This approach helps preserve PDL vitality during and after the surgical procedure.[6]

Fig. 7: All brackets were standard torque.

In preparation for the autogenous tooth transplantation from the UL8 to the LL6 site, an analog of the donor tooth (*UL8*) was produced from a 3D print of the CBCT image.[7] Analysis of the 3D image of the UL8 revealed a rotation of 90 degrees was required to achieve the best fit in the LL6 extraction socket. The sterilized UL8 analog was used to prepare the recipient site to achieve a socket slightly larger than the donor tooth (*Fig. 9*). Occlusal reduction and fixation grooves were prepared before extracting UL8. Following the prescribed two months of tooth movement, the donor tooth was easily removed with intact PDL tissue on the root. The transplant with an extraoral time <60 secs was fixed into place with a non-rigid fixation method for 2 weeks (*Fig. 10*).[8,9] One month after surgery, the LL6 recipient tooth was well healed, and after 3mo there were no symptoms nor evidence of root resorption (*Fig. 11*). At the same appointment, the archwires were changed to 0.018-in CuNiTi in both arches. Orthodontic preparation of the UR6 site was required because severe caries had reduced the arch-length at the crest to 8mm which was too small to receive the 10mm wide LR7 donor tooth. A compressed coil spring between the UR7 and UR5 was used to open

Fig. 8:
UL8 , LL6 and LR7 were bonded with brackets and aligned with the archwire for mobilization of the teeth in preparation for an extraction designed to maintain PDL cells on the root surfaces.

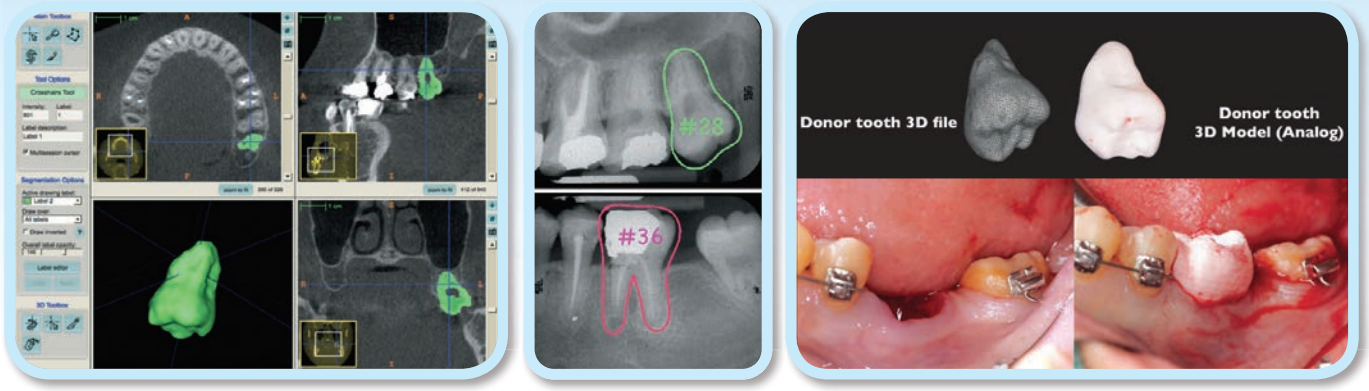

Fig. 9:
3D printing from a CBCT image (left) was used to make an analog for the donor tooth UL8 (upper right). The UL8 analog was used to prepare the recipient site to make the socket slightly larger to accommodate the donor tooth (lower right).

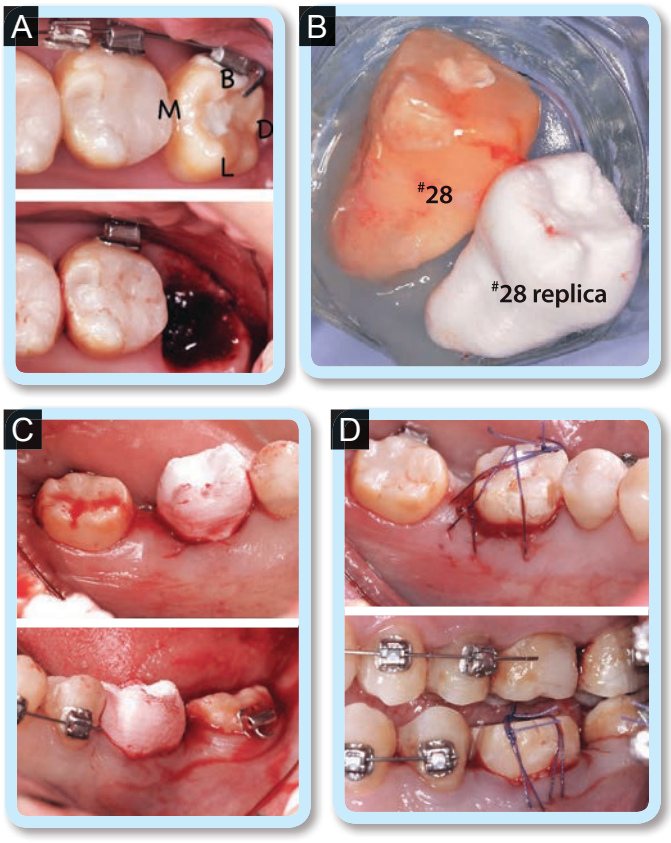

Fig. 10:
***A.** Upper view shows the mesial (M), buccal (B), distal (D) and lingual (L) surfaces of the UL8 (#28), and the lower view is post-extraction. **B.** The extracted UR8 with PDL tissue on the surface (#28) is shown next to the 3D replica (#28 replica). **C.** Occlusal and buccal views show the replica seated in the desired position. **D.** Occlusal and buccal views show the transplanted UR8 is stabilized in the site with nonrigid sutural fixation that traverses the prepared occlusal surface with fixation grooves.*

Fig. 11:
One month after surgery, the soft tissue for the LL6 transplant was well healed.

Fig. 12:
Upper: The panoramic radiograph (3M) shows the postoperative view following the initial transplantation procedure. Lower: An open coil spring between UR7 and UR5 opens space for the UR6 transplant.

the space (*Fig. 12*). In the 7th month of treatment, the UR6 space was sufficient to transplant LR7 (*Fig. 13*). The archwires were extended from UR5 to UL5 and LR6 to LL5 (*Fig. 14*).

Eleven months into the treatment, the lower arch wire was changed to 0.018x0.025-in CuNiTi with a tie back ligature was placed between the LR6 and LR8 to prevent dislodging of the wire (*Fig. 15*). One month later, LR8 protraction was activated by applying power chains from LR6 to LR8 on both the buccal and lingual surfaces. Class II elastics (*Fox 1/4-in 3.5-oz*) were applied on the left side to help correct the midline deviation (*Fig. 16*).

In the 16th month, the negative overjet was improved, and a 2x8mm stainless steel (*SS*) bone screw (*BS*) was installed mesial to the lower right third molar. A chain of elastics was applied from the lower right canine to the BS to help correct the lower midline deviation (*Fig. 17*). Three months later, space closure was inadequate so the BS was removed because it appeared to interfere with space closure (*Fig. 18*). Buttons were bonded on the lingual surface

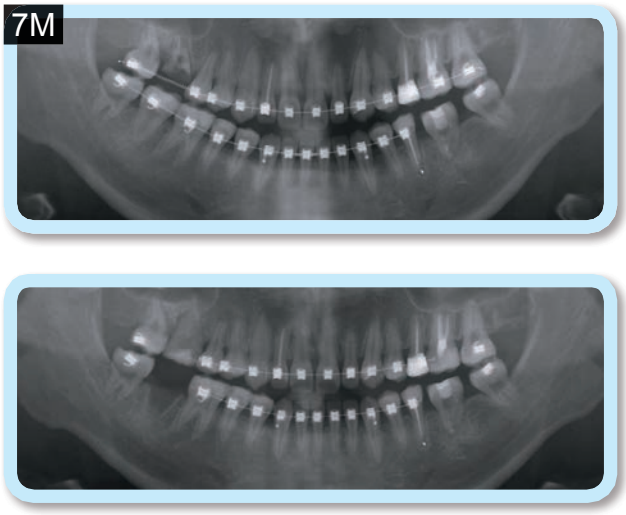

Fig. 13:
In the 7th month of treatment (7M) panoramic radiographs show the preoperative (upper) and postoperative (lower) views of the LR7 to UR6 autotransplantation procedure.

Fig. 15:
At eleven months (11M) a twisted ligature tie was placed to connect the LR6 and LR8. See text for details.

Fig. 14:
At seven months (7M) buccal intraoral photographs show the restored dentition following both transplantation procedures. See text for details.

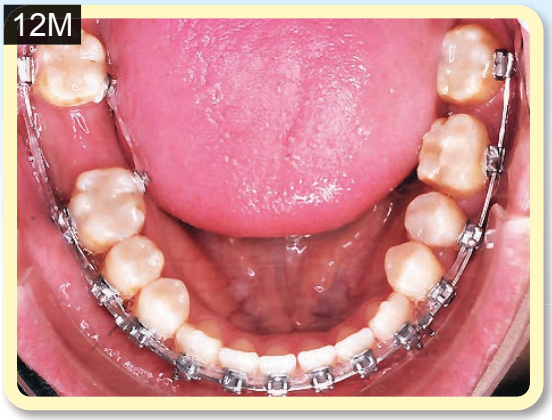

Fig. 16:
In the 12th month (12M), the LR8 protraction was initiated by applying power chains of elastics from LR6 to LR8 both buccally and lingually.

Fig. 17:
In the 16th month (16M), a 2x8mm SS BS was installed mesial to the lower right third molar to correct the lower midline deviation. See text for details.

of the LR6 and LR8 to attach a chain of elastics. Another chain of elastics was applied from LL3 to LR8. Class II elastics Fox (*1/4-in 3.5-oz*) were applied from UR4 to the LR6 and from UR4 to the LL8. Eight months later, the Class II elastics were increased to

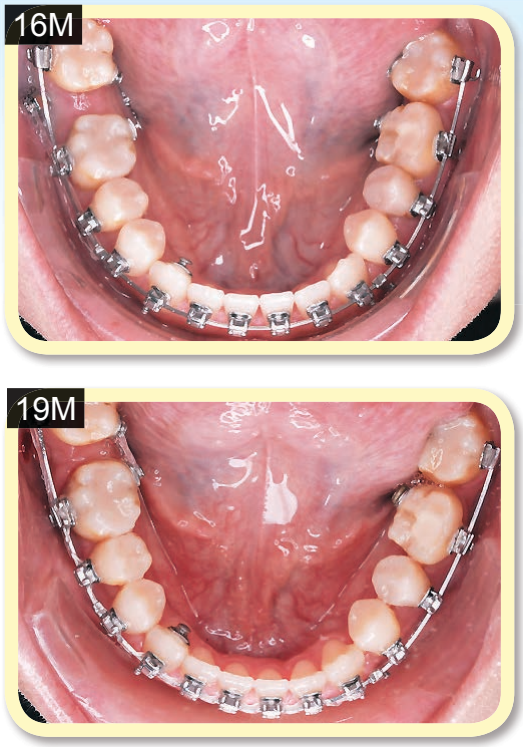

Fig. 18:
Compared to the start at sixteen months (16M), the lack of progress in the mesial movement of the LR8 at nineteen months (19M) was due to interference of the BS. See text for details.

Kangaroo (*3/16-in, 4.5-oz*) bilaterally.

In the 22nd month of the treatment, the upper archwire was changed to a 0.018x0.025-in CuNiTi and the lower archwire was changed to a 0.014x0.025-in CuNiTi. The dental midlines were almost coincident but a space between the LL3 and LL4 required a chain of elastics (*Fig. 19*).

In the 29th month, there was a gumboil on the mucosa apical to the UL3. Pulp necrosis was diagnosed that was probably related to a previous composite restoration (*Fig. 4*). The patient was referred for endodontics (*Fig. 20*). Precise bracket repositioning was performed repeatedly throughout the treatment to correct axial inclinations in the

Fig. 19:
At twenty-two months (22M) the midline was nearly aligned, but a space had opened distal to the LL3.

Fig. 20:
In the 29th month (29M), a gumboil was noted on the mucosa adjacent to the UL3. Pulp necrosis was diagnosed and the patient was referred for endodontics.

buccal segments. Archwires were adjusted to detail the occlusion.

In the 35th month of treatment both archwires were replaced with 0.014x0.025-in NiTi. Another 2x8mm BS miniscrew was installed on the mesial side of the

Fig. 21:
In the 35th month of treatment, both archwires were replaced with 0.014x0.025-in NiTi. A new 2x8mm SS BS miniscrew was installed to the buccal of the lower right first and third molars, and a chain of elastics was applied from lower right canine to help correct the lower midline deviation. See text for details.

LR8 area and a chain of elastics was applied from the LR3 to the BS to correct the dental midlines and close space between LR6 and LR8 (*Fig. 21*).

After 38 months of active treatment, all fixed appliances were removed.

Results achieved

Maxilla (all three planes)**:**

- A - P: *Maintained*
- Vertical: *Maintained*
- Transverse: *Constricted with correction of asymmetry*

Mandible (all three planes)**:**

- A - P: *Retracted (posterior rotation)*
- Vertical: *Increased (posterior rotation)*
- Transverse: *Constricted with correction of asymmetry*

Maxillary Dentition

- A - P: *Retracted*
- Vertical: *Incisors Extruded*
- Inter-molar / Inter-canine Width: *Decreased with correction of asymmetry*

Mandibular Dentition

- A - P: *Retracted the entire arch*
- Vertical: *Increased (molar and incisor extrusion)*
- Inter-molar / Inter-canine Width: *Decreased with correction of asymmetry*

Facial Esthetics:

- Lips: *Retracted lower lip to improve facial balance*
- Mentalis Strain: *Relieved by retracting incisors*
- Lip protrusion: *Improved balance*
- Facial Profile: *Relatively straight with acceptable lip protrusion*

Retention

Removable retainers were delivered for both arches to be worn full time for the first 6 months and nights only thereafter. Plaque control and the retainer maintenance instructions were provided.

Final evaluation of treatment

The final records are presented in Figs. 22-26. A 1% increase in both LFH and facial convexity was associated with the extrusion of the lower molars (*Fig. 26*). The relatively long, more retrusive facial pattern appears related to lower molar extrusion. The latter was deemed a sequelae of Class II elastics and the elastic chains used to close the LR extraction space. Despite the increase in facial convexity, acceptable lip protrusion and competence were achieved (*Figs. 25 and 26*). Dental alignment (*Figs. 22-24*) and functional occlusion (*Figs. 22, 25 and 26*) were near ideal. The final alignment was assessed at 27 points with ABO Cast-Radiograph Evaluation (*CRE*), as documented in the supplementary Worksheet 2 at the end of this report.[10] Major residual discrepancies were buccolingual Inclination (*13 points*) and occlusal contacts (*5 points*). The negative overjet was corrected to an ideal relationship. The Pink and White dental esthetic score was 2 points, as subsequently documented in Worksheet 3, which is consistent with the outcomes recommended by Sarver and Yanosky.[11]

Discussion

Surgical and technical factors that influence outcomes are the focus of the current case report. Clinical studies of dental autotransplantation and replantation report a short extraoral time for the donor tooth considerably improves success and survival rates to 80.0-91.1% and 95.5-100%, respectively.[12-17] A significant decrease in extraoral time and high success rates are associated with the use of donor tooth replicas.[12] Success depends on preserving vital PDL tissue on the root surface of a tooth that is extracted and autotransplanted. A 20-

Fig. 22: Post-treatment facial and intraoral photographs

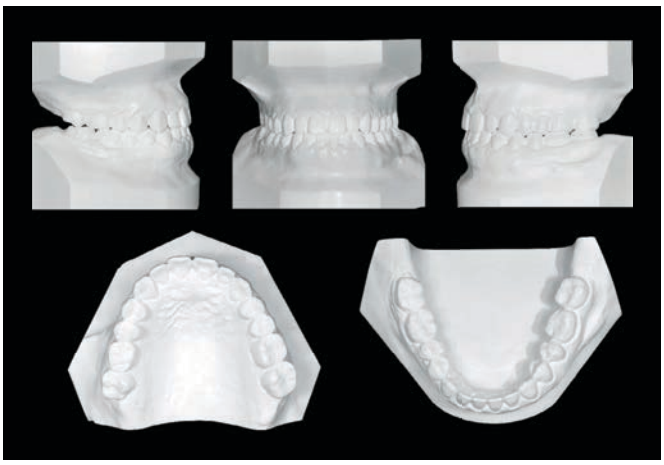

Fig. 23: Post-treatment dental models (casts)

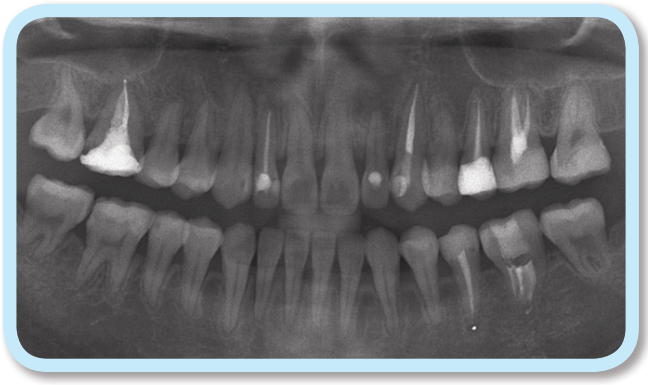

Fig. 24: Post-treatment panoramic radiograph

Fig. 25: Post-treatment lateral cephalometric radiograph

30 minutes interval between the time of extraction and subsequent re-implantation may be compatible with the preservation of PDL cells attached to the root surface,[13] but a much shorter transplant time is preferred for improved vitality. A pre-operatively designed surgical guide for autotransplantation enables accurate positioning which facilitates the surgery to substantially decrease the extraoral time for a transplanted tooth.[14-17]

Donor tooth morphology has been reported as a critical factor for success. Multi-rooted teeth complicate the extraction resulting in more PDL damage. When atraumatically extracted teeth with healthy PDL cells is transplanted within three minutes into a well-fitting prepared socket, the

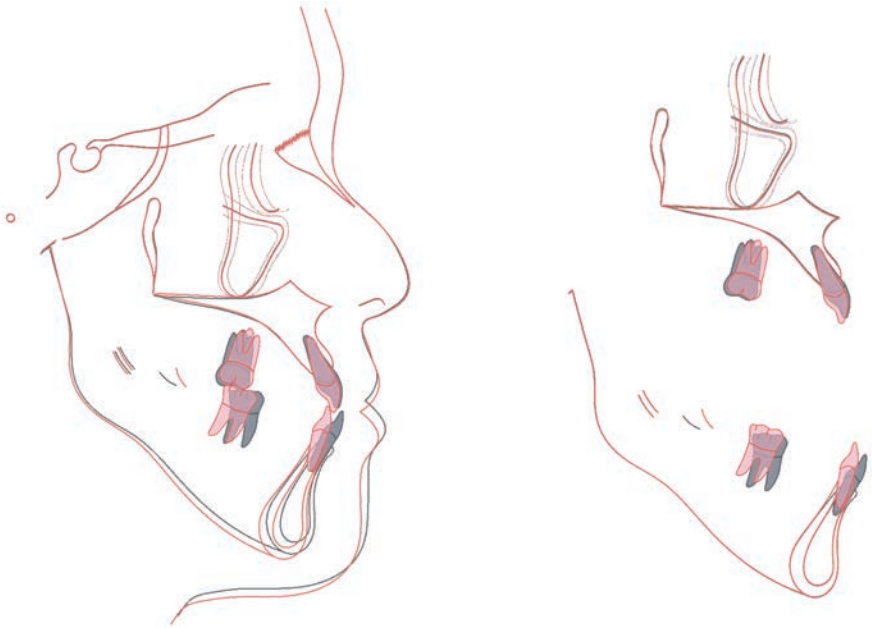

Fig. 26:
Superimposed cephalometric tracings show dentofacial changes over 38 months of treatment (red) compared to the pre-treatment position (black). The anterior cranial base superimposition (left) documents the retraction of the protrusive lower lip and opening of the VDO as the mandible rotated clockwise. The LFH increased and the mandible assumed a more posterior posture. The upper right superimposition on the maxilla shows the corrected dentition relative to the apical base of bone. The lower right superimposition on the mandible reveals the extrusion of the mandibular molars. See text for details.

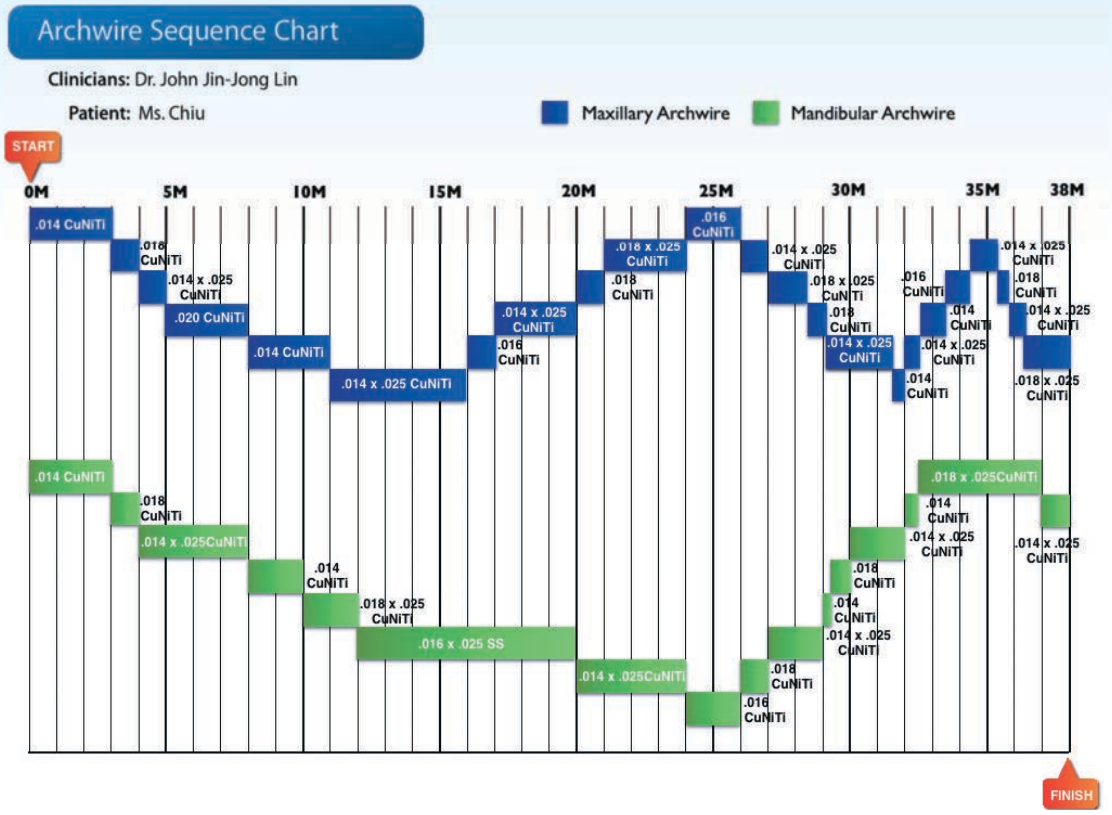

Table 2: Archwire sequence chart

success rate is almost 94%. The placement, location, and angulation of the transplant in the site can be accomplished with the replica without damaging the transplant. Therefore, the use of a replica increases the ease and control of the autotransplantation procedure (*Fig. 10*).[8,9]

The initial reaction to the trauma is acute inflammation. If there is no additional stimulus to maintain the inflammatory response, healing will occur naturally. The healing of a damaged root surface is dependent on the surface area of the damaged root that requires repopulation with PDL cells. The smaller the area of damaged root the more likely there will be a successful cellular repopulation to form new cementum and periodontal ligament. Large areas of traumatized root often result in ankylosis, which is an osseous connection of the tooth to alveolar bone. If the pulp of the transplant becomes infected, the periodontal reaction to bacterial toxins emitted at the apex prevents the healing reaction from progressing. This form of inflammatory root resorption is arrested in its early stage with successful endodontic treatment. Rapid bone regeneration and the emergence of lamina dura around the transplant are encouraging signs. Bone graft materials are unnecessary even if the space between the bone and the transplant is wide. Positioning of donor teeth is critical. Compromises such as inadequate bucco-lingual space results in root protrusion and dehiscence. Graft materials should be placed over the exposed root in order to

create space for bone regeneration. Bone induction around a transplanted tooth is a significant advantage compared to healing of implants.[9,18,19]

In recent decades, TADs have become increasingly popular for managing difficult adult malocclusions.[20,21] However, the interradicular position of miniscrews, a high failure rate, and their tendency to move when loaded has limited their application for managing crowding and skeletal malocclusions. Extra-alveolar or radicular TADs provide adequate anchorage for management of severe malocclusions without extensive patient compliance.[1-3]

The present patient with Class III malocclusion had an excellent prognosis for a relatively simple dento-alveolar correction according to the 3-ring diagnosis scheme (*Fig. 27*).[22,23] For this patient, a conservative camouflage treatment was also a viable alternative.[24] However, an orthodontic treatment plan and autotransplantation of the molars was the most conservative solution for this mutilated Class III patient (*Figs. 1-4*).

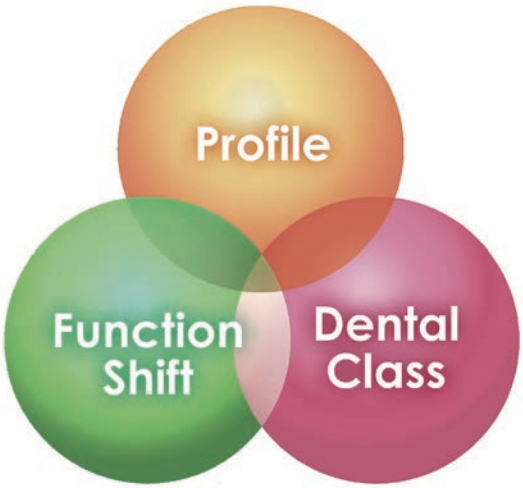

Fig. 27:
The 3-ring diagnosis scheme introduced by Dr. John Lin.[1]

Cephalometric superimposition on the mandible (*Fig. 26*) shows extrusion and distal movement of the lower molars, but no net retraction relative to the apical base of bone. This is an illusion in a 2D cephalometric view (*Fig. 25*). The lower arch was constricted, and the molars have been moved distally as shown in the post-treatment panoramic radiograph (*Fig. 24*).

Overall, the orthodontic treatment and molar autotransplantation has produced good dental alignment and reduced lip protrusion, but there was an increase in the VDO as reflected by ~2˚ increase in facial convexity and the mandibular plane angle (*FMA*). These undesirable sequelae are consistent with two changes noted in the cephalometric tracings:

1. Lower molars are extruded ~2mm in the mandibular superimposition (*Fig. 26 lower right*).

2. The mandible moved distally ~2mm as it rotated posteriorly ~2˚ in the anterior cranial base superimposition. The molar extrusion problem can be explained by the mandibular molars having moved distally (*Fig. 26 left*).

This problem can be avoided by using both maxillary and mandibular extra-alveolar (*extra-radicular*) bone screws for intra-alveolar force in each arch rather than relying on intermaxillary anchorage.[1,3,24-26] Intermaxillary elastics commonly extrude molars and

increase the VDO because of the vertical component of force and the rotation of the arches around their respective centers of resistance.[27]

This challenging malocclusion (*DI=54*), was treated conservatively in 38 months to an excellent dental alignment (*CRE=27*) with a third molar autotransplantation treatment plan to replace the hopeless teeth in both arches and to correct the asymmetrical Class III molar relationship. However, mandibular molar extrusion and an apparent $C_O \rightarrow C_R$ discrepancy contributed to increased facial convexity, which is associated with a more posterior position and clockwise rotation of the mandible.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 54

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 = 7 pt

Total = 7

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 = 4

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 = 0

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	4 pts.
Beyond Class II or III	=	1 pt. per mm. additional	3 pts.

Total = 7

Beyond Class III (right)

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 5

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° 7 x 2 pts. = 14

≤ 26° = 1 pt.

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

1 to MP ≥ 99° = 1 pt.

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

Total = 16

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. =	2
Missing teeth (except 3rd molars)	_____ x 1 pts. =	1
Missing teeth, congenital	_____ x 2 pts. =	_____
Spacing (4 or more, per arch)	_____ x 2 pts. =	2
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	_____
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	_____ x 2 pts. =	_____

Identify:

Total = 5

Cast-Radiograph Evaluation

Case # **Patient**

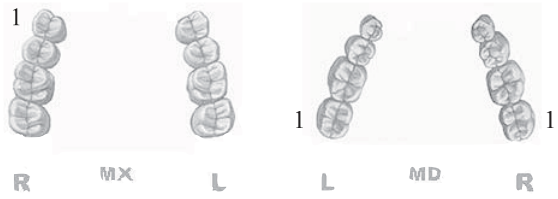
Total Score: 27

Alignment/Rotations

3

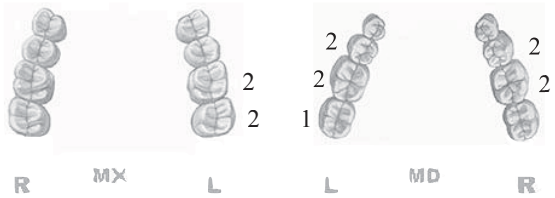
Marginal Ridges

3



Buccolingual Inclination

13

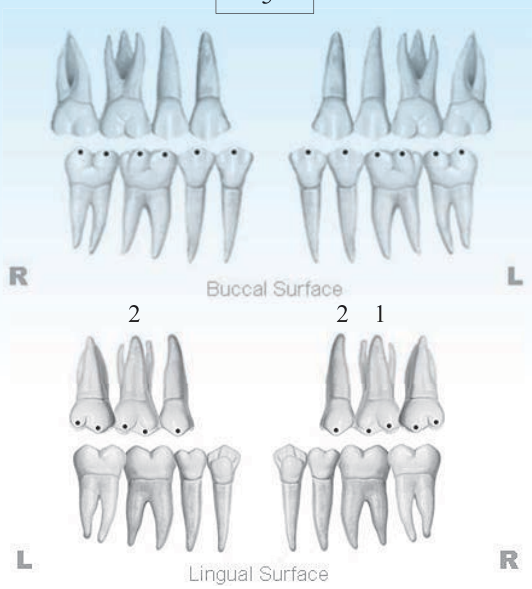


Overjet

1

Occlusal Contacts

5

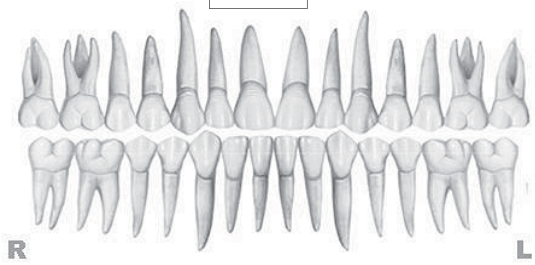


Occlusal Relationships

2

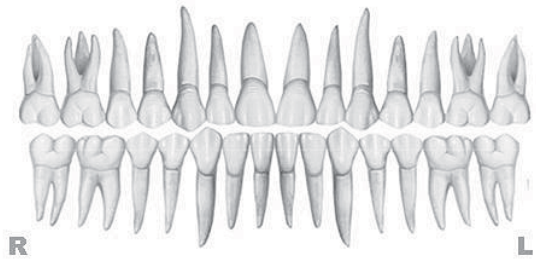
Interproximal Contacts

0



Root Angulation

0



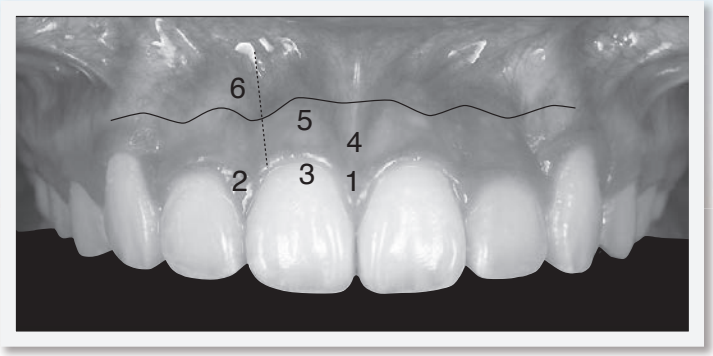
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 2

1. Pink Esthetic Score

Total = 0

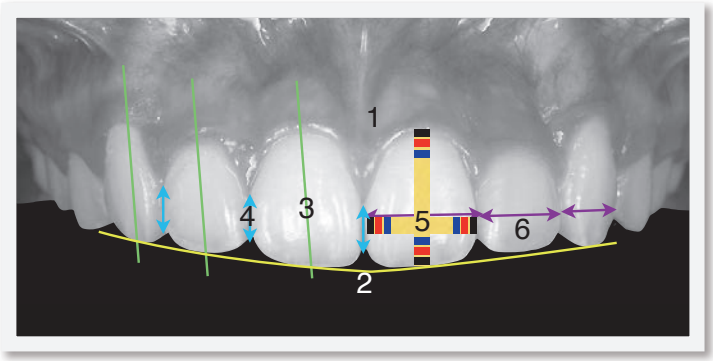


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

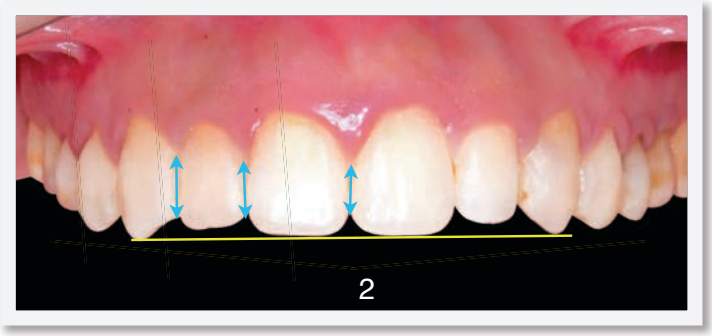
1. M & D Papilla	(0)	1	2
2. Keratinized Gingiva	(0)	1	2
3. Curvature of Gingival Margin	(0)	1	2
4. Level of Gingival Margin	(0)	1	2
5. Root Convexity (Torque)	(0)	1	2
6. Scar Formation	(0)	1	2

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

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Fig. 1. Bond strength of various self-adhesive cements to dentin (MPa)[5]

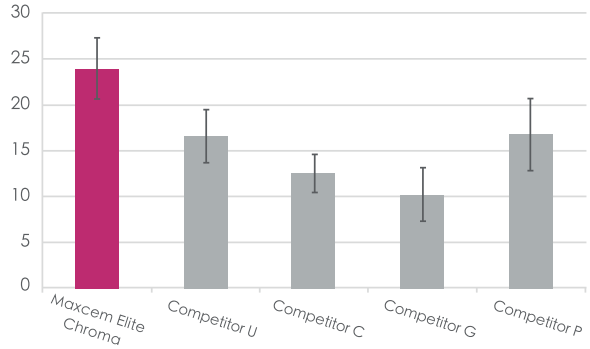
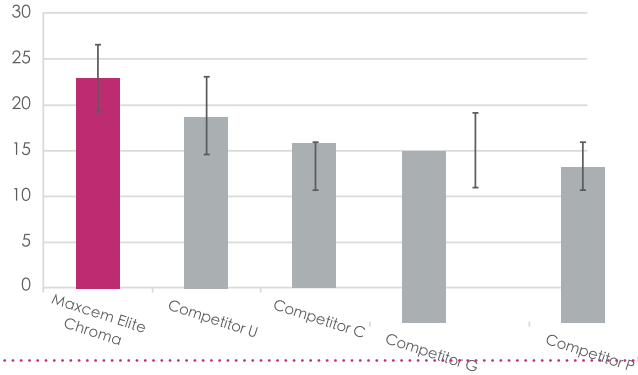
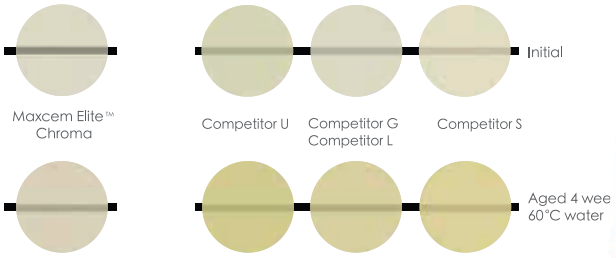


Fig. 2. Bond strength of various self-adhesive cements to enamel (MPa)[5]



LONG-TERM COLOR STABILITY



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2	4/19	邱上珍 醫師（明尼蘇達大學牙周病學碩士、美國牙周病科專科醫師） 題目：Flap design and suture (含操作，需自備縫合器械＆縫線)		
3	5/31	郭芯妤 醫師（哥倫比亞大學口腔生物學碩士 紐約大學補綴科助理教授） 專題演講：Full arch implant prosthesis		
4	6/21	USC 課程精選：黃育新 醫師（國際矯正植牙學會院士）	蕭浩宜 醫師（美國南加州大學植牙研究所進修）	翁蔚任 醫師（高雄醫學大學牙醫學士）
5	7/26	蘇筌瑋 醫師（高雄醫學大學牙周病學碩士、國際矯正植牙學會理事長） 題目：VISTA & hard/soft tissue application		
6	8/23	黃怡豪 醫師（賓州天普大學口腔生物學碩士、台灣大學牙周病科兼任教授 ） 專題演講：Full-arch rehabilitation		
7	9/27	林森田 醫師（中山醫學大學學士、國際矯正植牙學會院士） 題目：What is All-on-4?	顧傑 醫師（美國南加州大學植牙專科訓練）	黃育新 醫師（國際矯正植牙學會院士）
8	10/18	郭芯妤 醫師（哥倫比亞大學口腔生物學碩士、紐約大學補綴科助理教授） 專題演講：Digital dentistry + Abutment selection		
9	11/29	專題演講：張燕清 主任（波士頓大學口腔生物博士、國防醫學院牙醫系副教授） 題目：Current advanced technology and technique in dental implant		
10	12/27	蘇裕隆 醫師（陽明大學牙醫學士、FB 前牙美學達人） 專題演講：前牙美學	邱上珍 醫師（明尼蘇達大學牙周病學碩士、美國牙周病科專科醫師）	張慧男 醫師（美國印第安那普渡大學齒顎矯正研究所博士）

本課表僅供參考，植牙論壇保留課程變動之權利。

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VISTA and 3D OBS Lever-Arm to Recover a Labially-Impacted Canine: Differential Biomechanics to Control Root Resorption

Abstract

History: *A 15-year-old female presented with a chief complaint (CC) of unesthetic smile and protrusive lips.*

Diagnosis*: Lower facial height and convexity were within normal limits (WNL), but the lower lip was protrusive (3mm to the E-Line). Bimaxillary retrusion (SNA 79.5˚, SNB 76˚, ANB 3.5˚) and a high mandibular angle (SN-MP 38˚) were noted. Lower incisors were prominent (L1 to MP 96˚, L1 to NB 8mm). Molars were Class I, but the UR3 was Class II. The upper left deciduous canine (ULc) was retained, and the UL3 was labially impacted. An oblique direction of canine eruption wedged the impaction between the keratinized mucosa and the adjacent incisor, eliciting root resorption on the labial surface of the UL2. The Discrepancy Index (DI) was 16.*

Treatment*: Following extraction of all four first premolars and the ULc, all teeth except the UL2 were bonded with a Damon Q® passive self-ligating (PSL) bracket system. VISTA (Vertical Incision Subperiosteal Tunnel Access) technique was performed to produce a submucosal space for retraction and extrusion of the impacted UR3. A button was bonded on the UL3, and a power chain was attached. The elastomer chain exited the mucosa through a more distal incision, and traction was applied with a custom lever-arm, anchored by an OBS® inserted into the left infrazygomatic crest (IZC). The impaction was retracted into a normal position between the UL2 and UL4. Once the UL3 was extruded to the occlusal plane, the UL2 was bonded and its axial inclination was corrected with a labial root torquing auxiliary. Both arches were detailed and finished.*

Outcomes*: After 24 months of active treatment, the UL3 was well aligned, but the labial gingiva supporting it was immature and only partially keratinized. Follow-up visit 1.5 years later showed its maturation into a stable but relatively thin band of gingiva. In retrospect, this UL3 gingival problem may have been avoided by adjusting the 3D lever-arm for a more palatal emersion of the impaction. There was no change in the preexisting labial root resorption of the UL2, but no additional root resorption on any teeth occurred during active treatment. Final alignment and dental esthetics were excellent as evidenced by an ABO Cast-Radiograph Evaluation (CRE) score of 12, and the IBOI Pink & White Esthetic Score of 2.*

Conclusion*: VISTA with an OBS 3D lever-arm is an important advance for orthodontic impaction recovery. Submucosal retraction of a labially-impacted, partially transposed maxillary canine permits optimal emergence into the arch. Differential biomechanics of soft and hard tissue explains impaction-related root loss prior to treatment, as well as the mechanism for protecting an unrestrained lateral incisor while the impacted canine is recovered. (First printed in APOS Trends Orthod 2019;9(1):7-18. Reprinted with permission. J Digital Orthod 2019;54:28-48).*

Key words:
Impacted maxillary canine, vertical incision subperiosteal tunnel access (VISTA), bone screw anchorage, root resorption, differential biomechanics, follicle, dental sac, tooth movement, eruptive force

Introduction

Dental nomenclature for this report is a modified Palmer notation with four oral quadrants: upper right (*UR*), upper left (*UL*), lower right (*LR*) and lower left (*LL*). From the midline permanent teeth are numbered 1-8, and deciduous teeth are delineated a-e. Management of impacted maxillary canines (*U3s*) is one of the most challenging tasks for orthodontists. Studies have shown a prevalence of 0.27-2.4%,[1,2] second only to third

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molars.[3] In North American patients, about two thirds of the impacted canines are located palatally, with the rest positioned labially or within the alveolus.[4] In contrast, ethnic Chinese adolescents experience 49.85-67.7% of impacted canines on the labial side.[5,6] Labial impactions are more difficult to manage clinically because the recovery process is prone to root resorption and gingival recession.[7-9]

For labial impactions above the mucogingival junction (*MGJ*), Kokich[10] proposed the apically positioned flap (*APF*) or the closed eruption (*CE*) technique. The latter is favored because it does not expose the roots

Fig. 1: Pre-treatment facial and intraoral photographs

of the adjacent lateral incisors, which may result in devitalization.[8,11] Furthermore, it decreases the possibility of re-intrusion and gingival scarring.[12] Loss of attachment and gingival recession are best controlled with the tissue tunneling approach introduced by Crescini et al.[13]

Closed flap surgical approaches are well established for managing impactions in the maxillary anterior esthetic zone,[14] but impacted U3s with mesial transposition into the adjacent lateral incisor is a particularly challenging problem, both with respect to mechanics and preservation of gingival health. Traction of the impaction through the center of the alveolar ridge may impinge particularly on the adjacent lateral incisor, resulting in slow movement and/or extensive root resorption.[15] To avoid these problems, Su et al.[16] modified the Zadeh[17] vertical incision subperiosteal tunnel access (*VISTA*) technique to preserve gingival margins. Mesially-displaced, impacted U3s are retracted and extruded within the submucosal space. This minimally-invasive approach permits movement of the impaction away from adjacent teeth; it is then positioned vertically in the arch prior to emerging through the mucosa.[9]

History and Etiology

A relatively immature 15 yr 4 mo female sought orthodontic consultation for unesthetic maxillary anterior dentition and protrusive lips (*Fig. 1*). No contributing medical or dental history were reported, but some late facial growth was expected. Clinical examination revealed a convex facial profile and lip protrusion that was slightly protrusive, particularly to the ideal Chinese standard.[18] Overbite and overjet of the central incisors were WNL and the buccal segments were Class I, but there was bilateral irregularity in the maxillary lateral incisor and canine region (*Figs. 2 and 3*). An edge-to-edge relationship was noted between the upper and lower right lateral incisors, UR2 and LR2, respectively. Maximal overjet

Fig. 2: Pre-treatment upper left deciduous canine associated with a mesially and labially displaced UL2 crown.

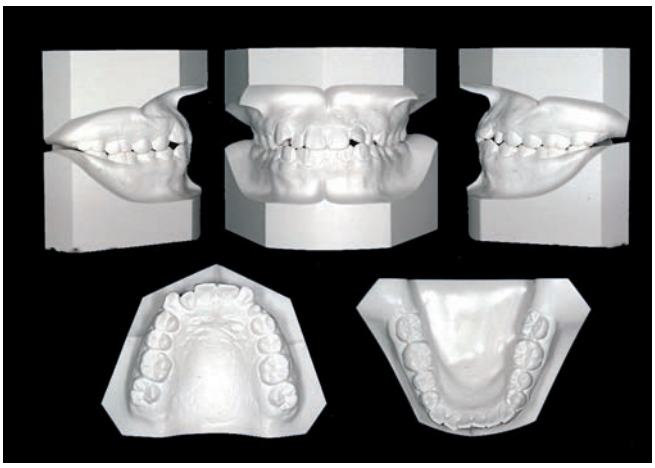

Fig. 3: Pre-treatment dental models (casts)

was 4mm for the upper left lateral incisor (*UL2*). The deciduous upper left canine (*ULc*) was retained with no mobility. Crowding was about 6mm in the upper and 4mm in the lower arches. Panoramic (*Fig. 4*) and lateral cephalometric (*Fig. 5*) radiographs revealed impaction of the upper left canine (*UL3*). Cone Beam Computed tomography (*CBCT*) images (*Figs. 6 and 7*) showed that the impacted UL3: 1. was impacted on the labial surface, 2. had a mesially and labially inclined crown, and 3. was impinged on the labial surface of the UL2 root. The root of the ULc was not resorbed, but modest root resorption was noted on the labial aspect of the apical half of the UL2 root (*Fig. 7*).

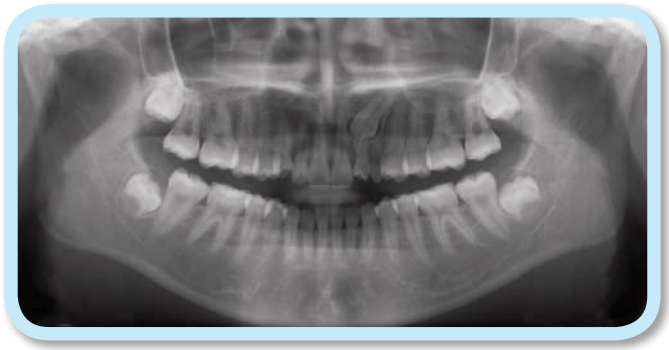

Fig. 4: Pre-treatment panoramic radiograph

Fig. 5: Pre-treatment lateral cephalometric radiograph

Fig. 6:
CBCT image of the maxillary dentition shows a labially-positioned impacted UL3 over the root of UL2.

Fig. 7:
CBCT cut through the long axis of the UL2 shows labial impingement of the impacted UL3 (arrow). Compression of the interposed soft tissues (dental sac and PDL) results in damage to the tooth root which is followed by resorption. See text for details.

Diagnosis

Facial:

- Convexity: *WNL (12˚)*
- Lip Protrusion: *Slightly protrusive (0mm/3mm to the E-line)*

Skeletal:

- Sagittal Relationship: *Bimaxillary retrusion (SNA 79.5˚, SNB 76˚, ANB 3.5˚)*
- Mandibular Plane Angle: *Increased (SN-MP 38˚, FMA 31˚)*

Dental:

- Occlusion: *Class I molar*
- Overjet: *4mm*
- Lower incisor: *Protrusive (L1-NB 8mm), increased axial inclination (L1-MP 96˚)*
- Impaction: *Labially impacted UL3, crown transposed impinging on the UL2 root*

American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*): 16.

Treatment Objectives

Maxilla and Mandible - normal growth expression in A-P, vertical and transverse planes

Maxillary Dentition

- A - P: *Retract incisors*
- Vertical: *Maintain*
- Inter-Canine Width: *Decrease*
- Inter-Molar Width: *Decrease as molars are protracted to close L4 spaces*

Mandibular Dentition

- A - P: *Retract incisors*
- Vertical: *Allow extrusion consistent with normal growth*
- Inter-Canine Width: *Maintain*
- Inter-Molar Width: *Decrease as molars are protracted to close U4 spaces*

Facial Esthetics:

- Lip Retraction: *Retract upper and lower lips according to ethnic preference*[18]

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA˚ (82°)	79.5˚	81˚	1.5˚
SNB˚ (80°)	76˚	78˚	2˚
ANB˚ (2°)	3.5˚	3˚	0.5˚
SN-MP˚ (32°)	38˚	37˚	1˚
FMA˚ (25°)	31˚	30˚	1˚
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	5 mm	2 mm	3 mm
U1 To SN˚ (104°)	106˚	102˚	4˚
L1 To NB mm (4 mm)	8 mm	3 mm	5 mm
L1 To MP˚ (90°)	96˚	86.5˚	9.5˚
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	0 mm	0 mm	0 mm
E-LINE LL (0 mm)	3 mm	1.5 mm	1.5 mm
%FH: Na-ANS-Gn (53%)	53%	53%	0%
Convexity: G-Sn-Pg' (13°)	12˚	13.5˚	1.5˚

Table 1: Cephalometric summary

Treatment Plan

Objectives for full fixed appliance treatment were to recover the impacted UL3, align the dentition, and retract the lips. Three options were considered:

1. Extract all four 1st premolars and the ULc. Use the modified VISTA and OBS 3D Lever-arm technique to align the impacted UL3.

2. Extract UR4, LL4, LR4, ULc, and the impacted UL3. Substitute UL3 with UL4.

3. Extract only the deciduous canine. Use the modified VISTA and OBS 3D lever-arm technique to align the impacted UL3.

First Option: Extraction of premolars permits retraction of the lips, but specialized surgery and mechanics are required to recover the impacted canine. This approach was expected to have the longest treatment duration.

Second Option: Premolars and the deciduous canine are extracted to achieve the patient's desire for less lip protrusion. Extracting the impaction rather than recovering it would decrease treatment time, but substituting the UL4 for the missing UL3 results in an esthetic and functional compromise.

Third Option: Extract only the ULc and recover the impacted UL3. This non-extraction approach offers the shortest treatment duration. Good dental esthetics and function are expected, but this plan is unlikely to correct lip protrusion.

After a thorough discussion of all three options, the patient and her parents preferred the first option because it delivered the most ideal dental and facial result, consistent with the family's preferred ethnic standard.[18]

Treatment Progress

Extraction of all four first premolars and the upper left deciduous canine was the first step in active treatment. A passive self-ligating (*PSL*) fixed appliance (*Damon Q®, Ormco Corporation, Glendora, CA*) was bonded on all upper teeth except for the UL2, and a 0.014-in CuNiTi archwire was engaged. High-torque brackets were chosen for the two upper incisors to control a loss of torque (*decreased axial inclination*) during space closure. Not bonding the UL2 prior to UL3 recovery is a very important aspect of patient management. When the infringed tooth (*UL2*) is not engaged on the fixed appliance, it is free to move spontaneously out of the path of movement as the impact is recovered.[19]

When the crown of the impacted canine is positioned at or near the mucogingival junction, it may spontaneously erupt into a high position much like the UR3. The initial treatment was planned with that possibility in mind. The first phase was to align all erupted teeth in the upper and lower arches, except the UL2. The archwire sequence was: 1. 0.014-in CuNiTi, 2. 0.014x0.025-in CuNiTi, and 0.017x0.025-in TMA. During the initial alignment phase, the impacted UL3 failed to erupt, and a panoramic radiograph eight months into treatment showed no change in the position of the impaction, so surgical intervention was indicated.

The preferred surgical approach (*Fig. 8*) was the VISTA technique of Zadah,[17] as modified by Su et al.,[16] combined with IZC OBS anchorage[19] and 3D lever-arm mechanics (*Fig. 9*).[20] CBCT imaging (*Figs. 6 and 7*) showed the precise location of the impaction, so the initial vertical incision was performed between the central and lateral incisors to expose the crown of the impaction (*Fig. 10A*). A periosteal elevator was then used to detach the periosteum and expose the UL3 (*Fig. 10B*). Bone covering the crown was removed down to the cementoenamel junction (*CEJ*). The impacted canine was carefully luxated with an elevator to control for ankylosis, and then a button was bonded in the center of the exposed enamel. A power chain was attached to the button, a second vertical incision was made in the vestibule superior to the edentulous space, superior to the normal position of the UL3, and the power chain exited the submucosal tunnel (*Fig. 10C*). Subperiosteal decortication, of the alveolar bone surface in the path of UL3 retraction, was achieved with a #4 round carbide bur. An OBS® (*iNewton Dental Ltd, Hsinchu City, Taiwan*) was inserted to the left infrazygomatic crest (*IZC*) and a 3D lever arm was inserted into the rectangular hole of the anchorage device (*Fig. 9*). Finally, the power chain that was attached to the impaction delivered a distal traction force via the lever-arm anchored by the IZC OBS. Following activation of the mechanism, the two vertical incisions were sutured to ensure minimal damage to the mucosa (*Figs. 10-12*).

Post-operative panoramic radiographs monitored the movement of the impacted canine relative to adjacent teeth (*Fig. 13*). After 7 months of activation, the UL3 was uprighted and internally positioned in the arch, coronal to the mucogingival junction. The canine crown and button were visible beneath the transparent gingiva (*Fig. 14*). After 9 months of retraction, the canine erupted to the level of the

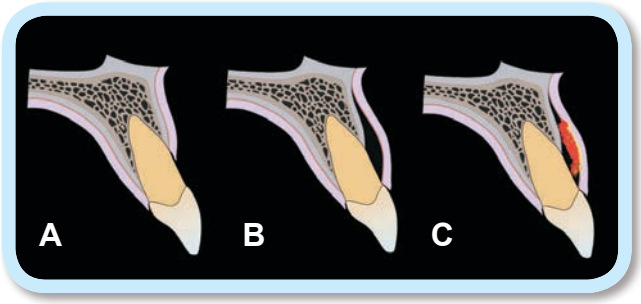

Fig. 8:
The VISTA procedure is a novel, submucosal tunneling procedure originally designed to surgically correct gingival recession (A). Via vertical incisions the labial mucosa is undermined and repositioned coronally as shown by the yellow arrow (B). The submucosal space fills with a hematoma (red) that provides platelet derived growth factors to promote healing (C). This minimally invasive approach is utilized to correct soft tissue defects in the maxillary anterior region.

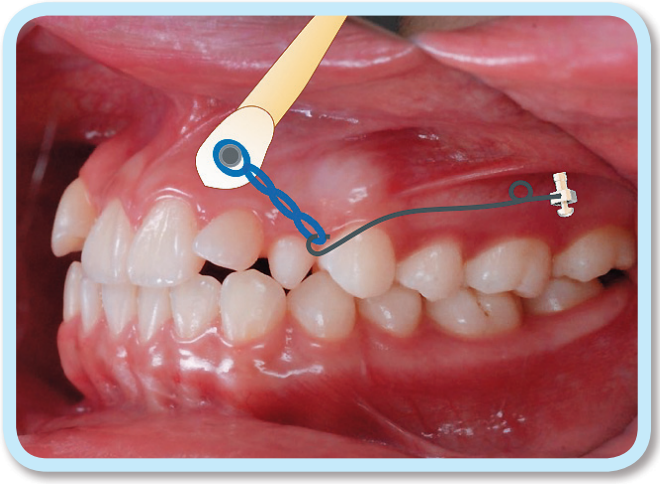

Fig. 9:
A diagram superimposed on an intraoral photograph illustrates the design of the implant recovery mechanism in the sagittal plane. The UL3 impacted against the UL2 root is accessed with a VISTA vertical incision, and a button is bonded on the labial surface. A blue chain of elastics applies distal and occlusal traction to the UL3, via a 3D lever arm inserted into the hole on an IZC OBS. See text and subsequent figures for details.

Fig. 10:

***A.** The first incision was made in the mucosa covering the crown of the impacted canine. **B.** Periosteal elevators were used to reflect the incision and expose the crown for bonding the button. **C.** A second incision was then made at the site where the power chain exits the soft tissue (arrow).*

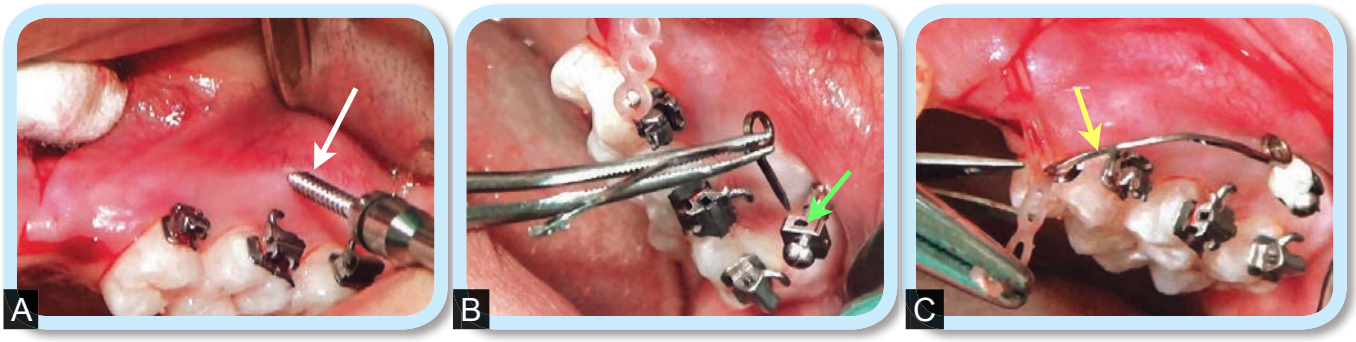

Fig. 11:

***A.** An OBS (white arrow) was inserted in the IZC to anchor the 3D lever arm. **B.** The distal end of the 3D lever-arm was inserted in the hole of the OBS (green arrow). **C.** The power chain attached to the UL3 was activated by the 3D lever-arm in the direction of the yellow arrow. See text for details.*

Fig. 12:

***A.** The two incisions were then sutured for primary healing. **B.** The occlusal view of the lever-arm shows it was contoured away from the cheek to prevent soft tissue irritation. **C.** The buccal view of the mechanics is illustrated with a drawing superimposed on the postoperative photograph. Red lines show 1st and 2nd sutured incisions and a gold chain of elastics show the line of traction. Note both ends of the lever-arm are secured with bonded resin (yellow arrows). See text for details.*

occlusal plane, but its buccal gingiva was immature and bright red in color (*Fig. 15*). The crown of the UL3 was tipped to the buccal and rotated distal in relative to the adjacent premolar. A high torque PSL bracket was bonded on the UL3, and a standard torque bracket was bonded on the UL2 (*Fig. 15*). A light force, continuous archwire (*0.014-in CuNiTi*) was utilized to align the upper arch (*Fig. 16*). A sequence of three additional upper archwires (*0.014x0.025-in CuNiTi, 0.017x0.025-in TMA and 0.016x0.022-in SS*), were used to refine the alignment (*Figs. 16 and 17*). Labial root torque was applied to the UL2 with a torquing auxiliary (*Fig. 18*). In the last month of treatment, the archwire was sectioned distal to the upper canines, and intermaxillary elastics (*Chipmunk 1/8-in 3.5-oz, Ormco, Glendora, CA*) were used for final finishing of the buccal segments (*Fig. 19*).

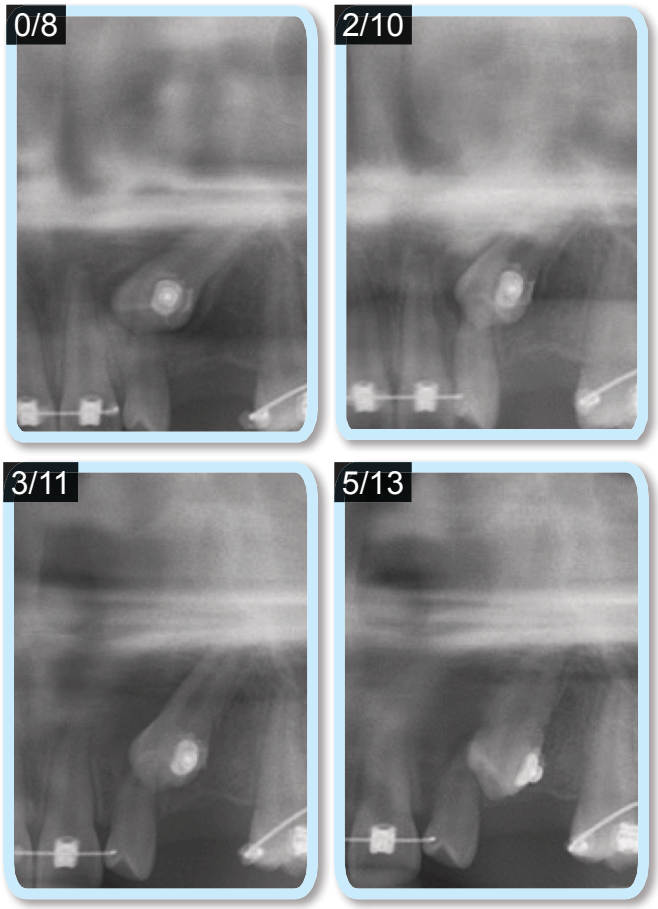

Fig. 13:
A panel of four radiographs shows progress in the recovery of the impacted UL3. Each radiograph is labeled with a code designating the time in months since VISTA surgery and initiation of traction (first number), and the number of months into active treatment (second number). Thus the upper left view (0/8) is the immediate postoperative radiograph for the surgery performed at eight months into treatment. The lower right image (5/13) shows the position of the UL3 after five months of traction, which corresponds to the thirteenth month of treatment.

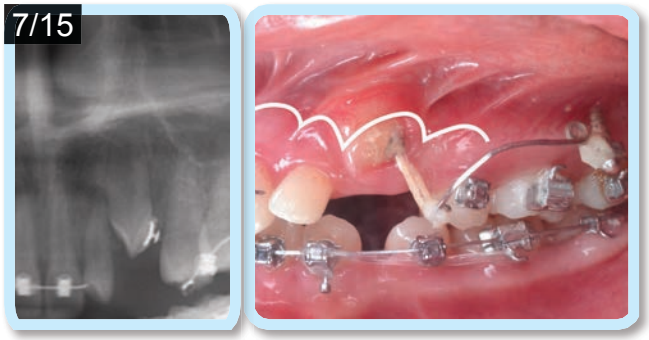

Fig. 14:
Left: *After 15 months of active treatment including 7 months of traction (7/15), UL3 is correctly positioned in the sagittal plane and there are no obstructions for extrusions.*
Right: *The UL3 crown is visible underneath the overlying gingiva, which is immediately coronal to the MGJ (white scalloped line). Note the line of traction for the lever-arm is buccal and occlusal. See text for details.*

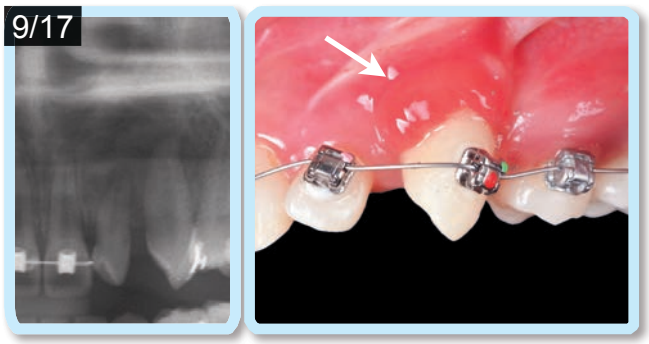

Fig. 15:
Left: *After 9 months of traction and 17 months of active treatment (9/17), the UL3 is extruded to the occlusal plane.*
Right: *Brackets were bonded on the UL2 and UL3, and a CuNiTi archwire is used to align the arch. Note the large red area of immature, nonkeratinized gingiva (white arrow) which will mature into the band of keratinized gingiva supporting the UL3. See text for details.*

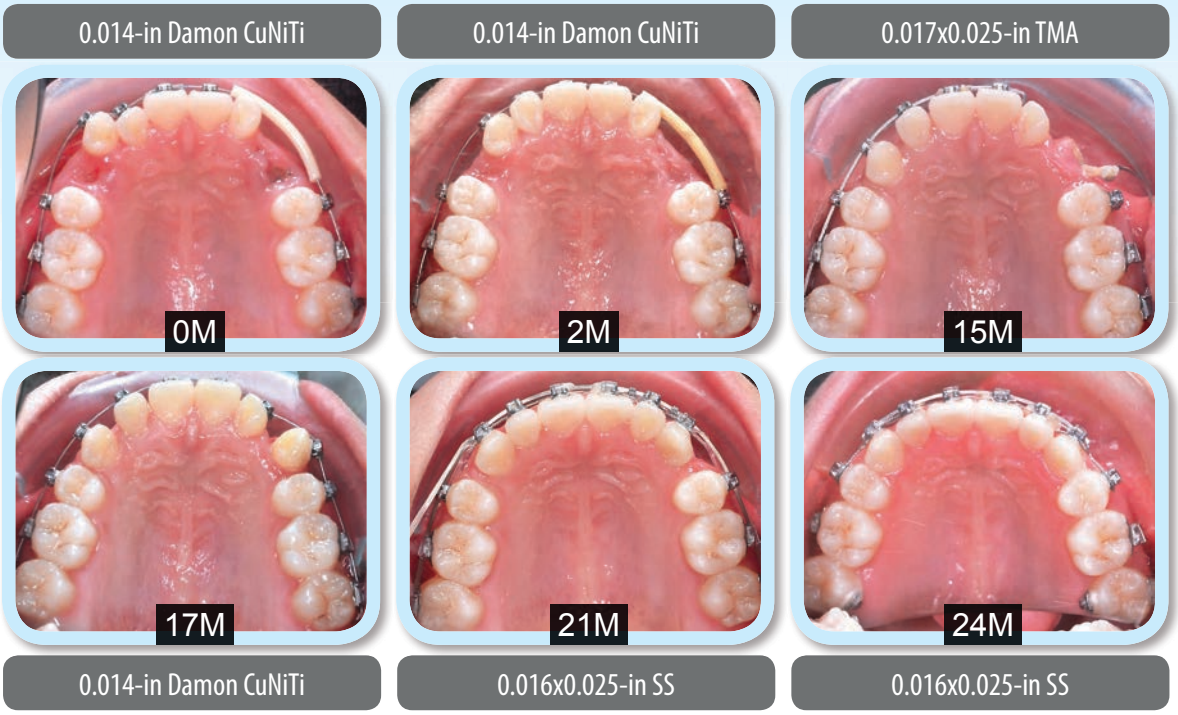

Fig. 16:

Treatment progress for the upper arch is shown in months (M) and the archwire progression is specified from the start of treatment (0M) to twenty-four months (24M).

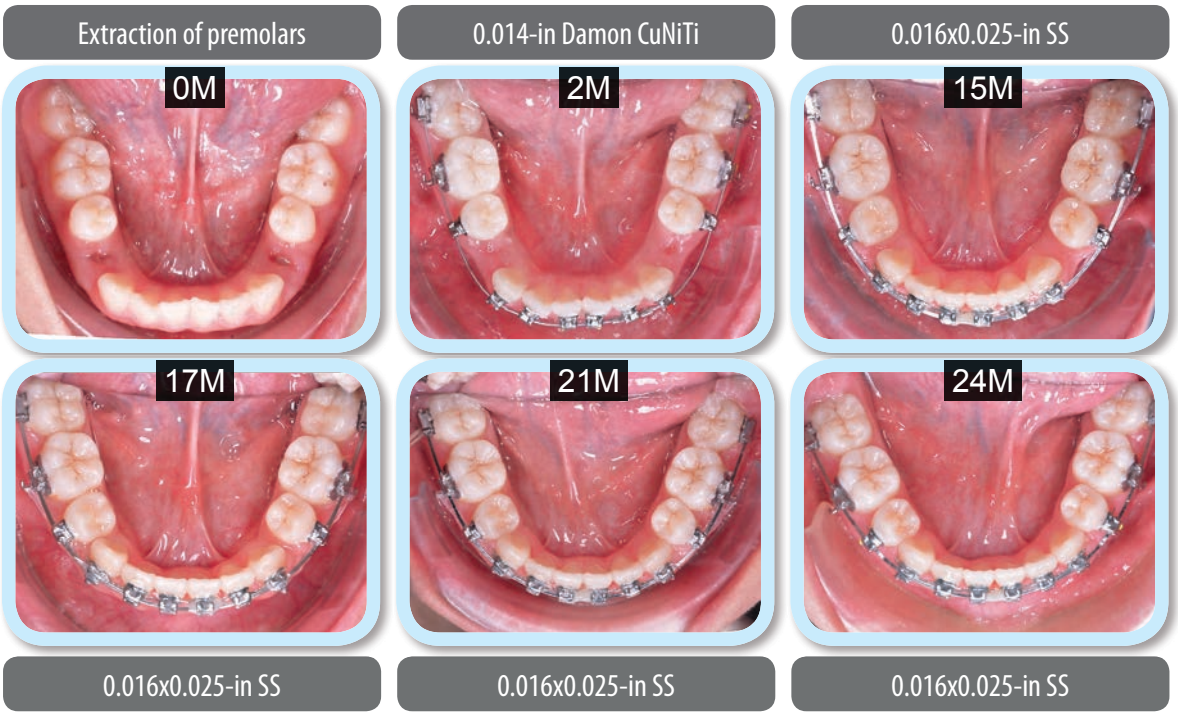

Fig. 17:

Treatment progress for the lower arch is shown in months (M) and the archwire progression is specified from the start of treatment (0M) to twenty-four months (24M).

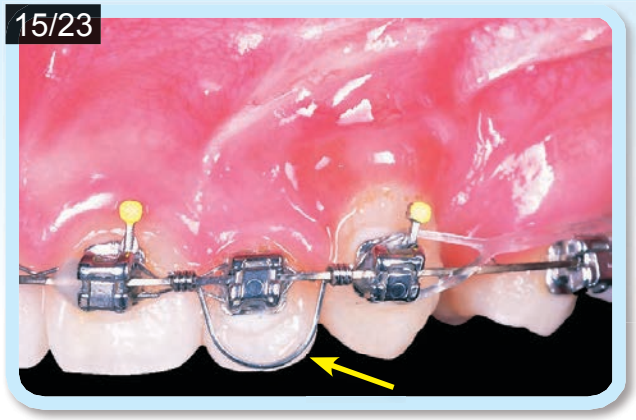

Fig. 18:
At 15 months after surgery and 23 months into treatment (15/23) an auxiliary torquing spring (yellow arrow) is shown on the UL2 to torque the root labially. See text for details.

Fig. 20:
Following the removal of fixed appliances at 17 months after surgery, and 25 months into treatment (17/25), gingivectomy and frenectomy were performed in the maxillary anterior segment to enhance esthetics.

Fig. 19:
To finish the occlusal contacts in the buccal segments, the upper archwire is sectioned distal to the canines, and vertical elastics are applied as shown.

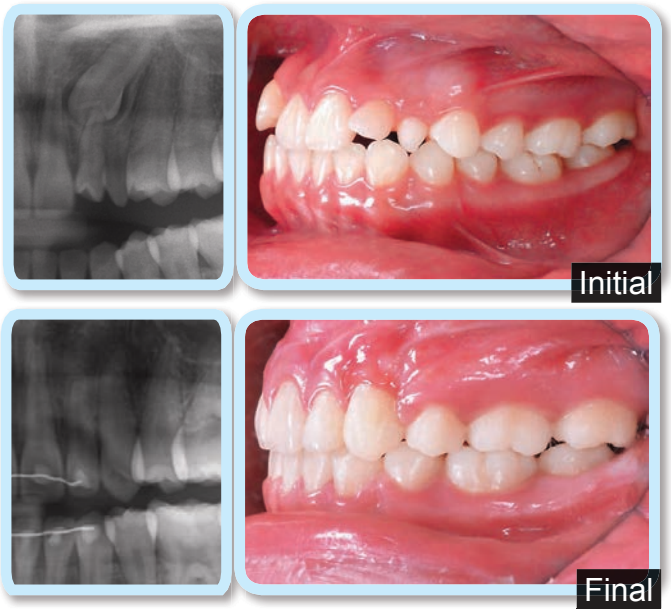

Fig. 21:
Four illustrations show a coordinated radiograph and intraoral photograph of the pretreatment (Initial) condition in the two upper views, and the corresponding final records are shown in the lower panel (Final).

Following 25 months of active treatment, all brackets were removed and fixed retainers were constructed on the maxillary incisors (*UR2-UL2*) and the mandibular anterior segment (*LR3-LL3*). Maxillary anterior frenectomy and gingivectomy were performed with a diode laser to optimize dental esthetics (*Fig. 20*). Fig. 21 is a panel of radiographs and photographs documenting the pre-treatment condition and the post-treatment outcome. The labial gingiva for the UL3 was irregular and only partially keratinized. For comparison, a 1.5-year follow-up view of the same region shows a narrow band of mature gingiva supporting the recovered UL3 (*Fig. 22*).

Post-treatment panoramic (*Fig. 23*), model casts (*Fig. 24*) and lateral cephalometric (*Fig. 25*) radiographs

Fig. 22:
At 1.5 year follow-up an intraoral photograph shows the relatively thin band of gingiva on the UL3 compared to adjacent teeth. Compare this follow-up view to Figs. 15 and 27 to assess the maturation of the gingiva on the buccal surface of the UL3. See text for details.

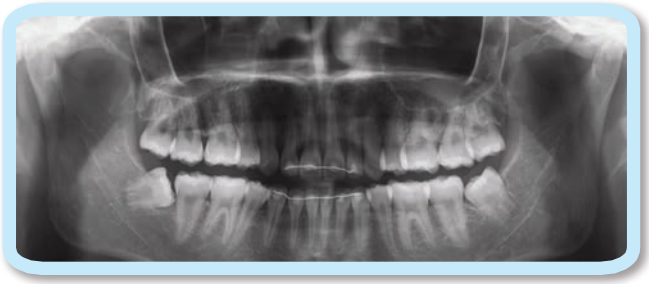

Fig. 23: Post-treatment panoramic radiograph

Fig. 24: Post-treatment dental models (casts) radiograph

document the outcome following 25 months of active surgical and orthodontic therapy. Superimposition of before and after treatment cephalometric tracings show the late growth and dentofacial orthopedic changes associated with active treatment (*Fig. 26*).

Results Achieved

Maxilla (all three planes):

- A - P: *Increased*
- Vertical: *Maintained*
- Transverse: *Maintained*

Mandible (all three planes):

- A - P: *Increased*
- Vertical: *Increased*
- Transverse: *Maintained*

Maxillary Dentition

- A - P: *Retraction of incisors, protraction of molars*
- Vertical: *Maintained*
- Inter-molar Width: *Maintained*

Mandibular Dentition

- A - P: *Retraction of incisors, protraction of molars*
- Vertical: *Slightly extruded consistent with normal growth*
- Inter-molar / Inter-canine Width: *Decreased / Maintained*

Facial Esthetics

- Convexity: *Decreased*
- Lips: *Retraction of the upper and lower lips*

Final Evaluation of Treatment

Clinical examination revealed an improved facial profile, i.e. the nasomaxillary complex grew anteriorly as the lips were retracted (*Figs. 26 and 27*). Maxillary and mandibular incisors were retracted and uprighted, as evidenced by decreased protrusion and axial inclination (*Table 1*). The score for the Cast-

Fig. 25: Post-treatment lateral cephalometric radiograph

Radiograph Evaluation (*CRE*) was 17 points. The major discrepancy was axial inclinations in the final panoramic radiograph (*Fig. 23*).

The total treatment time was 25 months for the partially transposed labially impacted maxillary canine, which is similar to the only other comparative report in the literature.[9] Post-treatment facial and intraoral photographs (*Fig. 27*), as well as similar records at 1.5-year follow-up showed the recovered canine and adjacent lateral incisor (*UL2*) were stable. No signs of re-intrusion, significant root resorption or inflammation of the soft tissue was noted. The keratinized gingiva around the UL3 was acceptable (*Fig. 22*), but should be followed longterm. Third molars were recommended for extraction (*Fig. 23*).

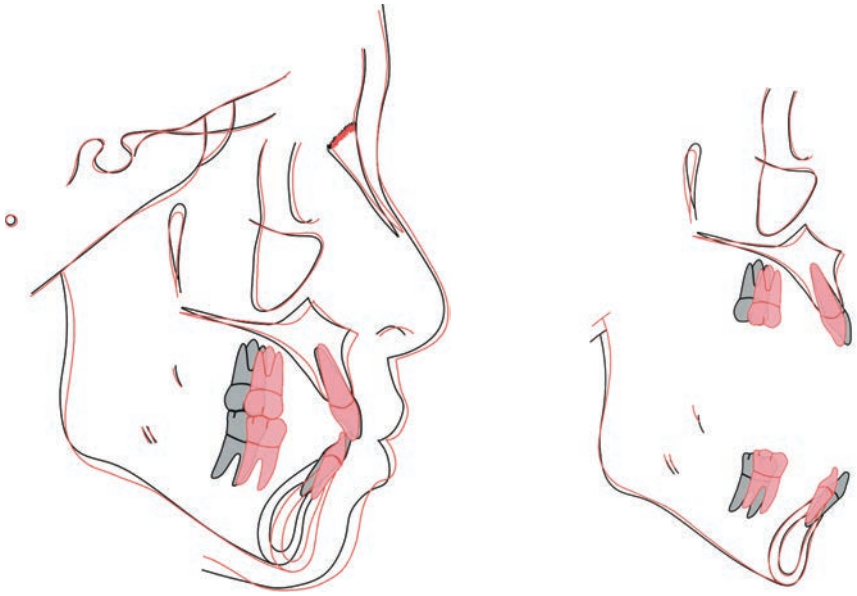

Fig. 26:
Initial (black) and final (red) cephalometric tracings are superimposed on the anterior cranial base (left) and the skeletal structures of the maxilla and the mandible (right).

Fig. 27: Post-treatment facial and intraoral photographs

Discussion

VISTA[17] is a novel method for management of labially-impacted canines.[16] The method as revised by Su et al.[19] preserves adequate keratinized tissue when the impaction emerges (*Fig. 22*). As the impaction is recovered, it is important to delay the bonding of the adjacent lateral incisor to control root resorption.[9] Preexisting root loss does not recover, but it also does not progress if the impingement is carefully corrected as the impaction is retracted. The use of the 3D lever arm anchored by an IZC OBS is particularly useful. It can be adjusted for staged movement in all planes of space as needed.[20]

Labial impaction exposure

A challenging aspect for recovery of labial impactions is maintaining keratinized gingival support. A minimum of 2mm of keratinized gingiva is necessary to maintain gingival health.[21] Labial impactions may emerge through alveolar mucosa rather than keratinized gingiva, so some degree of longterm gingival compromise is common.[10-12] The VISTA procedure allows for submucosal movement of a transposed impaction to its correct position in the arch (*Fig. 13*), prior to emergence through keratinized gingiva (*Fig. 21*). In retrospect, a wider

band of keratinized tissue on the UL3 may have been possible with a more vertical vector of traction when the UL3 was extruded (*Fig. 14*).

A crucial factor is the site of emergence relative to the mucogingival junction (*MGJ*). A frequently-cited study by Kokich[10] laid out three options: excisional uncovering (*EU*), apically positioned flap (*APF*) and, closed eruption (*CE*). EU is applicable if the crown of the impaction is coronal to the MGJ, but both APF and CE are used for impactions positioned superior to the MGJ. Vermette et al.[12] reported that the CE approach was superior to APF because it was less susceptible to gingival scarring and recession. These problems with gingival healing are attributed to "*overstretching*" of the keratinized layer following the primary healing of the gingival attachment. When an exposed tooth is moved coronally, the mucosa stretching may exceed the proliferative potential of the tissue. Furthermore, the strain may be in an oblique direction that tends to asymmetrically retract the gingival margin. Exposing an impaction, and repositioning the keratinized tissue for a centimeter or more, may devitalize or compromise the periodontal support of an adjacent tooth. For labially-impacted maxillary anterior teeth, CE is more reliable than ARF for optimal esthetic outcomes.[10,12,14]

Crescini et al.[13] proposed a CE approach mimicking a natural eruption route through the middle of the alveolus by performing a tunneling procedure from the crown of the impaction to the socket of its extracted predecessor. A gold chain is bonded to the enamel of the impaction to permit traction along the prepared path. The average time elapsed between the application of traction and the emergence of the cusp of the impacted canine is 11 months. A three-year follow-up study of the procedure showed no attachment loss or gingival recession. The problem with this approach is the requirement of no obstacles other than bone between the crown of the impaction and the desired emergence site. Partially or fully transposed teeth with an unfavorable orientation have a poor prognosis because the surgically prepared path would damage roots of adjacent teeth.[6,9,19] For the present patient, the preferred method was to retract the impacted canine away from the lateral incisor root with the OBS-anchored 3D lever-arm to expedite the recovery without precipitating additional root resorption.[22]

Previous impact recovery methods have relied on variations of linear traction. Unfavorable position and transposition of impactions may require staged movement in multiple directions with differential loads for an optimal outcome with minimal collateral damage. The present patient required swinging the impaction around the root of the lateral incisor without penetrating the oral mucosa at the corner of the arch, i.e. canine eminence. For precise submucosal movement, Su et al.[16] proposed a modification of the Zadeh[17] VISTA procedure to retract an impaction with a 3D lever-arm with modification of the line of traction, as needed (*Figs. 9, 11, 12 and 14*). To accelerate tooth movement, decortication was performed along the proposed traction path, a procedure referred to as the periodontally accelerated osteogenic orthodontics

(*PAOO*).[23] Via the VISTA and OBS 3D lever-arm approach, the partially transposed UL3 was retracted and extruded to emerge in its correct position in nine months (*Figs. 14 and 15*).

Delayed bonding of the lateral incisor

When lateral incisors are not bracketed, and restrained by an archwire or other retaining device, they are free to move away from the encroachment of a tooth follicle.[9] Broadbent[24] described the guidance of eruption theory that is commonly deemed the "*ugly duckling stage*" to explain the crown flaring and/or mesial root movement of maxillary lateral incisors due to development of the unerupted canines. The implied concept is that an unerupted tooth can elicit a malocclusion of an adjacent tooth (*teeth*), without damaging roots, as long as the force of the infringement is within an undefined physiologically acceptable range. The mechanism for controlling root resorption relies on the differential biomechanics of soft and hard tissues.

Differential biomechanics of root resorption

Recent imaging studies reveal that the critical factor for inducing root resorption is the proximity of the unerupted canine to the root of an adjacent incisor.[22] Deviated paths of eruption for impactions can result in severe root resorption of adjacent teeth[25-27] because eruptive force is ~10mN[28] which exceeds the compressive resistance of interposed soft tissues. Collectively the latter is probably similar to the pressure-induced necrosis of the periodontal ligament (*PDL*) associated with routine orthodontics.[29] In effect, exceeding the limit of PDL resistance (*8-10kPa*) results in maximal soft tissue compression, ischemia and necrosis similar to a bed sore.[29,30] Compression of the dental follicle and PDL depends on the direction of the force. An oblique load is more likely to result in displacement of a tooth without root resorption. However if the impaction is wedged between the mucosa and the tooth root, pressure is increased on the soft tissue (*dental follicle and PDL*) that separates the enamel from the root, and root resorption is noted (*Fig. 7*). In the absence of confinement, oblique force from a dental follicle rarely resorbs roots because stress in the PDL is <8-10kPa. As the load becomes more perpendicular, it is increasingly likely to exceed the resistance of the soft tissues (*dental sac and PDL*), resulting in a direct impact of the canine crown against the root of the incisor. Damage to the root surface occurs which elicits a root resorptive response.[26]

Under favorable circumstances of dental development, a tooth follicle can exert a very gentle, oblique force against the PDL that moves a tooth without eliciting root resorption. On the other hand, more perpendicular force associated with routine tooth movement[30] or perpendicular tooth eruption[28] tends to produce root resorption because the load is concentrated in a small area of the PDL, thereby exceeding the 8-10kPa necrotic threshold.[29,30] Even very light, perpendicular loads applied to individual teeth may result in PDL necrosis because of the long lever arm from the crown to the apex.[30] If an incisor root is moved into an unerupted canine follicle, or if

an erupting tooth follicle perpendicularly engages an incisor root, the load at the interface is likely to exceed the physiologic limit of the interposed soft tissues. Root resorption requires both injury and stimulation.[25] The root injury is due to the direct impact of the canine crown,[26] and the necrotic root surface is then colonized by multinucleated cells of the adjacent bone, i.e. osteoclasts. Because cementum turnover and healing is a slow process, root resorption prevails along the damaged surface of the injured root prevails. Root resorption due to impacted canines does not usually result in devitalization, but an unfavorable crown-root ratio may be detrimental to the longterm survival of the tooth.

Rationale for 3D lever arm

The 3D lever arm can deliver precise loads, coordinated forces and moments, in three planes of space. The load is adjusted as needed to produce the tooth movement required for each phase of impacted canine recovery. Close examination at the posttreatment photographs (*Figs. 21 and 26*) reveals an irregular and relatively thin width of gingiva on the recovered UL3, compared to adjacent teeth. Intuitively, a two phase impaction recovery, retraction followed by a closed eruption procedure, may be more predictable for enhancing keratinized gingiva. However, this approach requires an additional surgery and the potential for the procedure is limited by the width of the gingiva on the deciduous canine pretreatment. The MGJ is genetically defined, so the decrease in attached gingival width is probably due to normal apical migration of the gingiva as a result of passive eruption and the larger crown size of the permanent canine. Thus, it is unlikely that a two phase CE procedure would produce a superior result. As previously mentioned, the 3D lever-arm (*Fig. 14*) is adjustable for a more palatal emersion of the impaction. This is a more practical approach for achieving a more stable band of keratinized gingiva on the UL3 (*Fig. 22*). In any event, the outcome of a relatively thin band of UL3 gingiva should be pointed out to the patient. Specific dental hygiene instructions were provided for cleansing the soft tissue margin while avoiding tooth brush abrasion. The latter is a common problem at the corner of the arch (*canine eminence*).[31]

Conclusion

The VISTA surgical approach is a unique periodontal tunneling approach for submucosal movement of a transposed impaction, prior to penetrating the soft tissue and erupting into position. During the recovery process, adjacent teeth should not be bonded to allow them to physiologically move out of the path of canine movement. An OBS anchored 3D lever-arm is precisely adjusted for multiple phases in recovering labial impactions.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 16

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 =

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 = 1

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 = 4

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 = 0

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 = 2

OTHER (See Instructions)

Supernumerary teeth	_____ x 1 pt. =	_____
Ankylosis of perm. teeth	_____ x 2 pts. =	_____
Anomalous morphology	_____ x 2 pts. =	_____
Impaction (except 3rd molars)	1 x 2 pts. =	2
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	2 x 2 pts. =	4

Identify: Protrusive lower lip

Total = 6

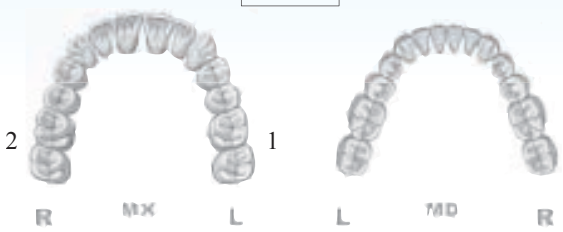
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 17

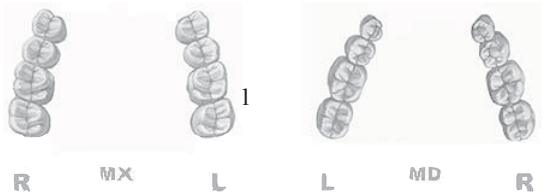
Alignment/Rotations

3



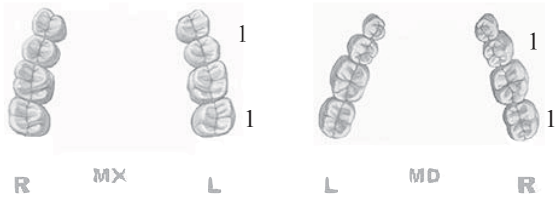
Marginal Ridges

1



Buccolingual Inclination

4

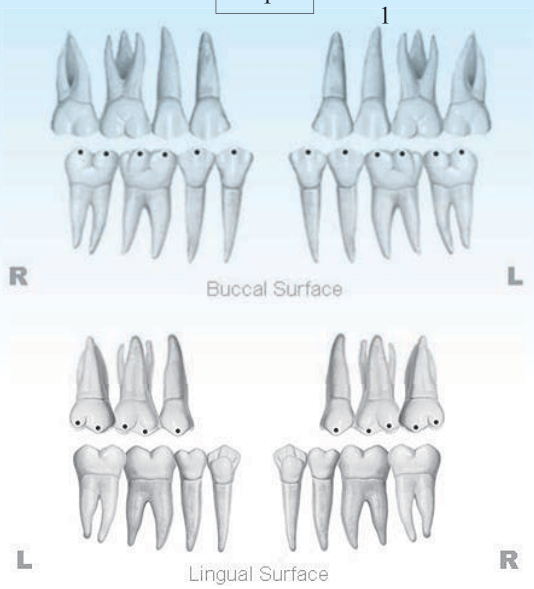


Overjet

3

Occlusal Contacts

1

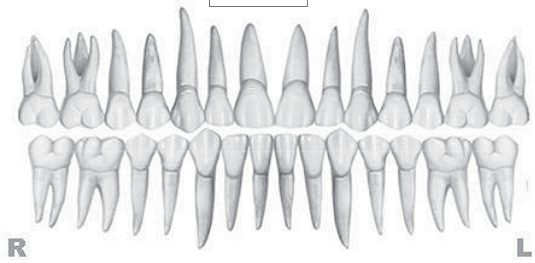


Occlusal Relationships

0

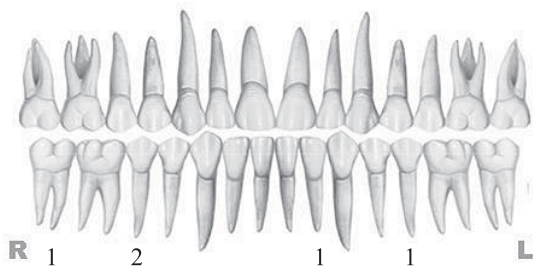
Interproximal Contacts

0



Root Angulation

5



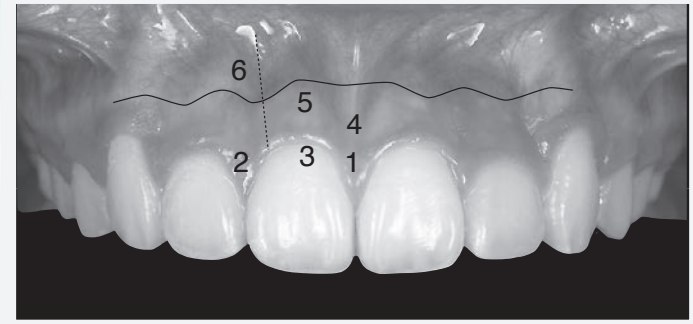
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 2

1. Pink Esthetic Score

Total = 2

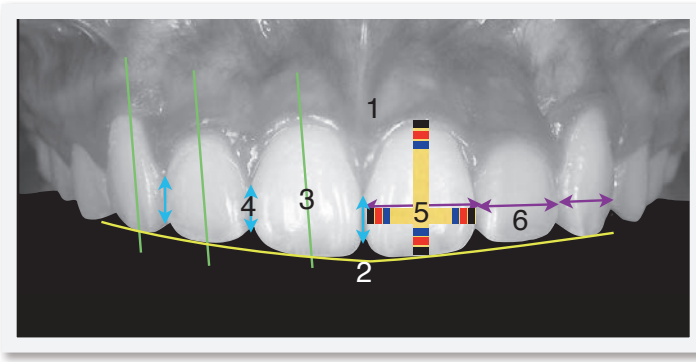


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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

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Link to the video

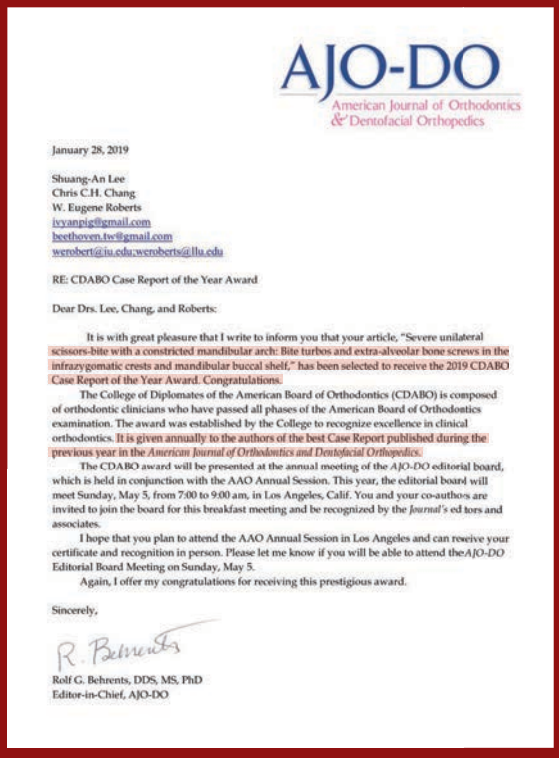
https://goo.gl/Dnu94Z

The **1st**
Chinese
Recipient


Shuang-An Lee


Chris H. Chang


W. Eugene Roberts



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RE: CDABO Case Report of the Year Award

Dear Drs. Lee, Chang, and Roberts:

It is with great pleasure that I write to inform you that your article, "Severe unilateral scissors-bite with a constricted mandibular arch: Bite turbos and extra-alveolar bone screws in the infrazygomatic crests and mandibular buccal shelf," has been selected to receive the 2019 CDABO Case Report of the Year Award. Congratulations.

The College of Diplomates of the American Board of Orthodontics (CDABO) is composed of orthodontic clinicians who have passed all phases of the American Board of Orthodontics examination. The award was established by the College to recognize excellence in clinical orthodontics. It is given annually to the authors of the best Case Report published during the previous year in the *American Journal of Orthodontics and Dentofacial Orthopedics*.

The CDABO award will be presented at the annual meeting of the *AJO-DO* editorial board, which is held in conjunction with the AAO Annual Session. This year, the editorial board will meet Sunday, May 5, from 7:00 to 9:00 am, in Los Angeles, Calif. You and your co-authors are invited to join the board for this breakfast meeting and be recognized by the *Journal's* editors and associates.

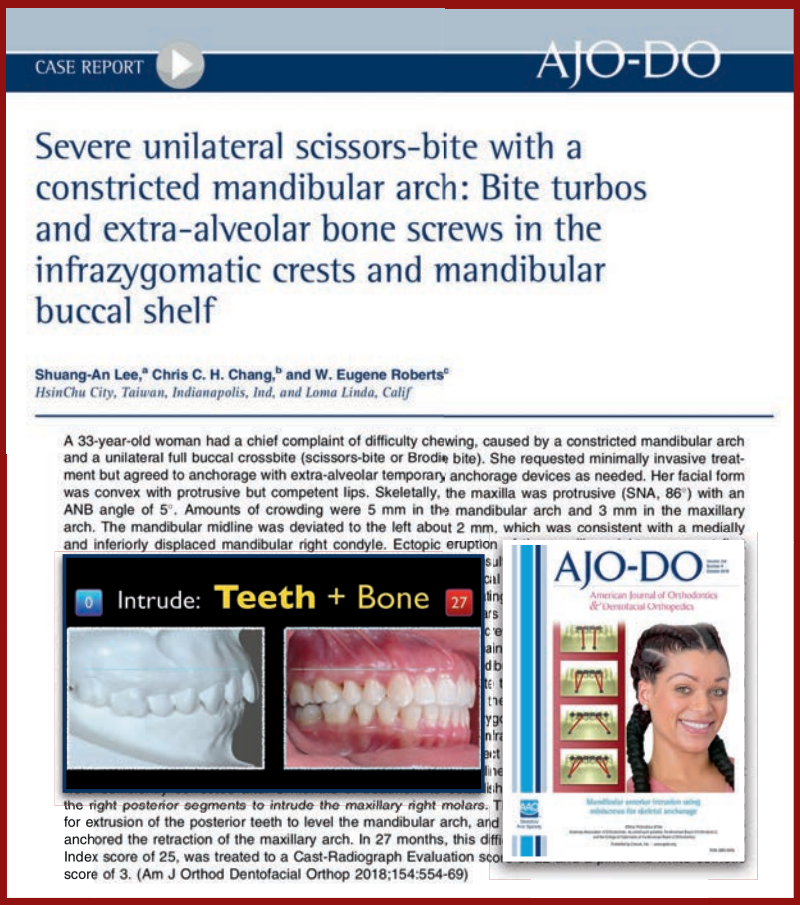
I hope that you plan to attend the AAO Annual Session in Los Angeles and can receive your certificate and recognition in person. Please let me know if you will be able to attend the *AJO-DO* Editorial Board Meeting on Sunday, May 5.

Again, I offer my congratulations for receiving this prestigious award.

Sincerely,

R. Behrents

Rolf G. Behrents, DDS, MS, PhD
Editor-in-Chief, AJO-DO



CASE REPORT AJO-DO

Severe unilateral scissors-bite with a constricted mandibular arch: Bite turbos and extra-alveolar bone screws in the infrazygomatic crests and mandibular buccal shelf

Shuang-An Lee,[a] Chris C. H. Chang,[b] and W. Eugene Roberts[c]
HsinChu City, Taiwan, Indianapolis, Ind, and Loma Linda, Calif

A 33-year-old woman had a chief complaint of difficulty chewing, caused by a constricted mandibular arch and a unilateral full buccal crossbite (scissors-bite or Brodie bite). She requested minimally invasive treatment but agreed to anchorage with extra-alveolar temporary anchorage devices as needed. Her facial form was convex with protrusive but competent lips. Skeletally, the maxilla was protrusive (SNA, 86°) with an ANB angle of 5°. Amounts of crowding were 5 mm in the mandibular arch and 3 mm in the maxillary arch. The mandibular midline was deviated to the left about 2 mm, which was consistent with a medially and inferiorly displaced mandibular right condyle. Ectopic eruption

the right posterior segments to intrude the maxillary right molars. T
for extrusion of the posterior teeth to level the mandibular arch, and
anchored the retraction of the maxillary arch. In 27 months, this diff
Index score of 25, was treated to a Cast-Radiograph Evaluation sco
score of 3. (Am J Orthod Dentofacial Orthop 2018;154:554-69)

AJO-DO, Volume 154, Issue 4, Pages 554–569

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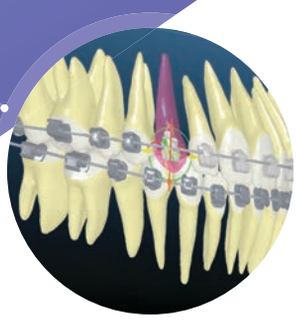

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KEYNOTE

THE LECTURERS

Dr. Chris Chang

CEO, Beethoven Orthodontic and Implant Group. He received his PhD in bone physiology and Certificate in Orthodontics from Indiana University in 1996. As publisher of Journal of Digital Orthodontics-*A journal for Interdisciplinary dental treatment*, he has been actively involved in the design and application of orthodontic bone screws.

Dr. John Lin

President of the Jin-Jong Lin Orthodontic Clinic. Dr. Lin received his MS. from Marquette University and is an internationally renowned lecturer. He's also the author of Creative Orthodontics and consultant to Journal of Digital Orthodontics-*A journal for Interdisciplinary dental treatment*.

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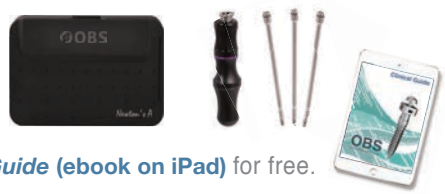

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* TADs made of Ti alloy have a lower failure rate compared to SS when placed in thin cortical bone. These results are consistent with a biocompatibility-related tendency for less bone resorption at the bone screw interface.
Reference: Failure Rates for SS and Ti-Alloy Incisal Anchorage Screws: Single-Center, Double Blind, Randomized Clinical Trial (J Digital Orthod 2018;52:70-79)

** The overall success rate of 93.7% indicates that both SS and TiA are clinically acceptable for IZC BSs.
Reference: Failure rates for stainless steel versus titanium alloy infrazygomatic crest bone screws: A single-center, randomized double-blind clinical trial (Angle Orthod; pending publication)

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2019~2020 第十一年度

貝多芬 矯正精修班

時間：週二上午 9:00-12:00
地點：金牛頓教育中心（新竹市建中一路25號2樓）

上課日期：

2020

8/27、9/10、10/22、11/12、12/10
1/14、2/25、3/24、4/14、5/19、6/16

- 09:00 ~ 10:00　精選文獻分析
- 10:00 ~ 10:30　精緻完工案例
- 10:50 ~ 12:00　臨床技巧及常犯錯誤分享

全新的第十一年度 2019-20 貝多芬精修班， 是由國際知名講師張慧男醫師主持，並偕同貝多芬牙醫團隊住院醫師群共同主講。

每月一次的課程之中，包含了：

1. 精選矯正權威期刊 AJODO 的文章做文獻分析與評讀。
2. 精緻完工 ABO 案例報告，其中因應數位矯正的世界趨勢，Insignia 與 Invisalign 病例為課程探討的主要內容之一。
3. 分享臨床上常犯的錯誤以及解決方法。

2019-20 貝多芬精修班內容豐富精彩，讓您經由每個月一次的課程，在面對各式的臨床案例時，更能游刃有餘、得心應手。

學習目的：

研讀最新趨勢文章可以窺知世界文獻公認的治療方式，而藉由評論文章的優缺點不僅能夠訓練判斷與思考能力，更可以清楚比較作法上的不同，達到完整理解治療方向、內容與穩定性的目標。

報名專線：03-5735676＃201，蔡佳汶

Probable Airway Etiology for Skeletal Class III Openbite Malocclusion with Posterior Crossbite: Camouflage Treatment with Extractions

Abstract

History: *A 27-year-old male presented for orthodontic consultation with a chief complaint (CC): front teeth do not contact. Upper right canine (UR3*) was previously extracted to alleviate maxillary crowding. Previous doctors suggested orthognathic surgery, but the patient was concerned about the cost and morbidity. Beethoven Orthodontic Clinic was consulted because of the reputation for managing skeletal openbite malocclusion conservatively.*

Etiology: *A childhood airway problem, probably related to enlarged pharyngeal lymphoid tissue, resulted in anterior posturing of the mandible and low tongue posture to open the airway. The patient is now able to breath through the nose with the mouth closed. Orthodontic correction of the malocclusion is expected to spontaneously resolve the low tongue posture which is the proximal cause of the anterior openbite and posterior crossbite.*

Diagnosis: *Skeletal (SNA 83˚, SNB 86˚, ANB -3˚) Class III malocclusion (10mm bilaterally) was combined with 6mm anterior openbite and bilateral posterior crossbite. The UR3 was missing and the maxillary midline was deviated 3mm to the right. The patient could breathe normally through the nose with the lips closed. The Discrepancy Index (DI) for this severe skeletal malocclusion was 103.*

Treatment: *Instruction and reinforcement of normal tongue posture is emphasized throughout treatment. Correct crowding and establish symmetry for the missing UR3 by extracting UL4, UR4, and LL4. Resolve the posterior crossbite with rapid palatal expansion of the maxillary arch, followed by cross elastics. Install a full fixed appliance with passive self-ligating brackets. Utilize standard torque for upper anteriors and super-high torque for lower anteriors. Supplement the torque correction in the lower anterior segment with an archwire sequence of 0.016x0.025-in 34mm with 20˚ Pre-Torque CuNiTi, and 0.016x0.025-in stainless steel with 3rd order bends. Follow-up with torquing auxiliary springs as needed.*

Results: *After 33 months of active treatment, this severe skeletal malocclusion was conservatively corrected to a near ideal Class I occlusion without orthognathic surgery or temporary anchorage devices (TADs). The Cast Radiograph Evaluation (CRE) was 22 points, and Pink & White dental esthetics score was 0.*

Conclusion: *Severe Class III openbite malocclusion may result from airway-related anterior positioning of the mandible and low tongue posture during childhood. Conservative correction with extractions and differential space closure is indicated, if the patient is able to breathe normally through the nose with the mouth closed. Spontaneous correction of the aberrant postural habits is probable when the malocclusion is corrected. Otherwise, specific habit correction therapy is indicated. (J Digital Orthod 2019;54:54-76)*

Key words:
Class III malocclusion, anterior crossbite, anterior open-bite, posterior cross-bite, etiology, childhood airway insufficiency, pharyngeal lymphoid tissue, torque selection

** International dental nomenclature is a modified Palmer notation relative to the midline for: 1. quadrants which are upper (U) and lower (L) on the right (R) and left (L) sides, 2. deciduous teeth are a-e, and 3. permanent teeth are 1-8.*

Dr. Chun Hung Chen,
Lecturer, Beethoven Orthodontic Course (Left)

Dr. Yu Lin Hsu,
Director, Anderson Pediatric Center,
Associate Editor, Journal of Digital Orthodontics (Center left)

Dr. Chris H. Chang,
Founder, Beethoven Orthodontic Center
Publisher, Journal of Digital Orthodontics (Center right)

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

Fig. 1: Pre-treatment facial and intraoral photographs

Introduction

Openbite is a severe problem for both patients and orthodontists. Airway compromise,[1] perioral habits,[2-4] and an unfavorable growth pattern[5] have been associated with open bite malocclusion. Opposing teeth passively erupt (*extrude*) until they contact, unless soft tissue interferes. Thus, the proximal etiology for most openbite malocclusions is aberrant interincisal posture of the tongue and/or lips.[6] Unless the etiology is resolved, functional deviations in soft tissue morphology manifest in childhood[7] may develop into stable malocclusions. Mechanical corrections with conservative orthodontics,[8] cribs,[9] extractions,[10] miniscrew anchorage[11] and/or orthognathic surgery[12,13] tend to relapse unless adequately retained. Although there is broad variance among studies,[8-13] an average of about 75% of openbite corrections are stable because the aberrant soft tissue posture spontaneously corrects when the open bite is closed. However, the residual 25% relapse despite the clinician's best efforts, because the etiology (*soft tissue posture*)[6] failed to resolve spontaneously. For consistent success, it is important to assess the etiology, discuss it with the patient, and plan a course of therapy that specifically addresses the proximal cause of the problem(*s*), if it does not spontaneously correct during treatment. Orofacial myofunctional therapy is an adjunctive approach that may help the patient resolve persistent aberrations in soft tissue posture.[14] It is important to emphasize that openbite is the patient's problem, not the doctor's! The clinician guides the correction of the malocclusion and its etiology, but the patient (*not the doctor*) is responsible for stability. The patient's satisfaction with the outcome of treatment depends on the pretreatment consultation. The patient must assume responsibility for correcting the etiology, often a pernicious habit. Otherwise, an elective treatment for an openbite is a high risk clinical procedure that may negatively impact the reputation of the clinician. Openbite correction is a team effort, and the patient is the star player!

The traditional treatment for skeletal malocclusions is surgical correction of the aberrant morphology, i.e. maxilla and/or mandible are repositioned to achieve ideal proportions.[12,15,16] Orthognathic surgery is expensive, involves considerable risk and morbidity, and furthermore may contribute to functional problems. The relapse rate for overbite corrected with surgery (*average of ~25%*) is about the same as for conservative correction. No matter how the openbite is closed the etiology must be corrected, either spontaneously or therapeutically. The operative and postoperative risks for orthognathic surgery are well known, but the functional sequelae and stability of openbite correction are more obscure. For instance, mandibular set-back surgery for skeletal Class III openbite malocclusion may relapse up to 40%,[17,18] result in neurosensory disturbances,[19] and compromise the airway.[20] The latter is a concern relative to obstructive sleep apnea, particularly in men.[21]

Because of expense, morbidity and instability of orthognathic surgical procedures, conservative alternatives for correcting skeletal Class III openbite malocclusion are of current interest. Bone screws placed lateral to the roots of the molars are effective anchorage for retracting and posteriorly rotating the lower arch.[1,22] The intrusion of the mandibular molars is particularly effective for decreasing the vertical

dimension of occlusion (*VDO*) for skeletal Class III patients with a long, convex face.[23]

Class III malocclusion, particularly with a skeletal basis, is challenging because of a complex diagnosis and uncertain prognosis. After completion of facial growth the traditional treatment options are orthognathic surgery[12,15,16] or camouflage treatment.[24,25] About 92% of adult Class III patients can be treated to a Class I occlusion by orthodontic therapy alone.[26] Camouflage treatment with extractions and Class III elastics usually results in an increase in the ANB angle, VDO, and facial convexity.[27-33] In effect a prognathic mandible is converted into long face.

This case report illustrates the nonsurgical treatment of the adult open bite having a slight prognathic mandible and a full cusp Class III molar relationship. Although the discrepancy index was 103, Lin's 3-ring diagnosis[34] and the Chang et al.[35] extraction chart, indicated this challenging malocclusion could be treated to a normal occlusion with good dentofacial esthetics.

Etiology

Unfortunately the proximal cause of environmental malocclusions is rarely considered in diagnosis and treatment planning. Instead, surgical procedures and mechanics have evolved to correct the morphology to a preconceived norm or standard. Orthodontic correction with or without surgery can be accomplished with many procedures: passive self-ligating (*PSL*) brackets,[1,22] high-pull head-gear therapy,[24,25] extraction treatment,[26,35] multiple-loop edgewise archwires (*MEAW*) mechanics,[36-39] molar intrusion,[40,41] and temporary anchorage devices with elastic traction.[41-43] These techniques can all result in acceptable overjet and overbite, but stability of the correction is uncertain unless the aberrant soft tissue posture is corrected.[6]

Diagnosis

A 27-year-old male presented for orthodontic treatment. His major complaint was no contact of the anterior teeth. Many doctors suggested orthognathic surgery, but that approach was unappealing to the patient. He consulted Beethoven Orthodontic Clinic for a conservative orthodontic solution to manage a 5mm anterior openbite with a bilateral posterior cross-bite. The facial profile was concave, overjet was -5mm, and there was a full-cusp Class III molar relationship, that was about a 10mm discrepancy bilaterally (*Fig. 1*). Dr. Lin's Three-

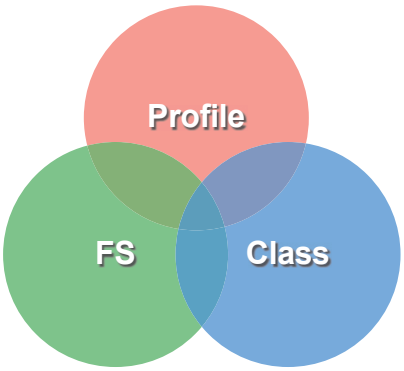

Fig. 2:
Dr. Lin's Three-Ring Diagnosis System assesses the potential for conservative correction of a Class III malocclusion with an anterior crossbite. Favorable factors are:

1. *Profile of the face is acceptable when the mandible is positioned in the centric relation (C_R),*
2. *Class I buccal segments in C_R*
3. *Functional shift (FS) is present from the C_R to centric occlusion C_O.*

Ring Diagnosis System (*Fig. 2*) suggested a good prognosis for conservative correction,[34] and that Chang Decision Making Chart (*Table 1*) indicated the camouflage treatment with extractions was a viable option.

The upper arch was crowded about 5mm, three teeth (*UR3, LL8, LR8*) were missing (*Fig. 3*), but the lower dentition was relatively well aligned (*Figs. 1 and 4*). Cephalometric analysis revealed bimaxillary protrusion (*SNA 83.5˚, SNB 85.5˚*), and an increased mandibular plane angle (*MP 41.5˚*) (*Fig. 5 and Table 2*).

The probable etiology was a childhood airway problem that resulted in low tongue posture and a functional protrusion of the mandible. There was no distress when breathing through the nose with the lips closed. This clinical test suggests the pharyngeal airway problem may have resolved during the adolescent years via a normal recession

	Ext.	Not
1. Profile	Protrusive	Straight
2. Md. angle	High	Low
3. Bite	Open	Deep
4. Ant. inclination	Flaring	Flat
5. Crowding	> 7mm	None
6. Decay/missing	Present	????
7. P't perception	OK	No
8. Etc...		

Table 1:
The Chang's extraction decision making chart helps the clinician to understand the pros and cons related to extracting teeth or not.

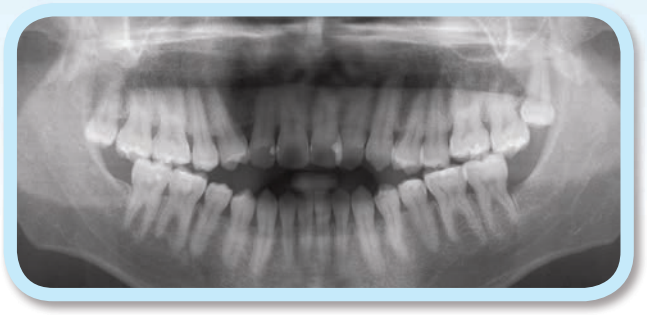

Fig. 3: Pre-treatment panoramic radiograph

Fig. 4: Pre-treatment study models (casts)

Fig. 5: Pre-treatment cephalometric radiograph

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	83°	83°	0°
SNB° (80°)	86°	84°	2°
ANB° (2°)	-3°	-1°	2°
SN-MP° (32°)	42°	44°	2°
FMA° (25°)	35°	37°	0°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	8 mm	4 mm	4 mm
U1 To SN° (104°)	114°	106°	8°
L1 To NB mm (4 mm)	8 mm	2 mm	6 mm
L1 To MP° (90°)	85°	70°	15°
FACIAL ANALYSIS			
E-LINE UL (2-3 mm)	-2.5 mm	-3.5 mm	1 mm
E-LINE LL (1-2 mm)	1.5 mm	-4 mm	5.5 mm
Convexity: G-Sn-Pg' (13°)%	2°	3°	1°
FH: Na-ANS-Gn (53±3%)	60%	60%	0%

Table 2: Pre- and post-treatment cephalometric analysis.

of oropharyngeal lymphoid tissue.[1] Adults with Class III malocclusions can usually be corrected without precipitating an airway problem if there is no distress with nasal respiration pretreatment.

There was crowding in the upper arch. UR3, LL8 and LR8 were missing. The lower dentition was in relatively good alignment (*Fig. 3*). From the cephalometric analysis, the maxilla was normal (*SNA 83.5°*), whereas the mandible was over-grown (*SNB 85.5°*). The mandibular angle was high (*MP 41.5°*).

Treatment Objectives

The treatment objectives were to (*1*) establish functional Class I molar and canine relationship, (*2*) close the anterior open-bite, (*3*) correct the posterior crossbite, (*4*) create ideal overbite and overjet, (*5*) relieve the crowding of the upper anterior teeth, and (*6*) improve facial esthetics.

Treatment Plan

Extract all 1st premolars except the UR4, which will be used for canine substitution. Correct the anterior crossbite with an anterior inclined bite-plate. If further retraction of the lower arch is required, install extra-alveolar bone screws (*2x12mm, OBS®, iNewton Dental Ltd, Hsinchu, Taiwan*) in the buccal shelves bilaterally to serve as anchorage. To correct the posterior crossbite, expand the 0.016x0.025-in stainless steel upper archwire, and utilize bilateral crossbite elastics. Detail and seat the posterior occlusion with vertical elastics as needed. Instruct the patient in the use of the Face Former® (*Dr. Berndsen GmbH Medical, Unna, Germany*) while sleeping to control mouth breathing.[44]

Treatment Alternatives

Option 1. Although two-jaw orthognathic surgery is often indicated for severe Class III openbite malocclusion, the patient refused that option because it was invasive, involved substantial morbidity, required prolonged hospitalization, and would result in substantial medical costs.

Option 2. If the patient had well formed lower 3rd molars bilaterally, extraction of the lower 2nd molars would have been a good choice. Not only would extraction of the L7s help resolve the open-bite, space closure would result in dental alignment over the apical base of bone. Unfortunately both lower third molars were missing, so extractions of L7s was not a viable option.

Option 3. Bilateral mandibular buccal shelf bone screws could be used to retract and distally rotate the entire lower arch. This method substantially decreases the lower facial height to correct severe lip incompetence.[23] However, the patient's lips were only slightly incompetent, so bone screw retraction of the lower arch risked an unfavorable decrease in the vertical dimension of occlusion (*VDO*).

Option 4. Extraction of all first premolars except the UR4 which is substituted for the missing UR3. Utilize both Class III and posterior crossbite elastics. This is a traditional camouflage option that is readily visualized,[10,30] and extractions are a well accepted treatment modality in Taiwan,[35] so the patient preferred this option.

Treatment Progress

The archwire sequence is summarized in Table 3, and the detailed treatment mechanics are outlined in Table 4. Figures 6-10 document treatment progress in the following views: right buccal, frontal, left buccal, upper occlusal and lower occlusal, respectively.

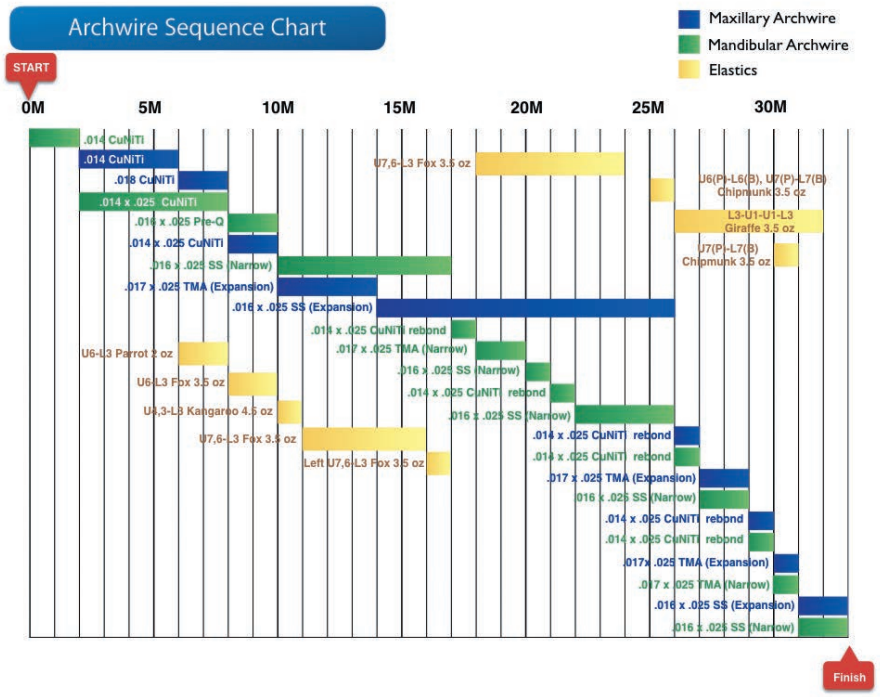

Table 3:
The archwire sequence chart is a treatment timeline for the procedures involved in managing the malocclusion: archwire changes, adjustments, elastics and bracket rebonding procedures. Bracket positions were corrected four times with rebonding procedures. Posterior intermaxillary relationships were corrected with multiple expansion and contraction adjustments.

Appointment	Archwire	Notes
1 (0 months)	L : 0.014-in Damon CuNiTi	Bond all lower teeth. LR4 and LL4 had been extracted. High torque brackets were selected.
2 (1 months)	U: 0.014-in Damon CuNiTi L : 0.014x0.025-in Damon CuNiTi	Bond all upper teeth except UL2. Use the open-coil spring to create space. UL4 had been extracted. Standard Torque brackets were selected for incisors while high torque brackets for canines.
3 (4 months)		Bond UL2 and rebond LL3, LR3 and LR5
4 (6 months)	U: 0.018-in Damon CuNiTi	Started using early light short Class III elastics (Parrot, 5/16-in, 2-oz) from U6s to L3s to retract mandibular anteriors.
5 (8 months)	U: 0.014x0.025-in Damon CuNiTi L : 0.016x0.025-in Damon Pre-Torque CuNiTi	Change the early light short Class III elastics to Fox (1/4-in, 3.5-oz) from U6s to L3s to retract mandibular anteriors.
6 (10 months)	U: 0.017x0.025-in Damon TMA L : 0.016x0.025-in Damon SS	Expand the upper archwire and constrict the lower archwire. Add 15˚ torque to the archwire from LR2-LL2. All the extraction spaces were closed with power chains.
7 (11 months)		All the extraction spaces were closed with power chains. The Class III elastics (Fox, 1/4-in, 3.5-oz) were used from L3s to U6s and U7s to retract the lower anteriors and to protract the upper posteriors.
8 (12 months)		Inclined bite plate on LL1 to guide the UL1 to a normal overjet.
9 (14 months)	U: 0.016x0.025-in Damon SS	Remove the inclined bite plate. Expand the upper archwire and constrict the lower archwire.
10 (16 months)		Continue to close all the space with power chains.
11 (17 months)	L : 0.014x0.025-in Damon CuNiTi	Rebond UR1, LL5, LL7, LR2. Stop elastics.
12 (18 months)	L : 0.017x0.025-in Damon TMA	The Class III elastics (Fox, 1/4-in, 3.5-oz) were used from L3s to U6s and U7s to retract the lower anteriors and to protract the upper posteriors.
13 (20 months)	L : 0.016x0.025-in Damon SS	Continue to expand the upper arch and constrict the lower arch. Close space with the power chains.

Tables 4A and 4B: The treatment sequence for all procedures is outlined in detail.

Appointment	Archwire	Notes
13 (20 months)	L : 0.016x0.025-in Damon SS	Continue to expand the upper arch and constrict the lower arch. Close space with the power chains.
14 (21 months)	L : 0.014x0.025-in Damon CuNiTi	Rebond LL5, LR1, LR5
15 (22 months)	L : 0.016x0.025-in Damon SS	Continue to expand the upper arch and constrict the lower arch. Close space with the power chains.
16 (24 months)		Bond the buttons on the palatal side of UR6 & UR7, then start crossbite elastics (Chipmunk, 1/8-in, 3.5-oz) to correct the posterior crossbite of the right side.
17 (25 months)		Bond the buttons on the palatal side of UL6 and UL7, then start crossbite elastics (Chipmunk, 1/8-in, 3.5-oz) to correct the posterior crossbite of the left side.
18 (26 months)	U: 0.014x0.025-in Damon CuNiTi L : 0.014x0.025-in Damon CuNiTi	Rebond UR1, UR4, UR5, LL1 to correct axial inclinations.
19 (27 months)	L : 0.017x0.025-in Damon TMA	
20 (28 months)	U: 0.017x0.025-in Damon TMA L : 0.016x0.025-in Damon SS	Use torquing spring to retract the root of the LR1. Bond the buttons on LL5, LL7, LR5, LR7, and hook the power chains to close the space between the posterior teeth.
21 (29 months)	U: 0.014x0.025-in Damon CuNiTi L : 0.014x0.025-in Damon CuNiTi	Interproximal enamel reduction of the upper incisors. Rebond UR1, UR4, LR1.
22 (30 months)	U: 0.017x0.025-in Damon TMA L : 0.017x0.025-in Damon TMA	Add 10˚ buccal crown torque for LL5, LR5 with a 3rd order-bend.
23 (31 months)	U: 0.016x0.025-in Damon SS L : 0.016x0.025-in Damon SS	Consolidation with continuous ligatures from UR5 to UL5 to prevent space opening.
24 (32 months)		Add torque springs to LL5, LR5 for lingual root torque.
25 (33 months)		Cut the archwire of the upper from U3s. Instruct patient to use intermaxillary elastics one by one from the premolars to molars in CIII patency.
26 (33 months & 2 weeks)		All appliances were removed. Fixed retainers were bonded on the lingual surfaces of all maxillary and mandibular incisors. 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 there-after. Instructions were provided for home hygiene and maintenance of the retainers.

■ *Tables 4A and 4B: The treatment sequence for all procedures is outlined in detail.*

Fig. 6: Treatment progression in the right buccal view is shown from the start (0M) to twenty-nine months (29M).

Fig. 7: Treatment progression in the frontal intraoral view is shown form the start (0M) to twenty-nine months (29M).

Fig. 8: Treatment progression in the left buccal view is shown from the start (0M) to twenty-nine months (29M).

Fig. 9: Treatment progression in the maxillary occlusal view is shown from the start (0M) to twenty-nine months (29M).

Fig. 10: Treatment progression from the mandibular occlusal view is shown from the start (0M) to twenty-nine months (29M).

Treatment Results

Both arches were well aligned in an ideal Class I occlusion, with coincident dental midlines (*Figs. 11 and 12*). Overjet was corrected from -5mm to 1mm and the overbite was increased from -5mm to 1mm. The post-treatment panoramic radiograph (*Fig. 13*) shows complete space closure with acceptable root parallelism and no significant periodontal bone loss, but the lower incisors experienced some mild root resorption. The post-treatment cephalometric radiograph documents the dentofacial correction in profile (*Fig. 14*).

Fig. 11: Post-treatment facial and intraoral photographs document 33 months of active treatment. See text for details.

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

Fig. 13: Post-treatment panoramic radiograph

Fig. 14: Post-treatment cephalometric radiograph

Superimposed cephalometric tracings show the uprighting and retraction of the lower molars as well as slight clockwise rotation (*opening*) of the mandibular plane (*Table 2, Fig. 15*). Intermaxillary extrusion and retraction of the incisors corrected the openbite and decreased lip protrusion. The Class III buccal segments were corrected primarily by posterior retraction and distal rotation of the lower arch.

The ABO Cast Radiograph Evaluation score was 22 points, as shown in Supplementary Worksheet 2. The most substantial uncorrected problem was anticipated: buccolingual inclination of the posterior teeth (*11 points*). This compensation is acceptable

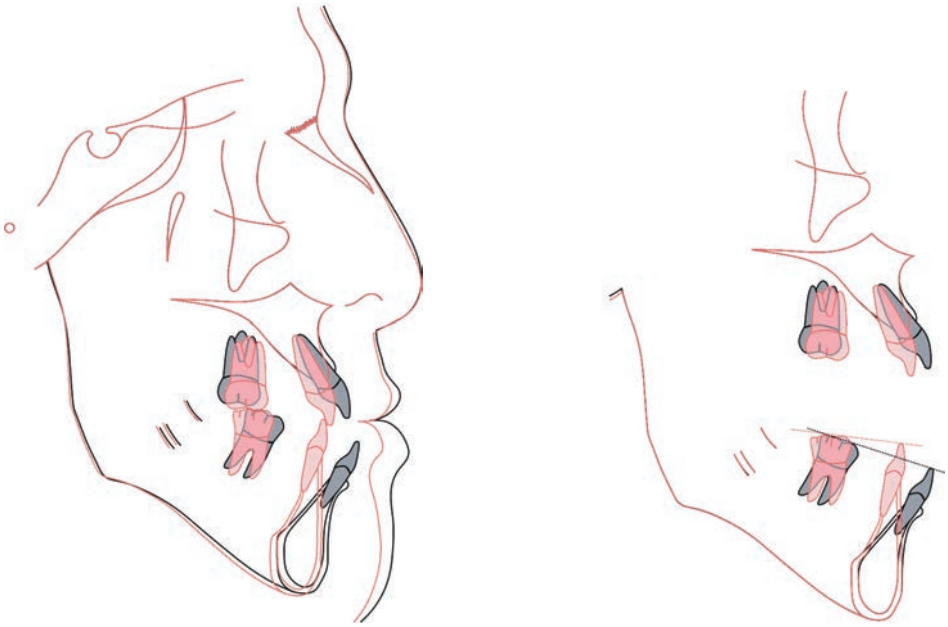

Fig. 15:
Cephalometric tracings are superimposed to show dentofacial changes from the start (black) to the finish (red) of treatment. Superimpositions are on the anterior cranial base (left), maxilla (upper right), and mandible (lower left). See text for interpretation and details of treatment.

for Class III camouflage correction (*Fig. 11*). Dental esthetics were acceptable as documented by the Pink and White dental esthetic index of 4, shown in Supplementary Worksheet 3. The conservative treatment plan required only 33 months of active treatment, and the patient was well pleased with the outcome.

Retention

Fixed retainers were bonded on the lingual surfaces of all maxillary and mandibular incisors. 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 oral hygiene and maintenance of the retainers. The patient was taught how to use the Face Former®[44] while sleeping to control mouth breathing (*Fig. 16*).

Fig. 16:
The patent is shown wearing the neuro-myo-functional training appliance (Face Former®). See text for details.

Discussion

Prevalence of Class III malocclusion ranges from 0.8-4.0% for Caucasians to 12-13% for Chinese and Japanese populations.[45] The etiology of Class III malocclusion may be genetic and/or environmental.[6,46-49] Anterior crossbite is often a function compensation for ectopic eruption of maxillary incisors or anterior posturing of the mandible.[50] Compensations for breathing problems, particularly sleep apnea, are well documented.[51-55] Airway compromise may be compensated by forward posturing of the mandible to achieve increased airway volume.[47,49,50] A low tongue posture, with the tip of the tongue positioned between the teeth, is consistent with openbite.[6,48]

Superimposition of cephalometric tracings (*Fig. 15*) documented extensive tooth movement in both arches. Retraction and counterclockwise rotation of the lower arch was primarily responsible for the correction of the severe (*10mm*) Class III buccal segments. The magnitude of lower arch retraction and posterior rotation was remarkable because no temporary anchorage devices (*TADs*) were used for anchorage. Several aspects of the mechanics contributed to this interesting therapeutic response. First, a PSL appliance can simulate the Class III correction capability of the Multiloop Edgewise Archwire (*MEAW*) technique introduced by Young.[36] It is suggested that this effect is due to 7.0-11.4° of play between a 0.019x0.025-in stainless steel wire and the PSL bracket slot (*Fig. 17*). The bracket play is inversely related to archwire size, so small diameter archwires deliver very light 3rd order force, thereby

mimicking the MEAW effect.[28] Second, extraction of lower 1st premolars was necessary to create space for the extensive retraction and the lower anterior teeth. The UL4 was also extracted for symmetry to compensate for the UR3 that was missing at the start of treatment (*Fig. 18*). Space closure in the absence of a compensating gable bend[51] deepens the overbite, which helps close the openbite (*Fig. 15*). Third, Class III elastics tipped the lower molars distally resulting in a counterclockwise rotation of the occlusal plane. This effect on the lower occlusal plane tends to correct Class III openbite malocclusion.[23]

Haas[56] reported that rapid palatal expansion (*RPE*) advances the maxilla, but Wertz et al.[57] found the effect to be limited and unpredictable. RPE may be necessary for some patients with very narrow upper arches, but for most Chinese Class III patients, RPE is not necessary.[58] For the present patient (*Fig. 1*), upper arch width was adequate, and the proximal cause of the Class III openbite was deemed excessive prominence of the mandible (*SNB 86°*). Positioning the casts in a Class I relationship (*Fig. 19*), demonstrated that the maxillary buccal segments

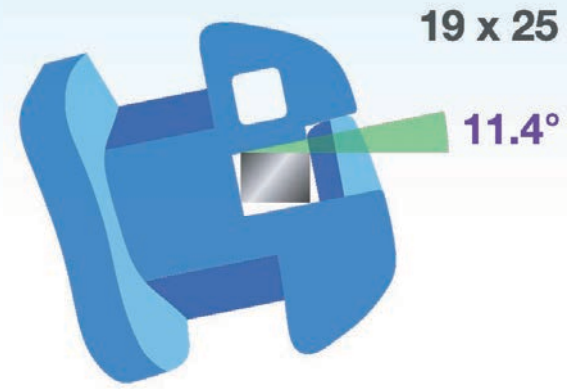

Fig. 17:
A cross-section through a PSL bracket reveals 11.4° of play between the slot and an 0.019x0.025-in archwire. This design is associated with low resistance to sliding mechanics.

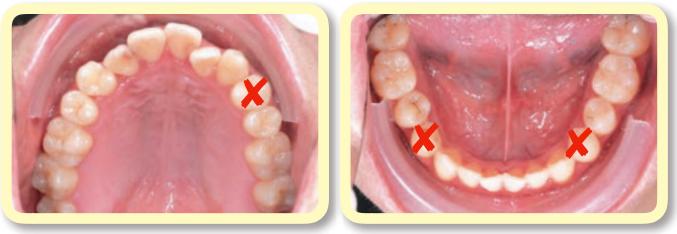

Fig. 18:
Left: *extraction of the UL4 (red X) balances tooth loss bilaterally and provides space for correction of anterior crowding.*
Right: *extraction of both lower 1st premolars provides bilateral space for retraction of the anterior segment.*

Fig. 19:
When the pretreatment study casts (Fig. 4) are positioned in a Class I molar relationship, the relative width of the intermaxillary buccal segments is acceptable, but will require compensation for buccolingual axial inclinations. See text for details.

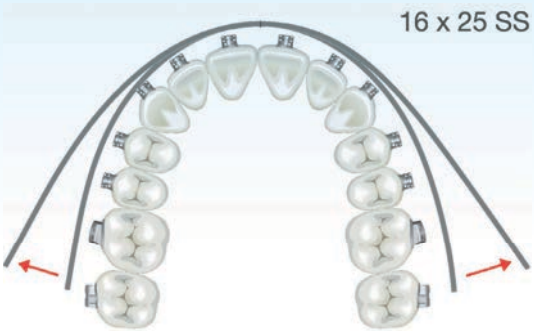

Fig. 20:
Expand a 0.016x0.025-in stainless steel archwire to increase the width of the arch.

Fig. 21:
In 24th month of treatment, buttons were bonded on the lingual surface of the maxillary molars (left) and 3.5-oz cross-elastics were utilized (right).

are of sufficient width to align the dentition, but the final buccolingual alignment (*Figs. 11 and 12*) will probably result in a compromise of buccolingual inclinations, as documented in a CRE score of 11 points. In the 24th month of treatment, the molar relationship was end-on Class III due to the efficiency of lower space closure. Arch width correction required expansion of the upper 0.016x0.025-in stainless steel archwire (*Fig. 20*), and use cross elastics in the posterior segments for several months (*Fig. 21*). The buccolingual compromise of the upper and lower posterior segments was an acceptable compromised outcome (*Fig. 11*).

Class III elastics and bilateral space closure produced the expected lingual tipping of the lower anterior segment. Low torque brackets were inverted on the lower incisors to produce high torque performance (*Fig. 22, left*). In the leveling and alignment stages, 0.016x0.025-in pre-torque CuNiTi was used to increase the incisal torque. When the archwire was changed to 0.016x0.025-in stainless steel for

Fig. 22:
Selection of bracket torque for the anterior teeth:

Left: *Inverted low-torque brackets deliver substantial lingual root torque (7-11˚) that results in super high-torque performance.*

Center: *Standard torque brackets (6-15˚) are adequate for the maxillary anterior segment.*

Right: *Class III elastics produce counterclockwise moments around the center of rotation (blue dot with a black pus sign) in both arches that tends to flare maxillary incisors, and tip mandibular incisors lingually. These undesirable incisor effects are prevented with incisor brackets that have normal lingual root torque in the maxilla and increased lingual root torque in the mandible. SQ is the moderating effect of standard torque. HQ is the lower incisor uprighting effect of high torque brackets.*

space closure mechanics, about 15˚ of lingual root torque was lost (*Table 2*). For the upper incisors, standard torque brackets were adequate to maintain lingual root torque because of the crowded arch. Most of the UL4 space was utilized for correcting crowding so the post-treatment axial inclination of the maxillary incisors was adequate (*U1-SN: 106˚*) as shown in Fig. 22 (*center and right image*) and Table 2.

Anterior openbite is typically associated with interincisal digit (*finger or thumb*) as well as soft tissue (*tongue or lip*) posture.[6,55] Extreme dentoalveolar compensation for treatment of skeletal Class III malocclusion[59] is successful for correction of openbite if the interincisal soft tissue posture corrects spontaneously.[6,55] To paraphrase Harold Frost,[60] "*conventional wisdom*" holds that transient mouth breathing and tongue thrusting are the etiology of anterior openbite. This conclusion is suspect because only continuous loads move teeth.[6,56,61] In any event, it is important to control mouth breathing because the aberrant tongue and mandibular posture to open the airway is associated with low tongue posture and an interincisal position of soft tissue (*lips and/or tongue*). The latter is the proximal etiology of openbite and not the former. Tongue thrusting is actually a response to openbite, not the cause of it, because it is impossible to swallow without an anterior tongue seal of the oral cavity.[6,56] It is important to control mouth breathing so that the aberrant soft tissue posture can be corrected, but the tongue thrusting usually corrects spontaneously once the openbite is closed. The FaceFormer® appliance, developed by Dr. Klaus and Sabine Berndsen,[44] helps stabilize the transient functions of the oral pharyngeal region that are associated with a patent airway, as well as normal head and neck posture. The patient was instructed to perform FaceFormer® training 3 times a day. There were 20 basic exercises together plus 20 pulling exercises to strengthen the lip-seal. Also, the patient was instructed to wear the device when sleeping to reinforce nasal breathing. To establish new posture and motion patterns that will be stable, the patient was instructed to perform the exercises and wear the device at night for at least 6 months.

Orthodontists should carefully evaluate skeletal Class III malocclusion because the discrepancy may have a longterm etiology related to breathing. The airway may be compromised early in infancy, particularly when sleeping. If an infant is unable to open the airway by reflex posturing of the mandible anteriorly and/or lowering tongue posture, the problem may result in sudden infant death syndrome (*SIDS*).[62] A skeletal Class III malocclusion may be the sequelae of mandibular and tongue posturing to maintain a patent airway. The habit often begins in infancy and is reinforced in childhood by hypertrophy of pharyngeal lymphoid tissue.[1] Although the pharyngeal airway improves during adolescence as the lymphoid tissue atrophies, the abnormal posturing of the mandible and soft tissue is an acquired habit that does not spontaneously correct. The critical diagnostic test for a skeletal Class III malocclusion is to assess nasal respiration with the mouth closed. If normal breathing through the nose with the mouth closed is a problem, an otolaryngology consult is indicated. Persistent airway problems for Class III patients are more common for

females,[63] but post-treatment sleep apnea is more of a concern for men.[20] However, most skeletal Class III patients can be corrected without developing airway problems or sleep apnea.[64] If a patient has no problems with nasal respiration, the malocclusion can usually be conservatively corrected and the airway postural problems will spontaneously resolve for about 75% of patients. For the 25% that maintain low tongue posture and/or an anterior openbite, habit correction therapy is indicated. Conservative treatment for the present skeletal Class III openbite patient resulted in spontaneous correction of the airway-related habits, so no additional therapy was required.

Conclusions

Skeletal CIII openbite malocclusion is a complex problem that requires a careful evaluation. Lin's three ring diagnosis is useful for determining if the problem can be managed conservatively. If a camouflage approach is feasible, Chang's extraction table is helpful for formulating a viable treatment plan. For the present patient, retraction and posterior rotation of the lower arch was a critical factor for managing severe skeletal malocclusion conservatively, i.e. without resorting to orthognathic surgery or TADs. A PSL bracket system achieved a MEAW effect that facilitated closure of the anterior openbite. Specific torque selection of the lower incisor brackets and a pretorqued archwire offset the severe distal tipping of lower incisors that was anticipated with space closure and Class III elastics.

Acknowledgment

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 103

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 =

Total = 21

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 = 29

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 4

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 = 4

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 = 18

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 8

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = 4 pts.

Each degree < -2° 1 x 1 pt. = 1

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

SN-MP

≥ 38° = 2 pts.

Each degree > 38° 4 x 2 pts. = 8

≤ 26° = 1 pt.

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

1 to MP ≥ 99° = 1 pt.

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

Total = 15

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. =	2
Missing teeth (except 3rd molars)	1	x 1 pts. =	1
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	_____	x 2 pts. =	_____

Identify:

Total = 4

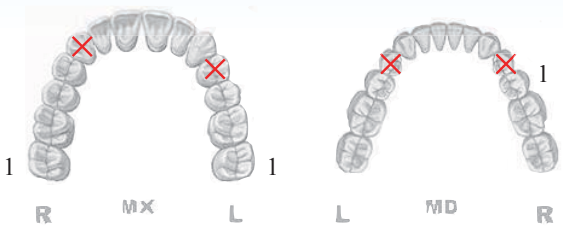
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 22

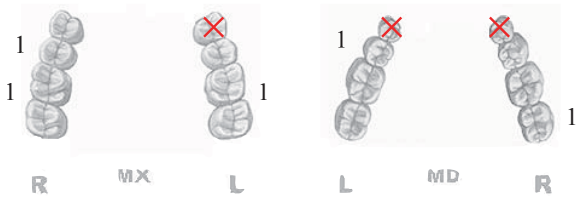
Alignment/Rotations

3



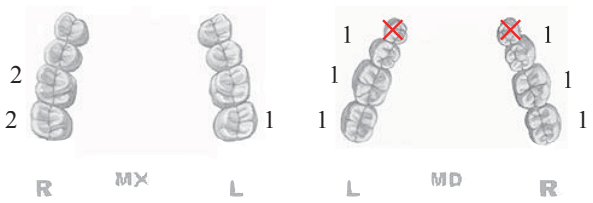
Marginal Ridges

5



Buccolingual Inclination

11

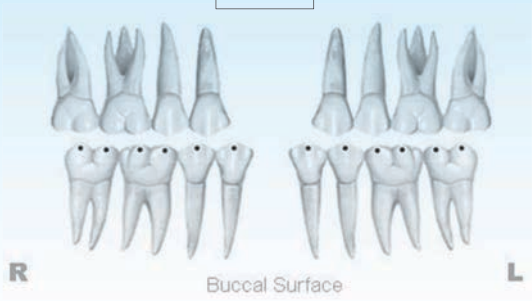


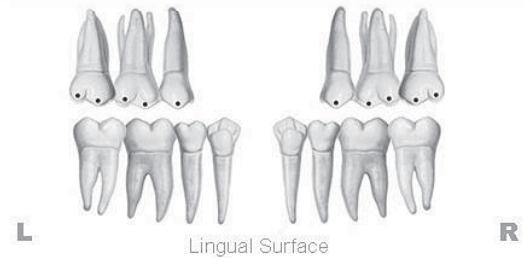
Overjet

3

Occlusal Contacts

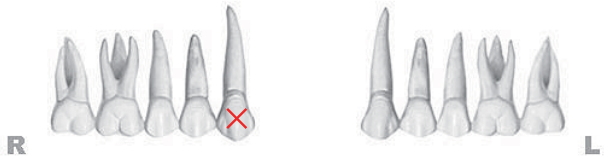
0





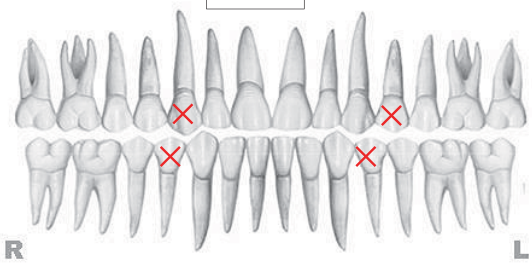
Occlusal Relationships

0



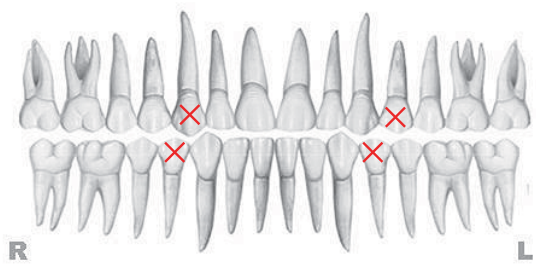
Interproximal Contacts

0



Root Angulation

0



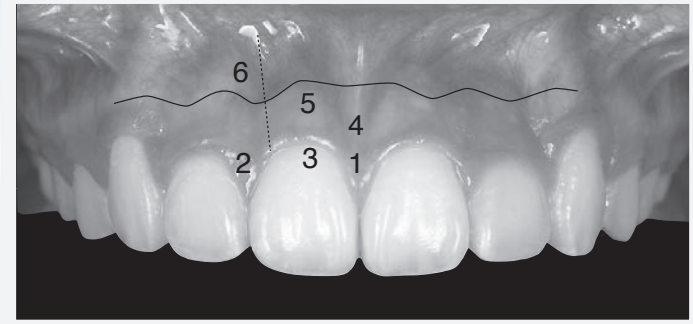
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score (Before Surgical Crown Lengthening)

Total Score: = 4

1. Pink Esthetic Score

Total = 1

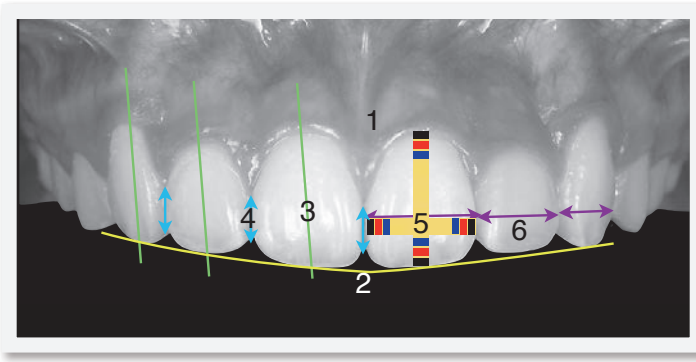


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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 = 3



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

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2019 Case Report of the Year **Award**

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Shuang-An Lee


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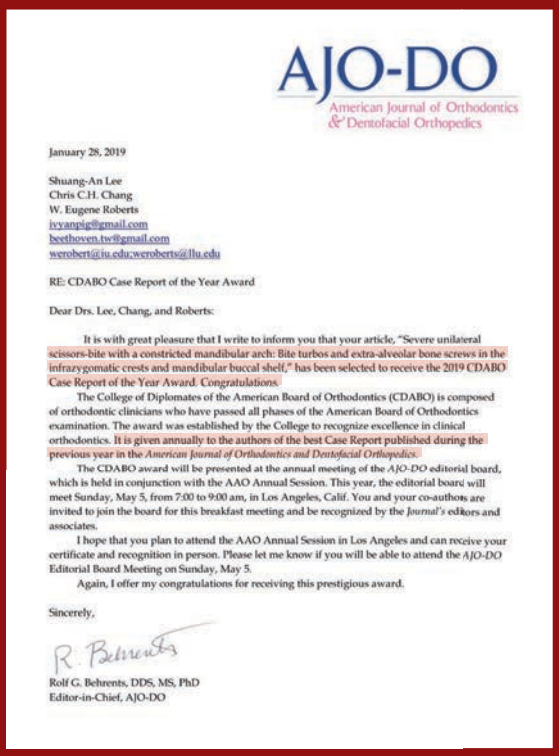

AJO-DO
American Journal of Orthodontics & Dentofacial Orthopedics

January 28, 2019

Shuang-An Lee
Chris C.H. Chang
W. Eugene Roberts
ivyanpig@gmail.com
beethoven.tw@gmail.com
werobert@iu.edu;weroberts@llu.edu

RE: CDABO Case Report of the Year Award

Dear Drs. Lee, Chang, and Roberts:

It is with great pleasure that I write to inform you that your article, "Severe unilateral scissors-bite with a constricted mandibular arch: Bite turbos and extra-alveolar bone screws in the infrazygomatic crests and mandibular buccal shelf," has been selected to receive the 2019 CDABO Case Report of the Year Award. Congratulations.

The College of Diplomates of the American Board of Orthodontics (CDABO) is composed of orthodontic clinicians who have passed all phases of the American Board of Orthodontics examination. The award was established by the College to recognize excellence in clinical orthodontics. It is given annually to the authors of the best Case Report published during the previous year in the *American Journal of Orthodontics and Dentofacial Orthopedics*.

The CDABO award will be presented at the annual meeting of the *AJO-DO* editorial board, which is held in conjunction with the AAO Annual Session. This year, the editorial board will meet Sunday, May 5, from 7:00 to 9:00 am, in Los Angeles, Calif. You and your co-authors are invited to join the board for this breakfast meeting and be recognized by the *Journal's* editors and associates.

I hope that you plan to attend the AAO Annual Session in Los Angeles and can receive your certificate and recognition in person. Please let me know if you will be able to attend the *AJO-DO* Editorial Board Meeting on Sunday, May 5.

Again, I offer my congratulations for receiving this prestigious award.

Sincerely,

R. Behrents

Rolf G. Behrents, DDS, MS, PhD
Editor-in-Chief, AJO-DO


CASE REPORT

AJO-DO

Severe unilateral scissors-bite with a constricted mandibular arch: Bite turbos and extra-alveolar bone screws in the infrazygomatic crests and mandibular buccal shelf

Shuang-An Lee,[a] Chris C. H. Chang,[b] and W. Eugene Roberts[c]
HsinChu City, Taiwan, Indianapolis, Ind, and Loma Linda, Calif

A 33-year-old woman had a chief complaint of difficulty chewing, caused by a constricted mandibular ar
and a unilateral full buccal crossbite (scissors-bite or Brodie bite). She requested minimally invasive trea
ment but agreed to anchorage with extra-alveolar temporary anchorage devices as needed. Her facial for
was convex with protrusive but competent lips. Skeletally, the maxilla was protrusive (SNA, 86°) with a
ANB angle of 5°. Amounts of crowding were 5 mm in th

anterior flaring of the incisors. The scissors-bite and lingu
were sufficiently corrected after 3 months of treatment to
the right posterior segments to intrude the maxillary right
for extrusion of the posterior teeth to level the mandibular
anchored the retraction of the maxillary arch. In 27 months, this difficult malocclusion, with a Discrepan
Index score of 25, was treated to a Cast-Radiograph Evaluation score of 22 and a pink and white esthe

AJO-DO, Volume 154, Issue 4, Pages 554–569

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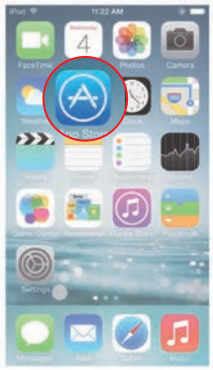
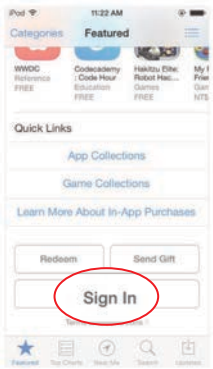
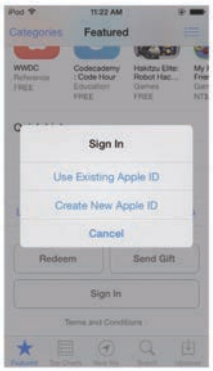
Step-by-step Instructions



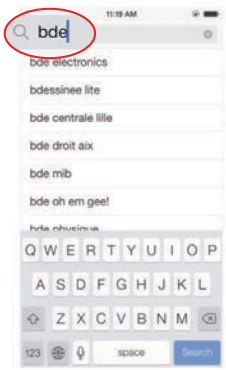
1. Go to App Store on your device.



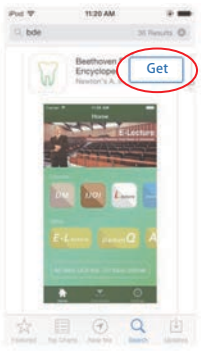
2. "Sign in" with your Apple ID.



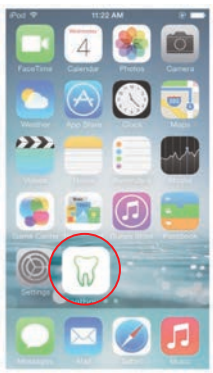
3. "Create Apple ID" if you don't have one.



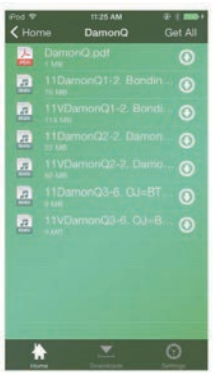
4. Search for "BDE."



5. Click "FREE" and "INSTALL APP."



6. Download completed!



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Introduction to Invisalign® Smart Technology: Attachments Design, and Recall-Checks

Abstract

Modern clear aligners are engineered to expand the boundaries for the utilization of removable appliances to treat a wide variety of malocclusions. Innovation is continually evolving to provide orthodontists with greater control of tooth movement to achieve desired outcomes. Three current technologies are SmartTrack, SmartForce, and SmartStage. Attachment design is an important aspect of ClinCheck. There are 5 questions that provide guide lines for choosing attachments. Two examples are presented to demonstrate the design of dental attachments to facilitate tooth movement. Invisalign G6 is a method for treating patients with extractions, particularly first premolars. It provides vertical and second order (root parallelism) control for predictable outcomes with maximum or moderate anchorage. Efficient management of space closure is an important aspect for aligner therapy because enamel stripping and extractions are common approaches for managing crowding and protrusion. At every appointment it is important to check aligner adaptation (fit), attachment positions, and anchorage preparation. This article reviews clinical procedures for numerous applications and also addresses clinical problems. (J Digital Orthod 2019;54:80-95)

Key words:

Invisalign clear aligners, ClinCheck software, SmartForce features, SmartTrack material, SmartStage, Attachment design, Invisalign G6, Aligner fit, TADs, CII elastics

Introduction

Over the past 15 years Align Technology has invested heavily in clear aligner research and development (*R&D*) to expand the clinical scope and predictability for management of a broad range of malocclusions in a global market of about 5 million patients. Innovations include SmartTrack, SmartForce, and SmartStage (*Fig. 1*). From interdental spacing to challenging Class III corrections, treatment options are available for treating a large range of malocclusions.

SmartTrack

SmartTrack is a materials innovation that evolved from 8 years of R&D investigating over 260 candidate materials with both biomechanics and materials science expertise.[1] Modern aligner materials are composed of polyurethane derived from methylene diphenyl diisocyanate and 1,6-hexanediol. This is a medical grade polymer with supplemental additives to adjust material properties to produce a product that is clear, strong, thin and flexible. In addition it is hypo-allergic, inert and biologically stable.[2] There are

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Dr. Chris H. Chang,
Founder, Beethoven Orthodontic Center
Publisher, Journal of Digital Orthodontics (Lower middle)

Dr. W. Eugene Roberts,
Editor-in-chief, Journal of Digital Orthodontics (Lower right)

three different varieties: 1. LD30 (*0.75mm*) for Invisalign® aligners, 2. EX40 (*1.02mm*) for Vivera® and Invisalign® retainers, and 3. EX15 (*<0.75mm*) for Invisalign® templates.

SmartTrack Features

1) Improved Control

Align Technology reports proprietary data from a pilot study of 1015 patients at 5 months follow-up. Compared to the original aligner material, SmartTrack delivers optimal loads over the two-week period of aligner wear designed to improve tracking and control of tooth movement. No data are presented but the company claims the results were highly significant ($p<0.001$) at a 99.9% confidence level (*Fig. 2*).[1]

Fig. 1: The 3 innovations of Align Technology.
SmartTrack: Aligner material to supply gentle and content force.
SmartForce: Precise 3D control of tooth movement.
SmartStage: Optimizes the progression of tooth movement.

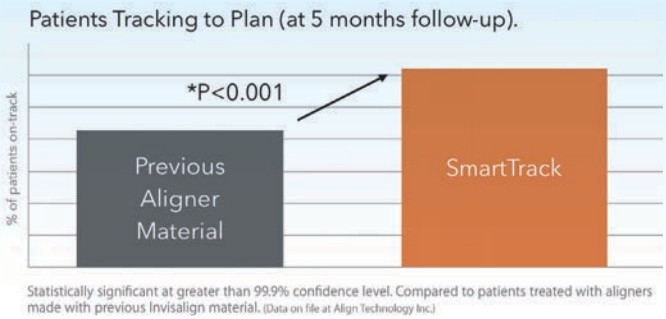


Fig. 2:
The percentage of patients remaining on track with Invisalign treatment was significantly higher at a 5-month review appointment (p< 0.001). See text for details.

2) Improved Constant and Gentle Force

The applied force for the original aligner material decayed rapidly over the first few days of wear, but decreased at a much slower rate for the last 10-12d of the two-week period. In comparison the SmartTrack material delivered a lower initial load, that decayed rapidly for the first couple of days and then delivered a relatively constant load for the next 12d (*Fig. 3*).[3] It is concluded that SmartTrack produces a more constant and gentle load over the entire two week period. Furthermore, there is a significantly lower initial insertion load for each new aligner, which improves patient comfort. The comparative

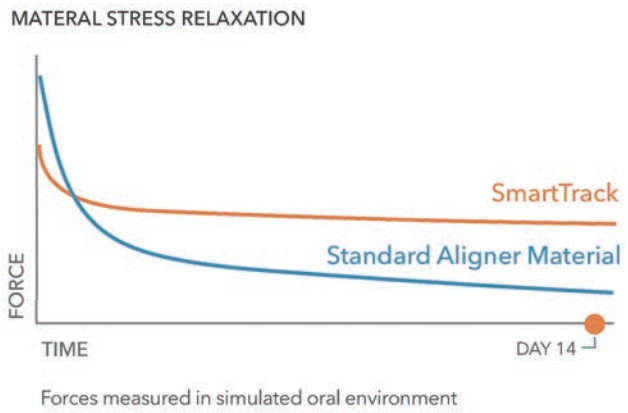


Fig. 3:
Invisalign SmartTrack has a more constant and gentle force to achieve tooth movement. The standard aligner material requires a high insertion force and the load quickly decays over the two week aligner wear period. See text for details.

curves, based on vitro measurements in a simulated oral environment, appear to be consistent with the conclusions, but "*Material Stress Relaxation*" is unclear because stress is typically measured in Pascals not Force. A more complete report or literature reference to the actual data for Fig. 3 would be helpful.

3) Higher Elasticity

SmartTrack aligners are composed of a more pliable material (*Fig. 3*) that is more easily stretched over a dental arch, and less likely to crack (*Fig. 4*). The aligner then returns more completely to its programmed shape (*memory*). The decreased permanent distortion illustrated helps facilitate precise tooth movement (*Fig. 5*). Reportedly the SmartTrack material is more comfortable to wear than previous aligners made with the EX30 material.[3]

4) More Precise Aligner Fit

The comparative fit (*adaptation*) of the more flexible material is tested with relatively opaque blue gel, that is added to the aligner before it is fitted on the arch. The overall less intense blue color of SmartTrack indicates it conforms more closely to the dental anatomy. Improved adaptation (*Fig. 6*) and the

Fig. 4:
The more elastic material is much less likely to crack when stretched over a patients' teeth.

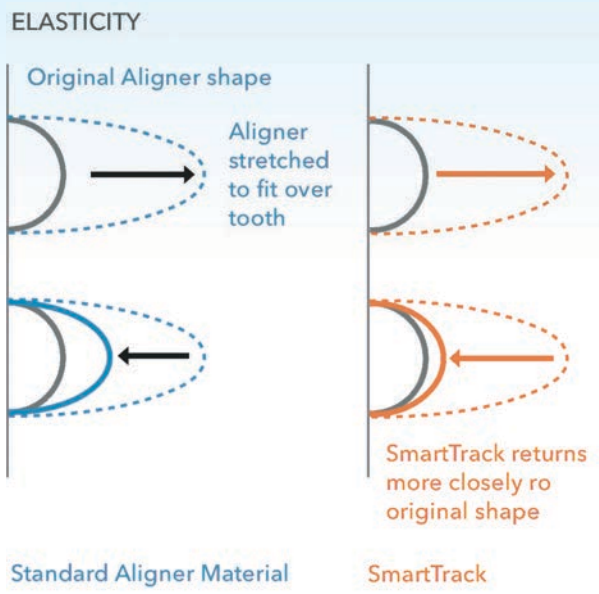


Fig. 5:
When deformed, the highly elastic SmartTrack returns more closely to the programmed aligner shape. See text for details.

tendency for less permanent distortion (*Fig. 5*) are expected to translate into improved control of tooth movement, particularly for finishing.[4]

5) Enhanced Patient Comfort

SmartTrack aligners are reportedly more comfortable to wear and easier to take in and out, which is an important feature if bonded attachments are present.[5] Despite the improved performance, the current aligners have good clarity, esthetics and transparency, so they are an almost invisible removable appliance.[6] In addition, SmartTrack has resulted in improved control of tooth movement, by applying a more gentle and relatively constant force (*Fig. 3*). These characteristics reportedly decrease treatment time up to 50%, and tooth movement is 75% more predictable[7] because of the improved conformity to the arch (*Fig. 6*) and less distortion (*Fig. 5*).

SmartForce

SmartForce was proposed for extrusion of teeth in 2009. Later a beveled surface was added on the occlusal surface of the attachment to enhance the delivery of extrusive force (*Fig. 7*).[4] When a load is transferred to the gingival surface of the attachment, the bevel allows the tooth to move occlusally (*extrude*). Similar force vectors were developed for attachments designed for rotational control,

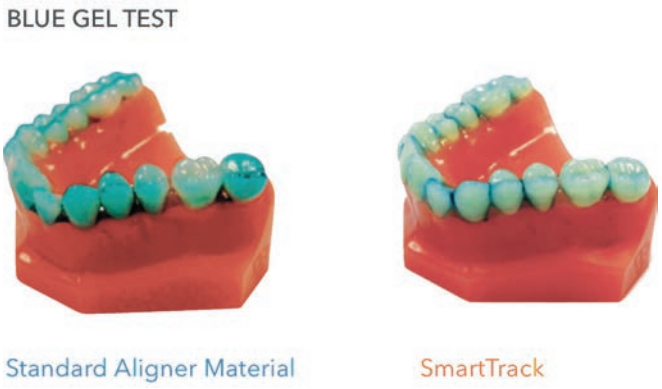


Fig. 6:
Aligners are filled with blue gel and seated on a typodont. White areas indicate direct aligner contact, and blue areas indicate a gap between the aligner and the teeth. SmartTrack demonstrates superior adaptation (fit), particularly in interproximal and attachment areas.

Fig. 7:
Invisalign® proposed the concept of SmartForce in 2009. A gingival rectangular beveled attachment was designed to extrude the tooth efficiently.

application of torque (*3rd order correction*), and intrusion. The G4-G7 concepts were developed later.

SmartForce Features

To understand SmartForce capabilities, it is important to carefully consider the attachment concept. Depending on the design of the attachment relative to the seating (*full engagement*) of an aligner, force and couples to generate moments can be applied to move teeth. In mechanics, a couple is two parallel forces that are equal in magnitude, opposite in direction (*sense*), and do not share a common line of action. When the treatment plan calls for anything other than tipping a tooth, an attachment(*s*) are necessary. It is essential to carefully evaluate the couple generated by a loaded attachment, relative to the force applied. The moment to force ratio (*M:F*) is directly related to the type of tooth movement: tipping (*low*), translation (*medium*) and root torque (*high*). Another important consideration is the equal and opposite effect of the force system on the anchorage unit. Bodily tooth movement (*translation*) and particularly root torque tax anchorage far more than tipping movements.

Fundamentally, a surface attachment is much like a handle to move a sliding door (*Fig. 8*). Prior to SmartForce, the principal attachments were ellipsoid, rectangular, and rectangular beveled (*Fig. 9*). Except for the latter, an aligner passively fitting an attachment only provides retention. The beveled attachments are worthwhile for aligning the dentition to achieve limited orthodontic correction, but they are not compatible with the complex movement required for comprehensive

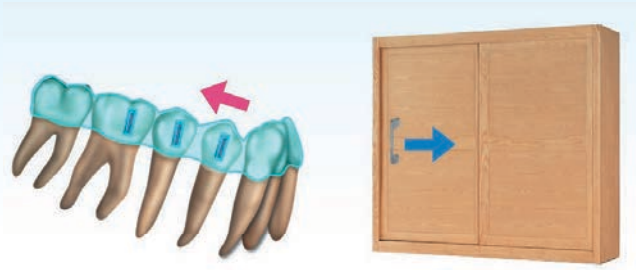


Fig. 8:
An attachment on an aligner is analogous to a handle on a wardrobe or cabinet. The attachment (handle) provides retention for an aligner.

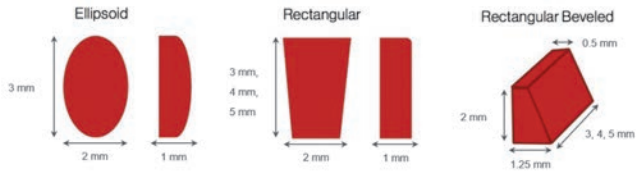


Fig. 9:
Three types of conventional attachments are shown. The ellipsoid is seldom used now because of poor retention. The rectangular attachment is effective for additional retention and can be used to apply a couple (moment) to the teeth. The beveled attachment is still a good choice for extrusion although the newer optimized attachments are now more common.

orthodontics. The G3 concept[5] for attachment-mediated tooth movement was aimed at more comprehensive applications such as rotations and torque control.[5,7] The principal difference for G3 was power ridges[6] built into the aligner, and a direction-oriented active surface on optimized attachments (*Fig. 10*).[7] With the improved elasticity of SmartTrack (*Fig. 3*) a force applied to an active surface can be used to effectively move a tooth in any direction. However, anchorage must be carefully considered particularly if the goal to move teeth bodily (*translate*). There is a tendency to tip teeth with an active surface unless there is an adequate moment for bodily movement. If it is desirable to retract a tooth,

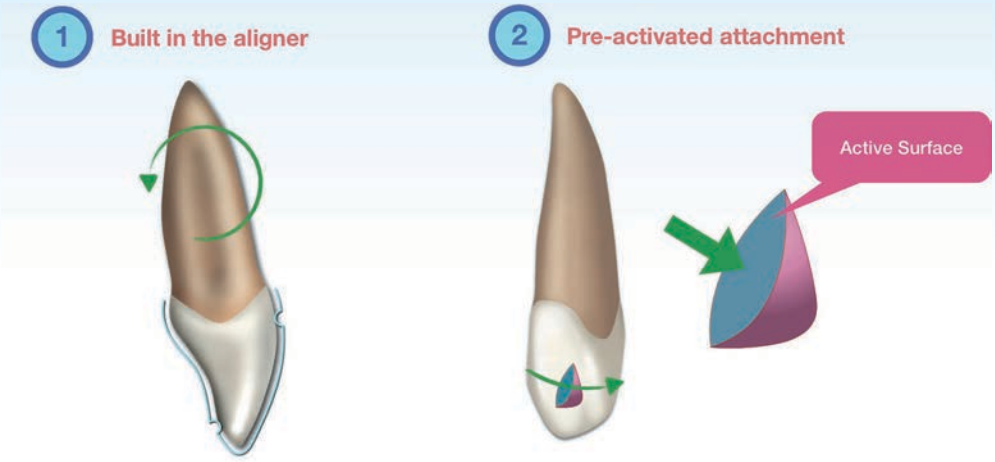


Fig. 10:
SmartForce is effective in two ways: 1. Built into the aligner, such as power ridges designed to control torque. 2. Active surface on an optimized attachment to control tooth movement precisely.

such as a lower third molar, the active surface will face mesially (*Figs. 11, 12*). The force developed to bodily move any tooth must be carefully balanced with an appropriate moment or the tooth will tip. The type of tooth movement depends on the M:F associated with the applied load.

There are many applications for SmartForce, depending on the design of the mechanics. The five basic movements for a tooth are rotation, extrusion, intrusion, torque control of the crown, and root control. If multiple types of movement are desired, there is a hierarchy for applicable attachments that is based on the Invisalign data base. Every optimized attachment comes with a set of rules based on the longterm experience of the manufacturer. Doctors can assess treatment progress, but changing optimized attachments is not an option. However, during a refinement (*reboot*) procedure, optimized attachments can be replaced with conventional ones if desired.[8]

Fig. 11 :
In this stage, retraction ("distalization") of LR8 (#17) is planned. The shape of the #17 attachment on the aligner is a little different from the one on the template. This configuration produces a force that pushes on the attachment of #17.

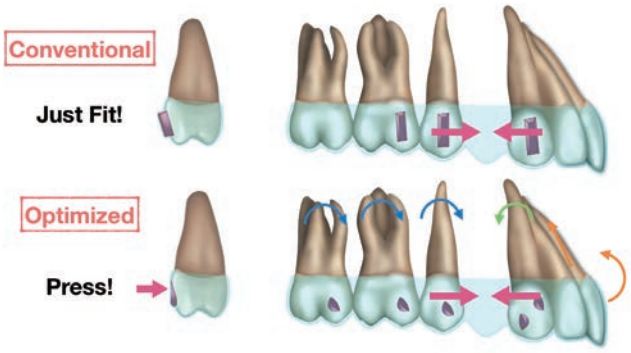


Fig. 12:
The active surface on an optimized attachment produces a couple that is designed as an anti-tip moment during space closure.

SmartStage

In 2015, Invisalign released G6 along with SmartStage to improve aligner performance for first premolar extraction treatment.[9] SmartStage is engineered to optimize tooth movement progression, but it is an abstract concept in mechanics that is challenging for many clinicians. The first application is to modify the shape of an aligner, and the other is to adjust the sequence of tooth movement. Combining SmartForce with SmartStage can enhance the predictability of clinical outcomes. A careful application of the method controls unwanted tipping and anterior extrusion of incisors during retraction.[10]

SmartStage Features

1) Optimaized Aligner Shape

Distal incisor tipping (*anterior torque loss*) and buccal segment mesial tipping (*posterior torque loss*) are common side effects when closing first premolar extraction spaces.[11] With fixed appliances, clinicians can reduce these side effects with archwire adjustments such as a curve of Spee adjustment, gable bends or selecting a full-size rectangular archwire.[12] Clear aligners can simulate these effects if they are designed to change form or modify in shape. These aligner activations work together with optimized attachments to effectively close extraction space. These mechanics require precise engineering to control both the moment to force ratio on each segment, and the equilibrium of the entire force system (*Fig. 13*).

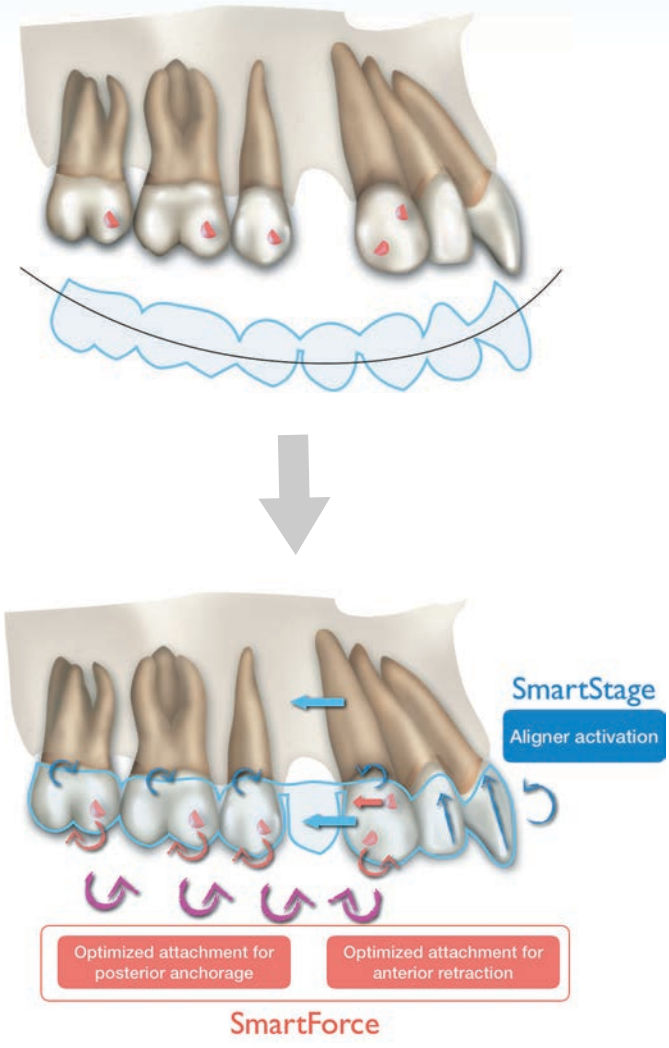
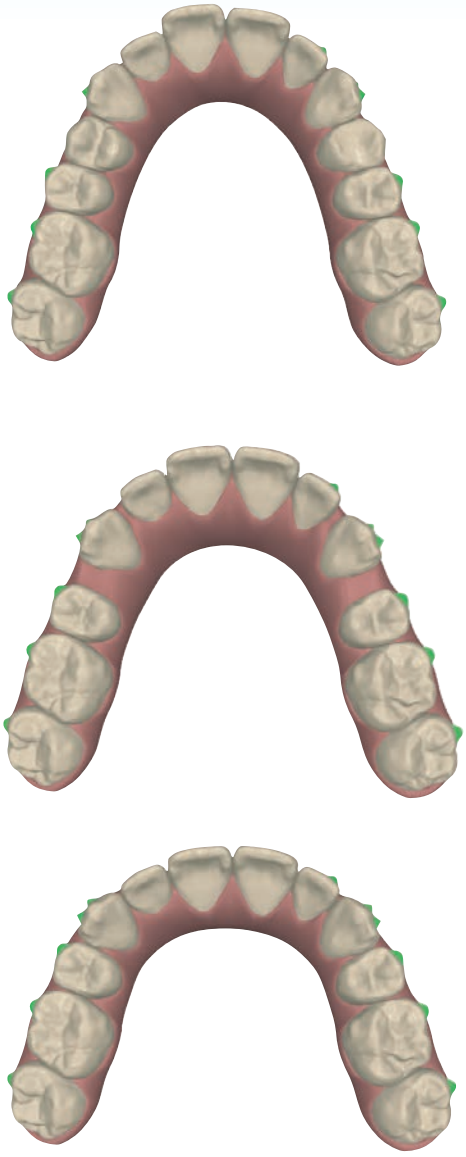


Fig. 13:
Aligner activation (SmartStage) compliments optimized attachments (SmartForce) to eliminate undesirable tipping extrusion during retraction. Magenta curved arrows are tipping moments when closing first premolar space. Red curved arrows are counter moments resulting from the aligner applying active force on optimized attachments. Dark blue curved and straight arrows show the direction of root control in addition to preventing anterior extrusion.

2) Optimized Tooth Movement Sequence

SmartStage technology is designed to optimize aligner shape and tooth movement progress to achieve more predictable clinical outcomes. To preserve posterior anchorage, a two-step anterior retraction method is proposed instead of en-mass space closure;[13] however, this tends to be an unattractive approach because it opens maxillary anterior spaces. Aligners can utilize this approach without an appreciable esthetic deficit because aligner material fills the space during the retraction process. Canines are retracted about 1/3 of the extraction space and then all six anteriors are retracted later, utilizing posterior arch anchorage (*Fig. 14*).[9] SmartStage adapted this modified two-step anterior retraction process, although not all clinicians accept this approach as effective and efficient.[14,15] Mini-screw anchorage for en-mass retraction with aligners is another option.



■ *Fig. 14:*
SmartStage can be programmed to optimize tooth movement sequence. Invisalign G6 is designed to retract canines first for about 1/3 of the predicted space closure movement. The six-anteriors are then retracted. This approach increases treatment time but may help preserve posterior anchorage. See text for details.

Attachments Design

Are attachments necessary to move teeth with aligners?

Aligners can accomplish many types of tooth movement without attachments because loads are applied to the teeth by the surrounding material. Tipping the crowns of teeth and incisor rotation rarely require any attachments. Complex tooth movement and rotation of most teeth is difficult to accomplish without attachments. Attempting to correct major malocclusions without attachments is

likely to be frustrating for both the patient and the clinician. Attachment design is an important aspect of diagnosis and treatment planning.

Tooth movement requiring attachments?

1) Rotation

Premolars have a small contact surface and relatively round shape, so they usually require attachments for rotation (*Fig. 15*).

2) Extrusion

Aligners use other teeth as anchorage to develop extrusive force, but the mechanics are ineffective unless the aligner has a firm attachment to the surface of the crown to be extruded. It is very difficult if not impossible to effectively extrude most teeth without attachments.

3) Translation

Bodily movement (*translation*) requires a relatively high moment to force ratio and substantial anchorage. Aligners are effective for delivering forces, but applying a significant moment to the crown of a tooth requires a couple, which depends on the active surface of an attachment. Optimized or vertical attachments can translate teeth by increasing the moment to force ratio (*M:F*) of the applied load. For pure translation, the M:F must approximate the equivalent force system, meaning the moment must be adequate to simulate a force passing through the center of resistance of the root. An inadequate moment results in tipping of a tooth while an excessive moment produces root movement without changing the relative position of the tooth.

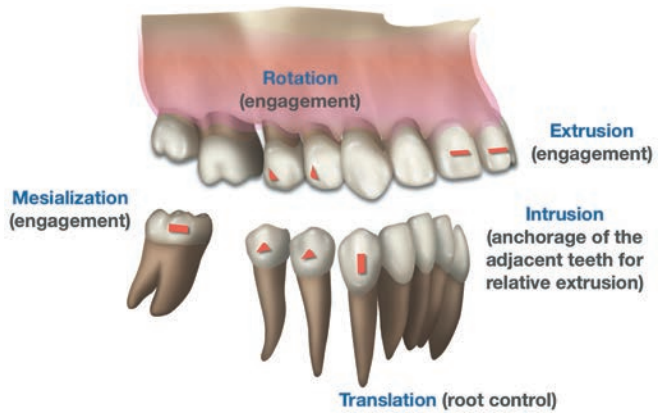


Fig. 15:
Attachments are required for tooth rotation, extrusion, translation, protraction ("mesialization"), and intrusion.

4) Mesial Tooth Movement

Anterior translation of posterior teeth such as a second molar is very difficult because the crown height is limited. Thus attachments are not effective for generating a large moment. With aligners the mesial force on the molar must be relatively low to avoid overcoming the limited moment generated by the attachment to prevent tipping the molar anteriorly. When substantial movement of molars is required, aligners may not be the optimal approach. Fixed appliance are much more effective in achieving substantial mesial translation of molars.[16]

5) Intrusion

When intrusion is prescribed, attachments are unnecessary because the aligner can easily develop intrusive force. However, there may be an undesirable extrusion of anchorage teeth. Like translation of a tooth, intrusion can easily compromise anchorage because it is much easier to extrude a tooth than to intrude it. Attachments are

usually required, for stabilization of anchorage teeth into segments, to resist extrusion.

5 Questions for Attachments Design

Clinicians are often confused by attachments. There are 5 questions to help define and design appropriate auxiliaries.

1. What is the planned direction of tooth movement? Mesial, distal, extrusion or intrusion?
2. What is the function of the attachment? Anchorage or delivering an active load?
3. Which is the active surface of an attachment? This calculation is critical for estimating the amount of force and the couple generated by programmed recoil of the aligner. The M:F, plane of force system, and underlying root structure dictate the path of tooth movement. Like archwires, aligners tie the arch together which is helpful for keeping tooth movement under control as the active surface of attachments move individual teeth.
4. Is it feasible for an active load from an aligner to produce the desired tooth movement? For instance, severely crowded teeth may require extraction, arch expansion and/or enamel stripping to avoid undesirable lip protrusion.
5. Is the active force parallel to the direction of tooth movement? If so, surface attachments are a wise choice.

Deep-bite Attachments

The solutions for a deep-bite are upper incisor intrusion, lower incisor intrusion, or buccal segment extrusion. Attachments are not required for incisors intrusion (*Fig. 16*), but the premolars serving as anchorage, do require them (*Fig. 17*). The attachments can be conventional (*for retention*) or optimized (*for extrusion and retention*).

Molar-Intrusion Attachments

The intruded molars do not need any attachments because the occlusal surfaces are adequate for delivering the axial load. However, the adjacent premolars do need attachments to resist the

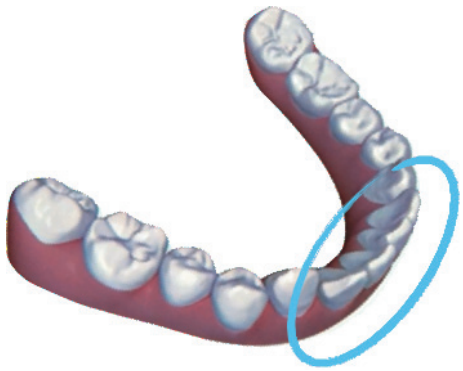


Fig. 16:
The blue circle indicate there is adequate surface area on each tooth for the aligner to apply the intrusive forces.

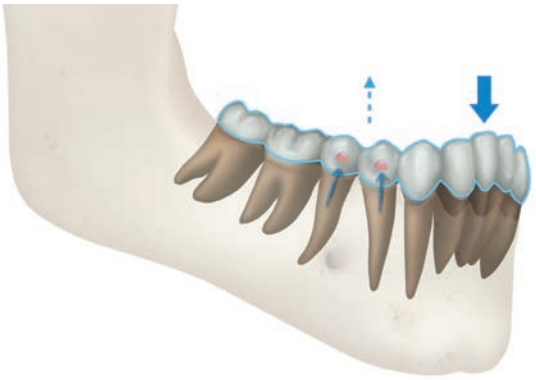


Fig. 17:
Attachments designed for managing deep-bite. The solid broad arrow indicates intrusive force. The dotted arrow is the resulting (counter) extrusive force.

resulting extrusive loads (*Fig. 18*). Again, attachments on the premolars can be conventional for retention, or optimized for extrusion and retention.

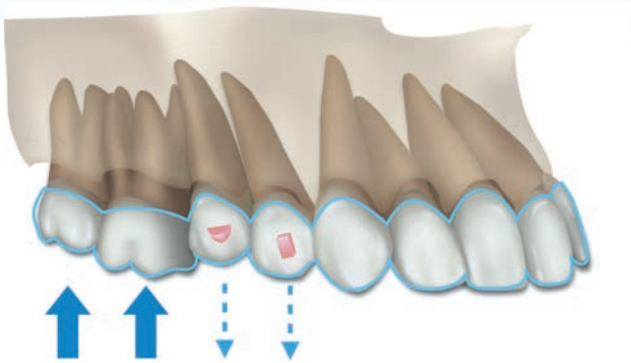


Fig. 18:
Attachments are designed for molar intrusion (solid broad arrows) and dotted arrows show the counter extrusive forces.

3 Key Points for Invisalign G6 Recall-Check

The Invisalign G6 is well designed to support first premolar extraction cases. It combines the three innovations of Smart Technology, to provide more predictable and efficient root alignment. The mechanics depend on carefully monitoring three key points: 1. aligner adaptation (*fit*), 2. attachment positions, and 3. anchorage preparation (*Fig. 19*).

Aligner Adaptation (Fit)

Teeth not fitting well into an aligner is deemed off-tracking, which is the most common problem with Invisalign aligners (*Fig. 20*). The first sign of off-tracking is a gap between the aligner and the incisal edges or cusps of the teeth. This may occur for two reasons. The first is extrusion of anterior teeth was programmed into the aligner, or a canine is moving distally. Initially there will be a small space between the incisal edge or cusp of the tooth and the aligner.

Fig. 19:
These 3 key points allow us to monitor our treatment result effectively at every appointment.

Fig. 20: Teeth are not fitting into the aligner (off-tracking).

This is normal when the aligners are changed, but it should not be allowed to increase as an aligner is worn. For example, the patient (*Fig. 21*) should be advised to bite on aligner "*chewies*" especially in the off-tracked area. The second reason for off tracking may be that aligners are changed too frequently, before the teeth have moved to the planned position for the next stage of treatment. The patient

may be trying to speed up treatment by changing aligners at 7-day intervals or less. The most common correction is for the patient to wear the problem aligner 3-5 days longer to determine if adaptation is self-correcting (*Fig. 22*).

Fig. 21:
Patient was advised to bite on the "chewies" to seat the aligner into an appropriate position for better adaptation.

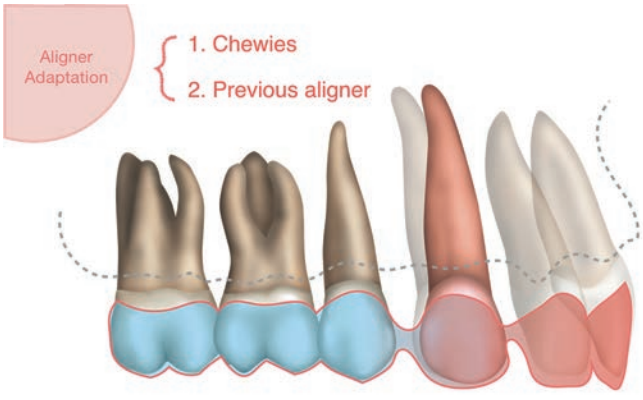


Fig. 22: Aligner adaptation problems and the relative solutions.

Attachment Position

G6 SmartForce features an Optimized Retraction Attachment that is designed to work with SmartStage technology to achieve effective bodily movement during canine retraction. The multi-tooth unit and staging of the G6 system is a complex system that is not adjustable. It is an all or none option (*Figs. 23 and 24*).

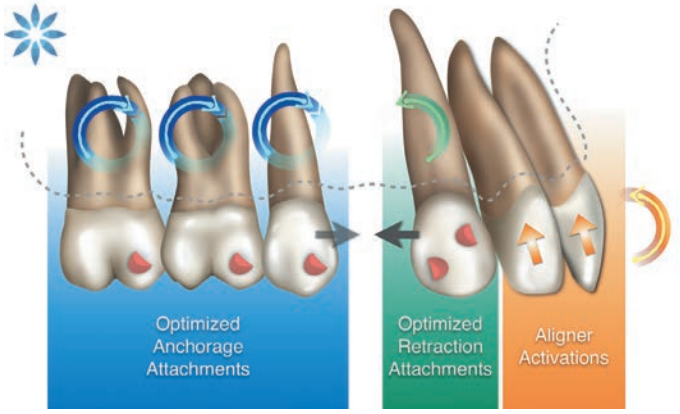


Fig. 23: The G6 features and biomechanics for space closure.

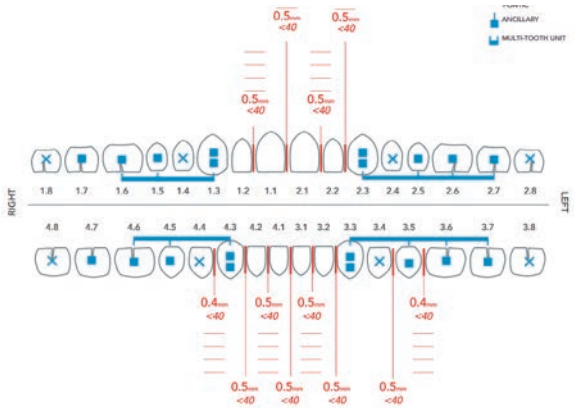


Fig. 24:
In the Invisalign treatment sheet, the blue horizontal bar means the multi-tooth unit that belongs to the same group and should be maintained. The red notation indicates tooth movement desired with aligner treatment.

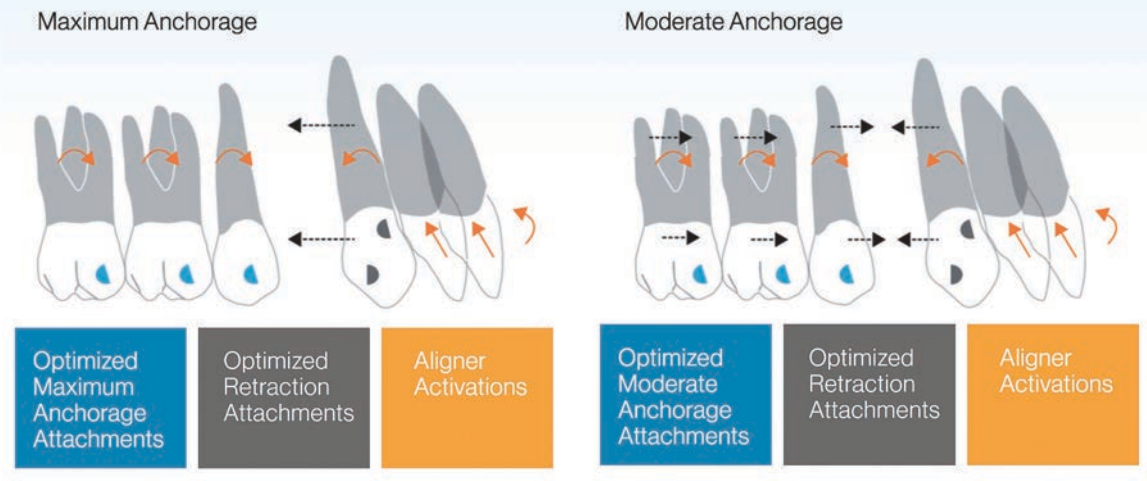


Fig. 25: Illustrations are shown for maximum anchorage and moderate anchorage in the G6 system.

The doctor's responsibility is to carefully check every attachment at each appointment. Any missing attachment must be replaced quickly with the template supplied. A full compliment of attachments is critical for space closure mechanics, so the patient is also asked to check the tooth surfaces with a finger every time they take out the aligner. If an attachment is lost, an appointment with the doctor is required within 7 days to repair the problem.

Anchorage Preparation

The G6 system can be programmed with SmartStage technology to provide maximum anchorage. Molar stability is programmed to hold the A-P position for achieving maximum retraction of the anterior segment. Moderate posterior anchorage permits <5mm of molar mesial movement (*Fig. 25*). These anchorage options are programmed with the ClinCheck system and must be carefully examined by the doctor prior to approval. In order to accomplish an ideal result, anchorage preparation can be supplemented with Class II elastics or temporary anchorage devices (*TADs*) (*Fig. 26*).

Integrating Aligners and Fixed Appliances

Achieving precise tooth movement to resolve malocclusion is the primary goal for orthodontics. Aligner therapy is popular with patients, who do not want to wear braces, but success with these removable appliance is dependent on both the

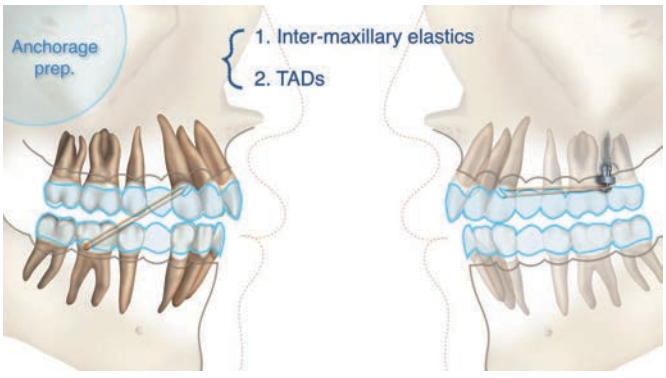


Fig. 26:
The intermaxillary elastics and TADs can be used as anchorage for a better treatment outcome.

doctor and patient following instructions precisely. The principles for applied mechanics and anchorage are the same for all tooth movement, but the clinical course for each approach is distinct. Both archwires and aligners are indeterminate mechanics[17] so periodontal ligament stress throughout the arch is unknown so the precise response to applied loads are variable. The same risks apply to aligners and archwires: uncertain course of tooth movement, relatively long treatment times, and root resorption.

The Insignia™ technology for fixed appliance treatment was the first patent in orthodontics for computer-aided design (*CAD*) and computer-aided manufacturing (*CAM*). However, Align Technology (*Invisalign®*) was the first company to actually market CAD/CAM appliances to move teeth. Invisalign has a long history of aligner innovations and clinical monitoring to improve outcomes. A trial and error approach is appropriate for indeterminate mechanics because the path and course for tooth movement cannot be calculated. Most teeth do not move precisely along the direction of the force, so considerable R&D is required to define how teeth will move in response to a given force system. The Invisalign team have monitored many outcomes to define the treatment scenarios available to manage complex malocclusions. Consequently, aligner therapy is less intuitive than fixed mechanics for both the doctor and patient. The advice of Invisalign technicians is based on algorithms developed with a massive data base which is the actual science of the mechanics. One can view the process for sophisticated aligner treatment as a form of artificial intelligence (*AI*), a type of technology based on massive data bases that is increasingly prevalent in dentistry. Utilizing vast resources, Invisalign has developed 3 innovative technologies to expand the scope of aligner therapy and make patients more comfortable during treatment.

At the initial consult, patients should be encouraged to share their chief complaint(*s*) so the doctor can properly diagnose the malocclusion, relative to the patient's needs, and decide on a general treatment plan. If a fixed appliance is selected, the mechanics are described in a straight-forward manner. On the other hand, an Invisalign consolation should focus on desirable outcomes and the necessity to follow instructions precisely. The actual mechanics are determined by technicians, utilizing automated routines and attachments based on industrial experience. The process is not intuitive so the doctor and the patient are not going to "*understand*" it, but must accept the necessity to adhere to the instructions provided, to achieve a predictable clinical outcome. Some problems, mechanics, and patients may be better suited to another CAD/CAM appliance, e.g. the Insignia™ system.

Aligner material is based on sophisticated polymer science and progressive mechanics are a stepwise iterative approach for applying loads directly to teeth and/or via attachments. The greatest advantage for aligners is esthetics during treatment, but space management and protrusion can be a problem so enamel stripping and/or extractions are often required. Fixed mechanics are based largely

on metals technology with an increasing emphasis on long range superelastic loads. The latter has substantial potential for controlling indeterminate mechanics to decrease treatment time for a precise correction of malocclusion. In addition, most severe skeletal problems can be conservatively managed with determinate mechanics, that is anchored with extra-alveolar bone screw anchorage.[17] It is clear that both CAD/CAM technologies (*Invisalign and Insignia*) are in the realm of a well-trained orthodontist.

In addition personalized treatment is rapidly advancing, based on specific genetic and environmental factors presented by the patient.[18] Orthodontist of the future must evaluate the patient carefully to prescribe an appropriate therapy. The preference of the patient will usually be the determining factor, because both CAD/CAM approaches (*aligners and fixed appliances*) offer excellent outcomes. The choice for the patient is esthetic treatment with aligners, but the treatment time will be substantial, and enamel stripping and/or extractions are often required. The emerging alternative with Insignia-SmartArch™ is relatively rapid, non-extraction treatment with braces. From the patient's perspective, the outcomes will be similar. The treatment will largely depend on patient preference: braces or not. A general dentist may only be comfortable with aligners, but a specialist should offer both options.

Conclusion

For clinicians transitioning from a "*brackets and wires*" practice to offering clear aligners, there is uncertainty relative to planning treatment and monitoring progress. The doctor must understand that Invisalign® is a very sophisticated therapeutic system that is not intuitive, so the aligners must be applied as prescribed. If progress is disappointing, it may be necessary to refine (*reboot*) the treatment process to achieve the desired outcome. Standard attachments can be changed at that time because a new series of aligners will be made. However, it is important for the clinician to refrain from changing mechanics while a series of aligners is being worn. The "*see it and fix it*" mentality that is common with fixed appliances is inappropriate for complex aligner treatment. Clinicians should practice and master the 3 check points as described in this article. The only periodic adjustments by the doctor are to replace attachments, increase the time an aligner is worn, or to insure that the teeth are well seated in the aligner with "*chewie*" exercises. The doctor and the patient must precisely follow instructions to benefit from the efficiency and precision of the prescribed treatment.

Acknowledgement

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本次報告主要是針對各種不同類型咬合合併有前齒擁擠及/或門齒前突的患者，提出個人的想法和治療方式，各個療程也將詳細說明。除提供初學者簡單合理且有效的方法外，並期待矯正老手恢復早期原有的治療思維。

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講座報名資訊

主辦單位	台大矯正同門會、中華民國齒顎矯正學會、台大矯正科
協辦單位	社團法人中華民國兒童牙科醫學會、湧傑企業股份有限公司
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Clinical Tip for Simultaneously Uprighting and Rotating Lower Molars

When a lower first molar is missing, the second molar usually tips into the space and may incline lingually. If the treatment plan is to move the right second and third molars mesially to close a missing first molar space, a rotation of the third molar complicates bonding procedures and mechanics application. This article describes an effective method for simultaneously uprighting and rotating molars utilizing a bonded button and the elastic properties of a resilient archwire.

A patient presented with mesiolingual inclination of the lower right second molar (*LR7*) and a 90˚ distal-in (*clockwise*) rotation of a lower right third molar (*LR8*) (*Fig. 1*). The treatment plan was to level, align, and close space via mesial movement of both molars. The malocclusion was complicated by a 4mm marginal ridge discrepancy with the LR8 locked under the distal height of curvature of the LR7. A clinical tip for uprighting the LR7 is to position the bracket mesial down (*clockwise*) rotation (*Fig. 2*), and bond a button on the buccal aspect of the LR8. An archwire through both molar tubes passes over the occlusal surface of the LR8, because it is intruded relative to the LR7 (*Fig. 3*). The preferred position for the archwire is gingival to a button on the buccal aspect of LR8, which is designed to apply uprighting loads (*root forward moments*) on both molars (*Fig. 4*). A power chain is attached to the hook on the LR8, passing gingival to the button, and extending to the hook on the LR5. These mechanics simultaneously rotate the LR8 and upright both molars.

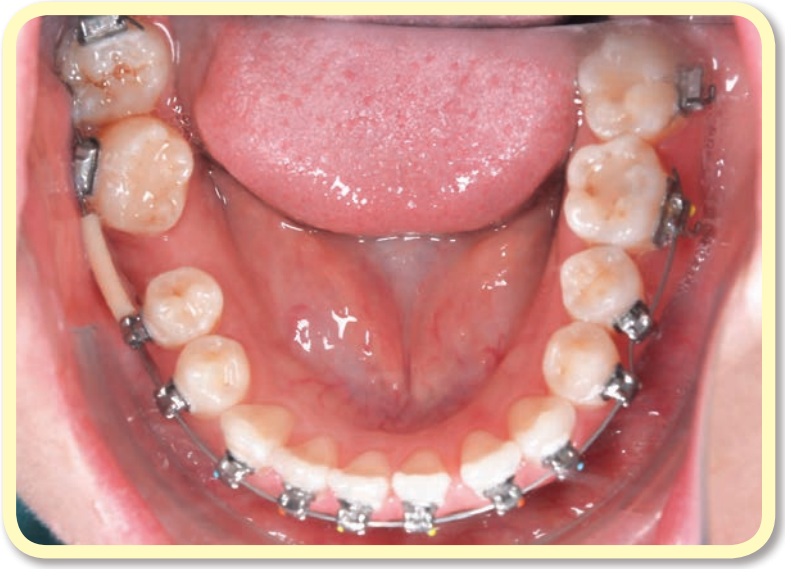

Fig. 1:
The patient has a mesially tilted LR7 that is tipped into the missing LR6 site. A distally rotated LR8 complicates the mechanics for alignment and mesial movement of both molars.

Dr. Linda Tseng,
Lecturer, Beethoven Orthodontic Course (Left)

Dr. Chris H. Chang,
Founder, Beethoven Orthodontic Center
Publisher, Journal of Digital Orthodontics (Center)

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

This case demonstrates the importance of carefully analyzing archwire placement. The application of a strategic button to retain the resilient archwire on the buccal aspect (*mesial surface*) of the rotated third molar results in consistent mechanics to efficiently address the multiple objectives required to resolve the complex malocclusion described.

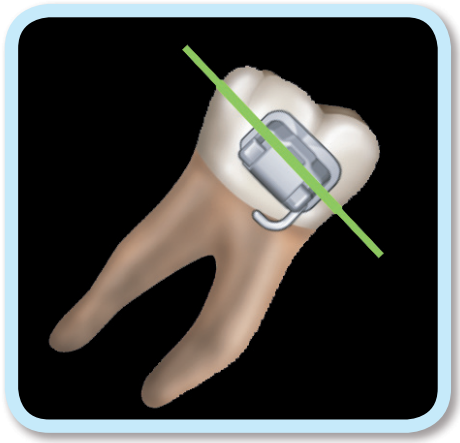

Fig. 2:
A tip for uprighting a mesially inclined molar is to bond the bracket in a more clockwise orientation.

Fig. 4:
A button is bonded on the mesial surface of the rotated LR8 to redirect the archwire to simultaneously rotate the LR8 and upright both molars. See text for details.

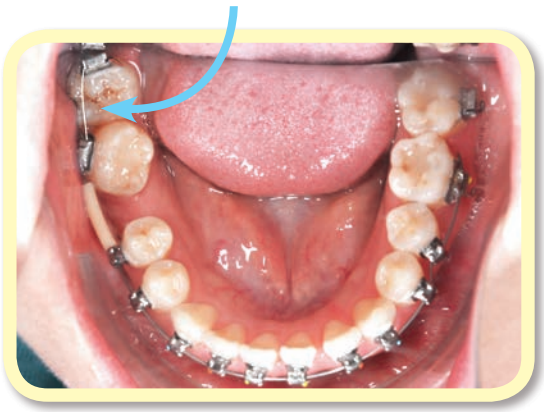

Fig. 3:
A resilient wire through both right molar tubes passes over the occlusal surface of the LR8, which is ineffective mechanics for uprighting either molar. See text for details.

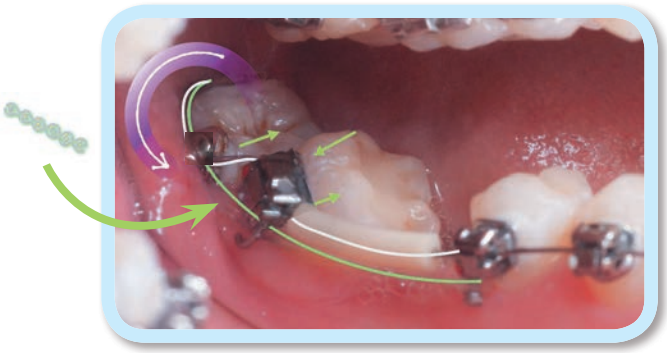

Fig. 5:
The deflected arch wire generates a distal out rotation on the LR8, and a root mesial moments on both molars. A power chain is attached from the third molar, passing under the button, and extending to the the second premolar assists the rotation of the LR8. See text for details.

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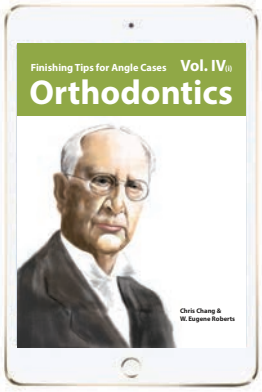

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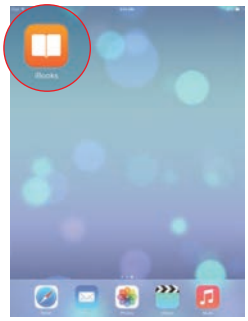

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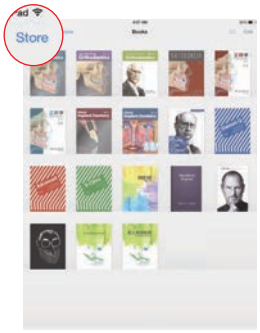

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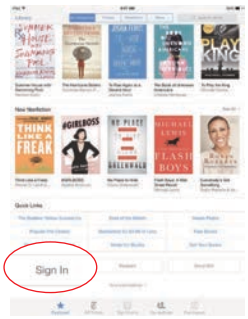

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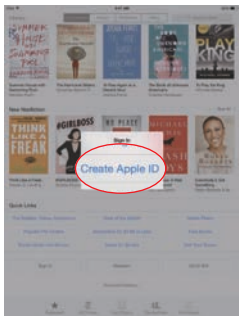

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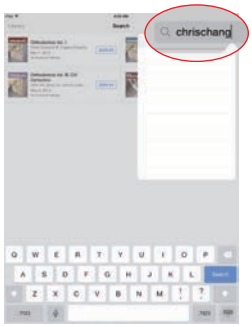

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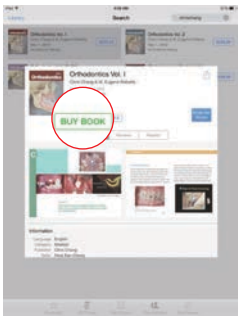

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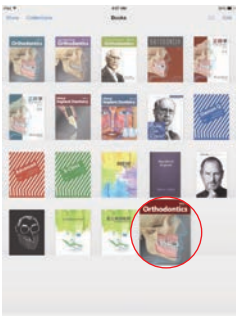

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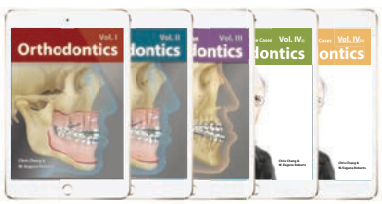

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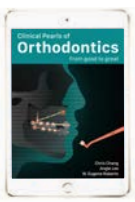

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