Conservative Management of Skeletal Class II Malocclusion with Gummy Smile, Deep Bite, and a Palatally Impacted Maxillary Canine

Abstract

***Introduction**: A 21-year-old female presented with chief complaints of crooked teeth, canine impaction, deepbite, and "gummy smile" (excessive maxillary gingival exposure when smiling).*

***Diagnosis**: Increased facial convexity (15.5°), increased lower facial height (56%), and incompetent protrusive lips (E-line to UL 2mm, E-line to LL 2mm) were associated with a severe Class II malocclusion (nearly a full cusp bilaterally). There was 7.5mm of overjet, 100% anterior deepbite, and a left posterior buccal crossbite. Cephalometrics revealed a skeletal discrepancy due to a protrusive maxilla and a retrusive mandible (SNA 85°, SNB 78°, ANB 7°). Cone-beam computer tomography (CBCT) imaging revealed a palatally impacted right maxillary canine (UR3) in close proximity to the adjacent lateral incisor (UR2).*

***Treatment**: The retained right primary canine (URc) was extracted. A simplified open window technique was utilized to surgically expose its impacted successor. A maxillary anterior miniscrew provided anchorage to align the UR3 in its correct anatomical position. Non-extraction treatment with a passive self-ligating fixed appliance was indicated to align and level both arches. Anchorage provided by infrazygomatic crest (IZC) bone screws and maxillary anterior miniscrews was used for correction of Class II malocclusion and gummy smile. To achieve more esthetic crown lengths in the maxillary anterior segment, gingivectomy was performed with a diode laser 2 months after fixed appliances were removed.*

***Outcomes**: This challenging skeletal Class II malocclusion with a Discrepancy Index (DI) of 38, was treated in 32 months to excellent outcomes: Cast-Radiograph Evaluation (CRE) score of 25, and an Pink & White dental esthetic score of 2. All facial and dental corrections were stable at the six month follow-up evaluation. (Int J Orthod Implantol 2017;48:24-46)*

***Key words**:*
Gummy smile, deepbite, Class II malocclusion, palatal canine impaction, self-ligating brackets, bite-turbos, temporary anchorage devices, arch retraction, laser gingivectomy, infrazygomatic crest, extra-alveolar, bone screws

History and Etiology

A 21-year-old female patient presented for orthodontic consultation (*Fig. 1*). Her chief complaints were crooked teeth, canine impaction, deep bite, and gummy smile. Facial evaluation showed a convex profile, protrusive lips, increased lower facial height (*LFH*), hyperactive mentalis muscle (*"golf ball chin" on lip closure*), and a retrusive mandible (*Fig. 1*). A full smile revealed an asymmetric, excessive gingival display (*"gummy smile"*) (*Fig. 2*). The casts showed a full-cusp Class II malocclusion of the right first molars and almost a full cusp Class II on the left (*Fig. 3*). Overall the buccal segments were severe Class II (*6mm*) bilaterally. Intra-oral

Ms. Ariel Wong,
Class of 2018 DDS Candidate, Indiana University School of Dentistry (Left)
Dr. Chris Chang,
Founder, Beethoven Orthodontic Center
Publisher, International Journal of Orthodontics & Implantology (Center)
Dr. W. Eugene Roberts,
Editor-in-chief, International Journal of Orthodontics & Implantology (Right)

examination revealed a retained right maxillary deciduous canine (*URc*), ~4mm of interdental spaces in the maxillary anterior segment, buccal crossbite of the left premolars (*Fig. 3*), deepbite, and 7.5mm of overjet (*Fig. 4*). The upper dental midline was coincident with the facial midline, but the lower dental midline was shifted 1mm to the right of the other two midlines.

Fig. 1: Pre-treatment facial and intraoral photographs

Fig. 2:
Gummy smile, asymmetrical gingival display, and occlusal canting are documented in a frontal photograph.

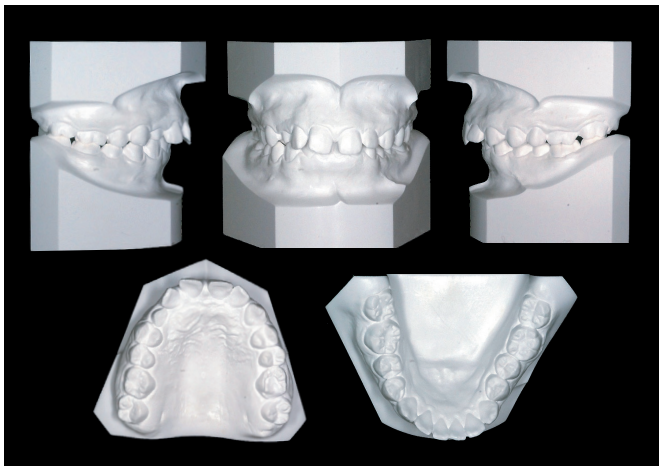


Fig. 3: Pre-treatment dental models (casts)

Fig. 4:
Inferior (left) and lateral (right) intraoral views show Impinging (100%) anterior deepbite and large overjet (7.5mm).

Radiographic documentions are lateral cephalometric (*Fig. 5*) and panoramic radiographs (*Fig. 6*). Both panoramic (*Fig. 6*) and CBCT imaging (*Fig. 7*) revealed a palatally impacted right permanent canine (*UR3*) and three developing third molars (*UL8, LL8 and LR8*); the UR8 was missing. There was no additional contributing medical or dental history. Cephalometric measurements are presented in Table 1 and diagnostic details are outlined below.

Diagnosis

Skeletal:

- Class II relationship due to maxillary protrusion and relative mandibular retrusion (*SNA 85º, SNB 78º, ANB 7º*)
- High mandibular plane angle (*SN-MP 39º, FMA 32º*)

Fig. 5: Pre-treatment lateral cephalometric radiograph

Fig. 6: Pre-treatment panoramic radiograph shows both condylar heads outlined in yellow.

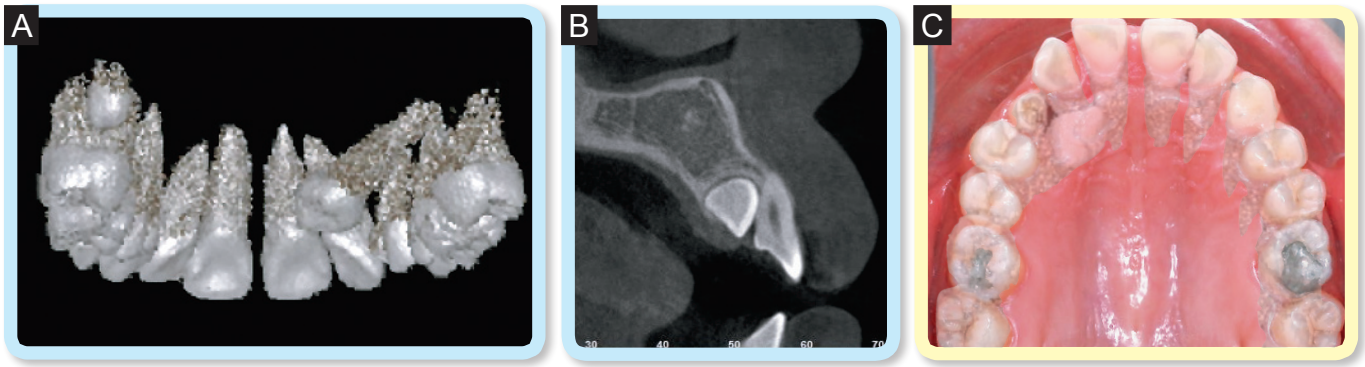


Fig. 7:

A. 3D image of the maxillary dentition documents the relative position of the impacted canine.

B. A sagittal cut through the UR2 region of a CBCT image shows a cross-section through the cervical region of the impacted UR3.

C. A CBCT image of the maxillary arch is superimposed on an occlusal intraoral photograph to reveal the position of the impacted canine.

Dental:

- Class II molar relationships: *near full cusp bilaterally (6mm)*
- Overjet of 7.5mm
- 100% impinging deepbite
- Retrusive upper incisors (*U1 to NA 1mm*) with decreased axial inclination (*U1 to SN 96º*)
- Increased axial inclination the lower incisors (*L1 to MP 102º*)

Facial:

- Convex profile (*15.5º*)
- Protrusive lips (*2mm/2mm to the E-line*)
- Hyperactive mentalis with the lips closed

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	85°	84°	1°
SNB° (80°)	78°	77°	1°
ANB° (2°)	7°	7°	0°
SN-MP° (32°)	39°	41°	2°
FMA° (25°)	32°	34°	2°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	1 mm	4 mm	3 mm
U1 TO SN° (104°)	96°	90°	6°
L1 To NB mm (4 mm)	6 mm	6 mm	0 mm
L1 TO MP° (90°)	102°	97°	5°
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	2 mm	2 mm	0 mm
E-LINE LL (0 mm)	2 mm	1 mm	1 mm
%FH: Na-ANS-Gn (53%)	56%	57%	1%
Convexity: G-Sn-Pg' (13°)	15.5°	15.5°	0°

■ Table 1: Cephalometric summary

The American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*)[1] was 38 points as shown in the subsequent worksheet at the end of this report.

Treatment Objectives

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

- A - P: *Maintain*
- Vertical: *Maintain*
- Transverse: *Maintain*

Maxillary dentition

- A - P: *Retract the maxillary anterior segment*
- Vertical: *Intrude the maxillary anterior segment*
- Inter-molar / Inter-canine Width: *Expand to properly occlude with the lower dentition*

Mandibular dentition

- A - P: *Maintain*
- Vertical: *Maintain*
- Inter-molar / Inter-canine Width: *Upright molars to increase inter-molar width*

Facial Esthetics: Retract protrusive upper and lower lips

Treatment Alternatives

First Option: Extract three teeth (*retained URc, impacted UR3, and UL4*). Move the UR4 into the UR3 position. Disadvantages for this treatment option include compromised dental esthetics and ipsilateral loss of canine guidance.

Second Option: Extract two teeth (*retained URc and impacted UR3*), followed by prosthetic restoration with a fixed partial denture or an implant-supported prosthesis. The disadvantages for this approach include cost, loss of tooth structure for conventional prosthesis, implant failure if bone fixtures are used, and a potential compromise in both esthetics and function with either prosthetic option.

Third Option: Extract the retained URc and align the dentition with a fixed passive self-ligating (*PSL*) appliance. Expose the impacted UR3 with an open-window technique, allow it to erupt spontaneously,[2]

and align the entire arch orthodontically. Place maxillary anterior miniscrews to intrude the upper incisors for correction of the deep bite. Install maxillary posterior bone screws bilaterally in the infrazygomatic crests (*IZC*) to provide anchorage for retraction of the entire maxillary dentition. The perceived disadvantages for this option include increased treatment time and potential root resorption of UR2. After weighing the pros and cons, the patient preferred the least invasive, most conservative approach (*Option 3*) despite the treatment risks. Upon completion of active treatment, a gingivectomy is indicated on the labial surface of the maxillary anterior segment. Assuming there is adequate biologic width of the gingival attachment, as defined later in this report, a gingivectomy with a diode laser is indicated to increase the crown length of the dentition in the maxillary anterior segment (*the esthetic zone*).

Treatment Progress

Following extraction of the URc, a full fixed appliance with 0.022-in slot Damon Q® PSL brackets (*Ormco, Glendora, CA*) was installed on the maxillary arch. The upper archwire sequence was: 0.014-in CuNiTi, 0.018-in CuNiTi, 0.014x0.025-in CuNiTi, 0.017x0.025-in TMA, and 0.016x0.025-in SS.

In the 2nd month of treatment, surgical exposure of the impacted UR3 was completed using a simplified open window technique (*Fig. 8*). CBCT imaging was

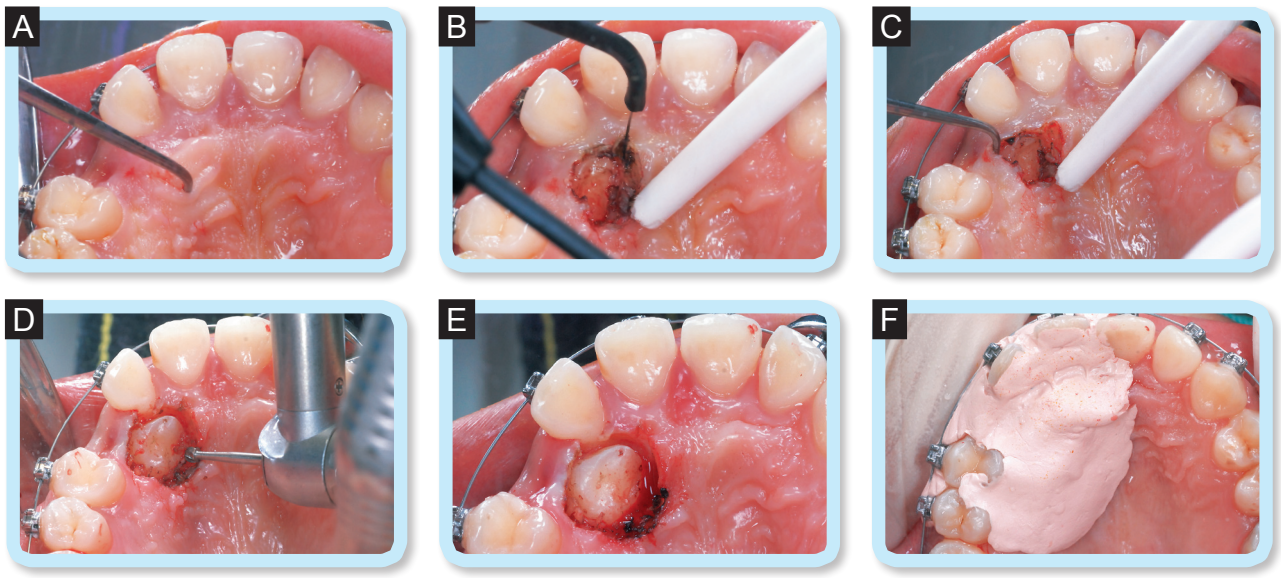


Fig. 8:

A. The simplified open-window technique begins with precise location of the crown of the impaction by sounding through the soft tissue to detect enamel.

B. The palatal soft tissue covering the crown is removed with electrosurgery.

C. An explorer is used to penetrate the overlying cervical bone to estimate the location of the CEJ.

D. Bone covering the crown is carefully removed with a round bur in a high speed hand piece down to the level of the CEJ.

E. Canine crown is exposed without severing the greater palatine artery or damaging the tooth.

F. COE-PAK® periodontal dressing is placed for patient comfort and to prevent soft tissue from recovering the exposed crown.

required for precise localization of the impaction relative to adjacent teeth (*Fig. 7*). Local anesthesia was administered at the surgical site and the location of the crown was marked with a sharp surgical explorer (*Fig. 8*). A dental electrosurgical unit was used to remove the soft tissue covering the crown of the UR3, while carefully avoiding the greater palatine artery. Uncovering a palatally impacted UR3 in the maxillary anterior area has the potential for severe bleeding if the adjacent artery is severed. The use of an electrosurgical unit for the uncovering procedure provides the surgeon with the means to rapidly coagulate the bleeding artery if it is accidentally severed.

An explorer was used to determine the position of the UR3 crown. Since spontaneous tooth eruption is facilitated by removing bone apical to the height of contour of the crown,[2] a high speed handpiece with a carbide round bur and irrigation was used to remove the overlying bone down to the level of the CEJ. To insure patient comfort and control hyperplastic soft tissue, COE-PAK®periodontal dressing was placed over the wound.

In the third month, an open coil spring was installed to create space for the impacted canine (*Fig. 9*). Approximately two months after the surgical procedure, a button was bonded on the UR3. At the same appointment, a 2x12mm bone screw (*OrthoBoneScrew®, Newton's A Ltd, Hsinchu City, Taiwan*) was inserted on the labial aspect of the alveolar ridge position. The latter anchored an elastic power chain that was attached to the button bonded on the UR3 to apply traction for guiding the canine laterally (*Fig. 10*). Additional 2x12mm bone screws were placed in each IZC for bilateral extra-alveolar (*E-A*) anchorage (*Fig. 10*). Furthermore, glass ionomer bite turbos (*GIBTs*) were bonded on the lower first molars to open the bite for correction of the left posterior crossbite tendency (*Fig. 11*).

Eleven months into treatment the miniscrew providing anchorage for labial movement of the UR3 was removed, and one month later (*12 mo into treatment*) brackets were bonded to the UR3 and the entire lower dentition (*Fig. 11*). The lower archwire sequence for was 0.014-in CuNiTi, 0.014x0.025-in CuNiTi, 0.017x0.025-in TMA, and 0.016x0.025-in SS.

■ *Fig. 9:*
In the third month (3M) of treatment, an open coil spring was placed between the right maxillary lateral incisor and first premolar to create space to align the impacted canine.

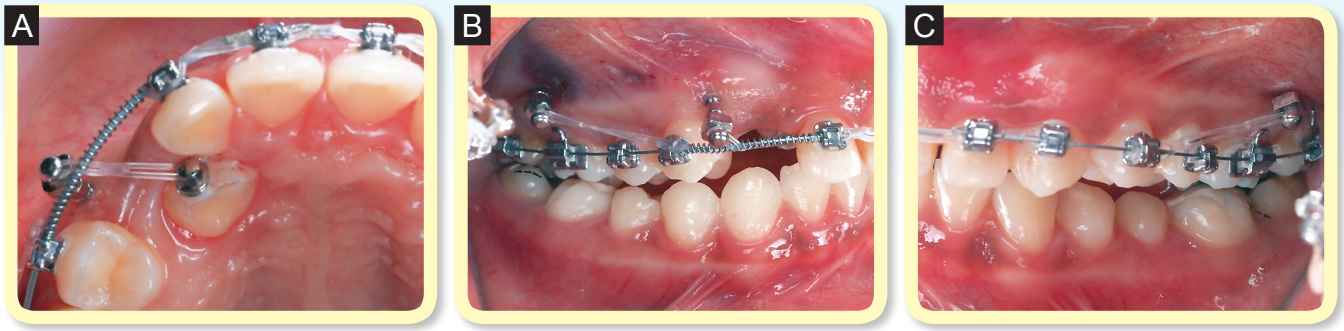


Fig. 10:

A. In the fourth month, a miniscrew is placed between the 1st premolar and canine position and loaded with 150gm-force (cN) of traction to move the impacted canine into its correct anatomical position.

B. A right lateral intraoral radiograph shows the mechanism for retraction of the right buccal segment as the palatally displaced canine is moved into the arch.

C. A left lateral view reveals symmetric mechanics to retract the left buccal segments with 280gm-force (cN) per side.

Fig. 11:

In the 12th month of treatment brackets are bonded to the maxillary right canine (left) and also on the entire lower arch (center). BTs are noted on the occlusal surfaces of the mandibular first molars (right).

In the 16th month, two anterior bite turbos (*BTs*) were bonded on the maxillary central incisors to aid in correction of the 100% deepbite. Class II elastics (*Fox 1/4-in, 3.5-oz*) were applied bilaterally to correct the Class II molar and canine relationships.

In the 17th month, two 1.5x8mm miniscrews (*Newton's A Ltd, Hsinchu City, Taiwan*) were placed between the roots of the upper central and lateral incisors for anchorage to prevent extrusion of the maxillary anterior segment when Class II elastics were applied (*Fig. 12*). In the 26th month, the anterior miniscrews were removed. In the 30th month, interproximal reduction (*IPR*) was performed to address the black triangles noted between the maxillary anterior teeth.

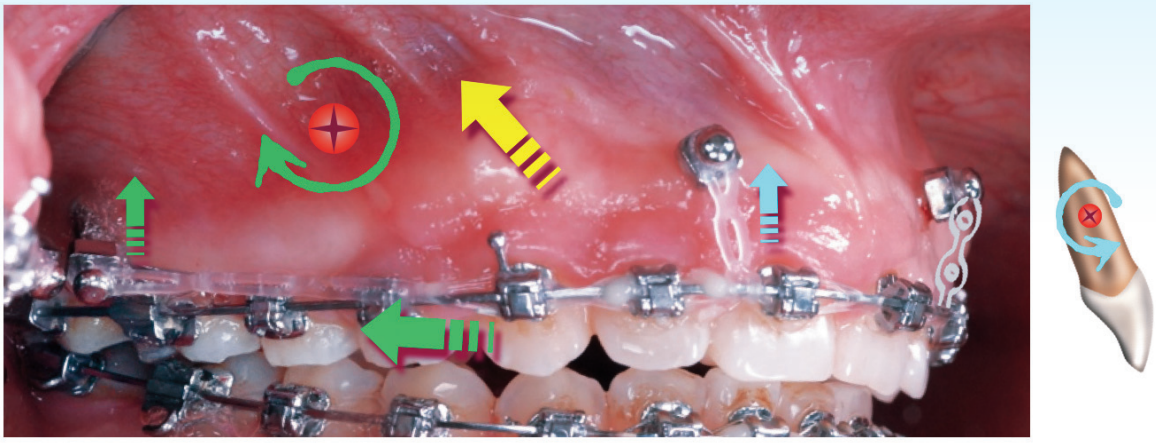


Fig. 12:
Based on a presumed center of resistance (C_R) for the maxillary arch (red circle with a cross), the chain of elastics from the IZC bone screw to the cuspid bracket has distal and vertical components (straight green arrows) that produce a clockwise moment around the C_R. The maxillary anterior miniscrew anchors an intrusive force (blue arrow) that creates a counterclockwise moment (blue curved arrow) tending to flare the maxillary incisors. The presumed resultant for all the applied loads is the yellow arrow.

Fig. 13:
A. Pre-operative photograph shows the irregular gingival margins and clinical crown lengths in the maxillary anterior esthetic zone. There is also a low attachment of the maxillary midline frenum.
B. Image taken immediately after diode laser gingivectomy and frenectomy which was performed 2 months into active treatment.
C. Follow-up one month later shows esthetically pleasing tooth proportions and gingival contours, as well as an apical migration of the revised frenum attachment.

After 32 months of active treatment, all fixed appliances were removed. Upper 2-2 fixed retainers and upper and lower clear removable retainers were delivered. The patient was instructed to wear the retainers full time for the first 6 months and nights only thereafter. Home care and retainer maintenance instructions were provided. Two months into retention a diode laser was used for a maxillary midline labial frenectomy, as well as for esthetic crown lengthening of the teeth in the maxillary anterior segment (*Fig. 13*).

Fig. 14: Post-treatment facial and intraoral photographs

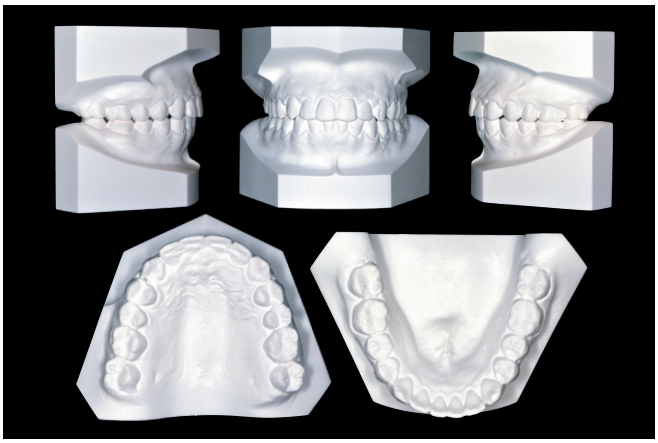


Fig. 15: Post-treatment dental models (casts)

Fig. 16: Post-treatment panoramic radiograph

Treatment Results

Optimal results were obtained through interdisciplinary treatment with surgical exposure of the UR3 and the use of a passive self ligating bracket system for alignment (*Fig. 14*). The ABO Cast-Radiograph Evaluation (*CRE*)[3] score was 25, which documents an excellent result for a severe malocclusion with a DI of 38 points. The major residual discrepancies scored for the CRE included marginal ridges (*4 points*), buccolingual inclinations (*7 points*), and occlusal relationships (*10 points*). Comparison of the before (*Figs. 1-7*) and after (*Figs. 14-18*) treatment records revealed a dramatic improvement in facial form and dental alignment. Post-treatment radiographic results are documented in the cephalometric and panoramic radiographs

Fig. 17: Post-treatment lateral cephalometric radiograph

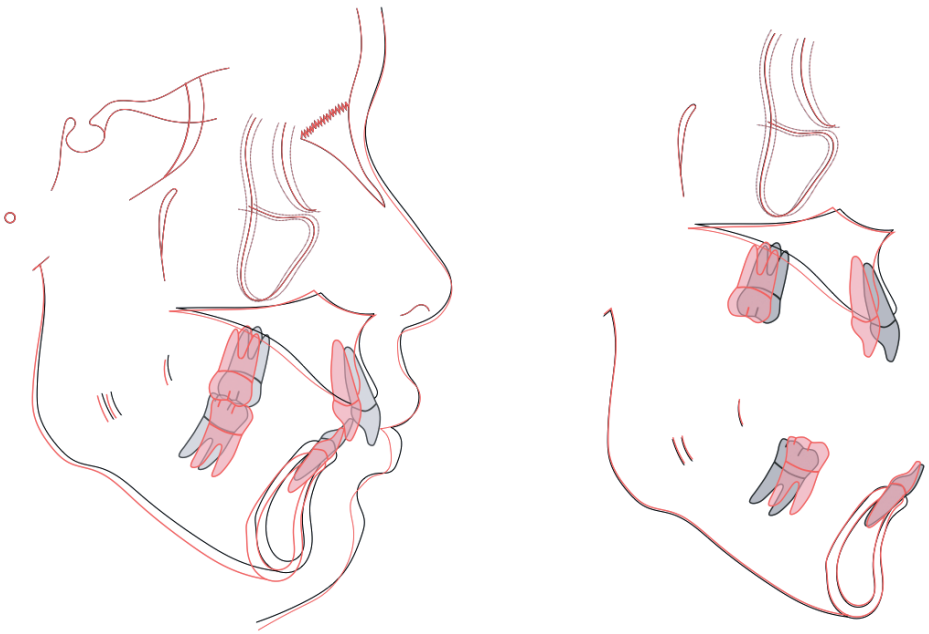


Fig. 18:
Superimposed cephalometric tracings showing dentofacial changes resulting from 32 months of active treatment (red) compared to the pre-treatment (black). Note that the maxilla and particularly the maxillary incisors did not move as expected in the presumed loading diagram (Fig.12). See text for details.

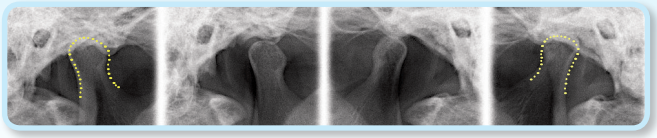


Fig. 19:
Post-treatment TMJ radiographs show that mandibular contours and articular relationships are within normal limits for both on the right and left sides. The open and closed positions for the right TMJ are shown in the two images on the left side, and the same relationships for the left TMJ are shown on the right side of the illustration.

(*Figs. 16 and 17*). Dentoalveolar changes are shown in the superimposition of cephalometric tracings before and after treatment (*Fig. 18*). Post-treatment TMJ radiographs in the opened and closed positions show symmetrical and well-positioned condylar heads of the mandible (*Fig. 19*). Lip strain was improved dramatically, but the soft tissue profile of the upper lip did not follow the hard tissue in a 1:1 manner as the maxilla was retracted, so the patient's protrusive lip profile was not completely corrected. Overall, the post-treatment photographs show optimal correction of the palatally impacted canine, deep bite, posterior buccal crossbite, gummy smile, and lip strain. The patient was well satisfied with the result.

Discussion

Palatally impacted maxillary canines

After third molars, maxillary canines are the second most commonly impacted teeth, affecting approximately 2% of the population.[4] Two-thirds of maxillary canine impactions are palatal, and the remaining third are transalveolar or labial to the roots of the adjacent teeth.[5,6] The etiology for the location of palatally impacted maxillary canines is unknown,[7] but both guidance and genetic theories have been proposed.[8,9] The guidance theory holds that the lateral incisor root serves as a guide for canine eruption, so a missing lateral incisor or deformed root interferes with the normal path of eruption. The genetic theory proposes an inherent predisposition to palatally impacted maxillary canines.[10] There are multiple sequelae associated with canine impactions including: 1. migration of adjacent teeth, 2. internal or external root resorption of the impaction and/or adjacent teeth, 3. cyst formation, 4. infection, and 5. referred pain.[11]

The maxillary canines are important keystones for optimal dental esthetics and function,[12] so their proper eruption and alignment is a high priority. Proper diagnosis is critical for efficient surgical and orthodontic management of eruption anomalies. Cone Beam Computed Tomography (*CBCT*) is a precise method for three dimensional (*3D*) localization of an unerupted canine.[13] Without 3D imaging, it is difficult to plan an efficient and relatively atraumatic uncovering of an impaction. CBCT imaging is also useful for planning the orthodontic mechanics to recover the canine and align it in the arch.

There are two methods for managing palatal impactions: preventative and surgical.[5,14] Prevention with interceptive treatment is preferable if the problem is diagnosed at an early age. This approach for an unerupted maxillary canine involves extracting the deciduous canine, and then orthodontically opening the space between the maxillary permanent lateral incisor and the primary first molar or permanent first premolar. Ericson and Kurol[5]

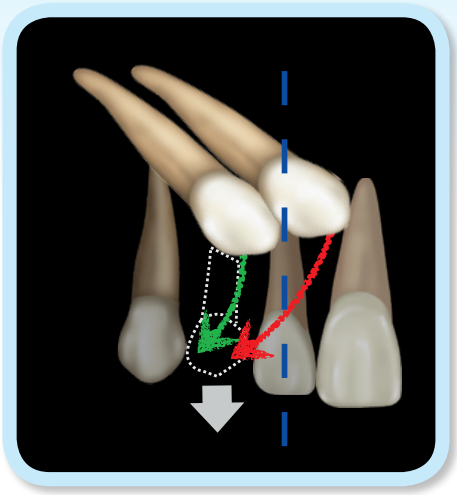


Fig. 20:
Illustration of the concept proposed by Ericsson and Kurol (1988) for prevention of maxillary permanent canine impaction by the timely extraction of the retained deciduous canine (outline dotted in white) and space opening if needed to accommodate the erupting canine. The probable success of the procedure depends on the sagittal position of the unerupted canine relative to the midline of the maxillary canine in a 2D radiograph. See text for details and references.

reported that removing the maxillary deciduous canine before 11 years of age has a differential effect on the normal eruption of the succedaneous canine. If the radiographic image of the canine crown is located distal to the midline of the lateral incisor root, 91% of the potentially impacted canines erupt normally (*Fig. 20*). However, the success rate decreases to 64% if the canine crown is located mesial to the midline of the lateral incisor root. Timely extraction of the deciduous canine is very effective for enhancing the eruptive potential of a canine, with a deviated path of eruption, but the space opening must be carefully managed to avoid root resorption if the unerupted canine is near the roots of the adjacent lateral incisors and/or premolars.[15]

If prevention is not feasible, or the procedure fails to prevent the impaction, the most desirable approach is surgical exposure of the canine in combination with orthodontic treatment.[14] This type of interdisciplinary treatment requires careful communication between the orthodontist, surgeon, and patient. Kokich[2] described several advantages of pre-orthodontic uncovering and spontaneous eruption of the palatally impacted canine, when compared to the closed eruption technique. Removing the relatively thick palatal mucosa and bone covering the impacted canine allows for more predictable spontaneous eruption. However, in young adult patients, the passive pre-orthodontic eruption process requires almost a year, and the procedure is less predictable in adolescent patients.[14]

For the present patient, miniscrew guided eruption of the impacted canine was performed in conjunction with surgical uncovering and orthodontic treatment (*Fig. 21*). After exposing the impacted canine using a simplified open-window technique, the previously impacted tooth extruded 2-3mm in two months. A miniscrew was placed on the labial surface for anchorage to guide the movement of the canine into the arch-form. As palatal impactions are moved facially, gingival accumulation on the labial surface is common, and may result in an unesthetic short clinical crown. The excess gingival tissue is easily removed with a diode laser prior to bracket placement.[16]

Efficient management of impacted maxillary canines requires a proper diagnosis and thorough

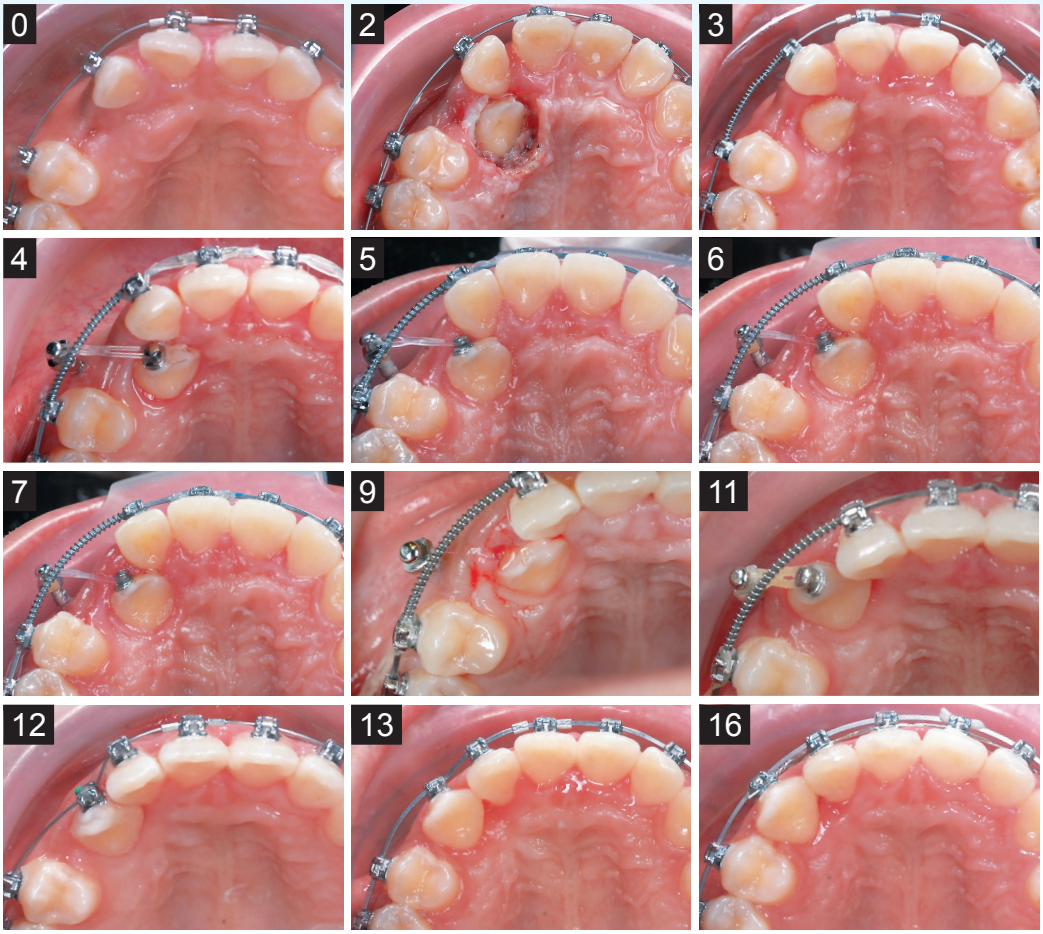


Fig. 21:
The progression for the recovery and alignment of the palatally impacted right maxillary canine is shown in a series of occlusal photographs taken at monthly intervals from the start of treatment at zero months (0) to completion of the initial alignment at sixteen months (16).

understanding of anchorage demands for proper alignment. Becker et al.[17] analyzed a sample of 37 impacted maxillary canines and found that the most common reasons for failure to recover an impaction were related to two diagnostic deficiencies: 1. inaccurate assessment of the location and orientation of the impaction, and 2. failure to understand to anchorage demands for proper alignment.[17] For the present patient, the CBCT image was used to plan the surgical uncovering and miniscrew anchorage. This approach resulted in ideal functional and esthetic alignment without periodontal or esthetic compromise.

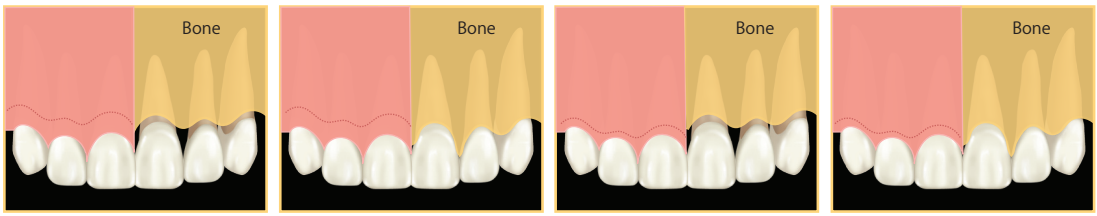
Gummy Smile

The ideal amount of gingival display when smiling is around 1-2mm.[18] Excessive maxillary gingival

exposure is commonly referred to as "*gummy smile.*" The problem may be generalized or localized, and has multiple etiologies.[19,20] Extra-oral factors include: 1. short and/or hypermobile upper lip, 2. maxillary anterior dentoalveolar extrusion, and 3. vertical maxillary excess. Intra-oral manifestations include gingival hypertrophy and altered passive eruption.

Altered passive eruption (*APE*) occurs when the gums do not physiologically recede following active tooth eruption. Coslet's[21] classification of APE is based on the width of attached keratinized gingiva and the location of the osseous crest in relation to the CEJ. There are four classifications of APE: Type I Subgroup A, Type I Subgroup B, Type II Subgroup A, and Type II Subgroup B. In all four groups, the free gingival margin is located occlusal to the CEJ. Classification of APE is helpful in determining subsequent treatment,[22] and a summary can be found in Table 2.

APE-related, short clinical crowns were diagnosed as the etiology of the current patient's gummy smile. Measuring gingival sulcus depth and bone sounding under local anesthesia to determine the level of crestal bone are important diagnostic tools for determining if a gingivectomy is indicated to correct gummy smile.[23] The present patient exhibited an adequate zone of attached gingiva and the bone sounding depth was found to be 5mm. Based on Coslet's[21] classification (*Table 2*) of altered passive eruption, the patient was classified as Type I-A (*excessive gingival width*), and a diode laser gingivectomy was deemed an appropriate



	Type I-A	Type I-B	Type II-A	Type II-B
Zone of attached keratinized gingiva	Adequate	Adequate	Inadequate	Inadequate
Osseous crest in relation to the CEJ	Osseous crest is 2-3 mm apical to the CEJ	Osseous crest is at the CEJ	Osseous crest is 2-3 mm apical to the CEJ	Osseous crest is at the CEJ
Treatment	Gingivectomy	Gingivectomy + Osseous surgery	Apically Positioned Flap	Apically Positioned Flap + Osseous surgery

■ Table 2:
Coslet's classification for Altered Passive Eruption relates to the zone of keratinized gingiva, osseous crest relative to the cementoenamel junction (CEJ). The mucogingival junction (MGJ) is marked by the black dotted line. The MGJ is noted by a dotted line. Types I and II reflect the width of attached gingiva, and subtypes A and B is defined by the CEJ to crestal bone height dimension. See text for details and references.

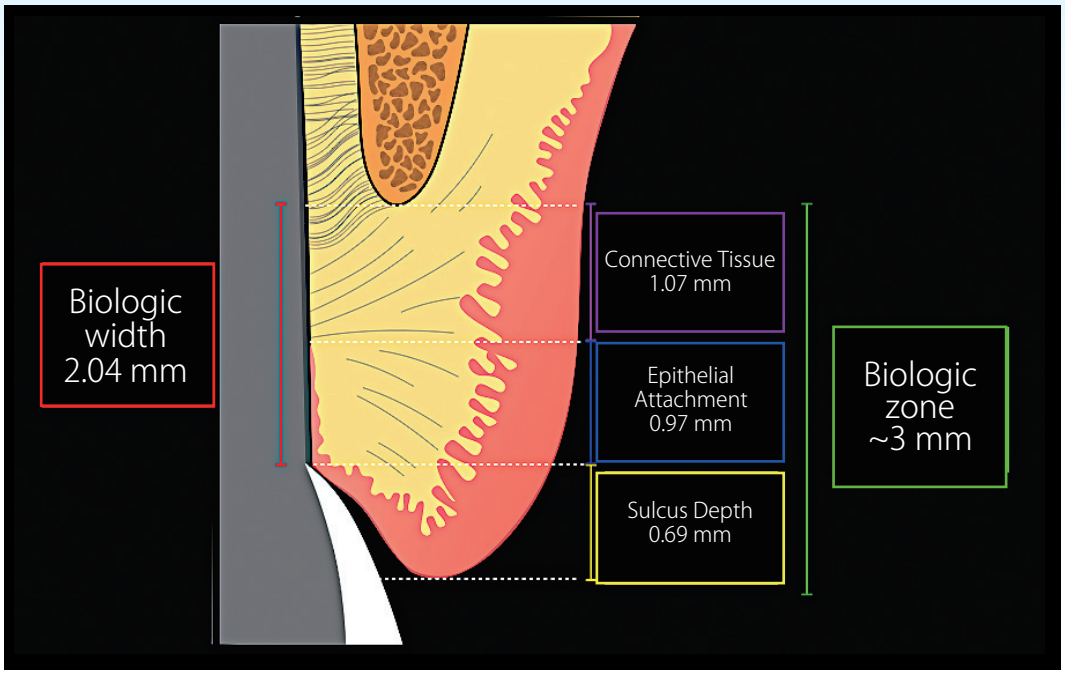


Fig. 22:
A diagram of the periodontal attachment to a tooth illustrates the concept of biologic width: sulcus depth+width of the epithelial attachment+connective tissue attachment of collagen fibers directly into cementum occlusal to the alveolar bone crest. The total width of the biologic zone is ~3mm. See text for details and references.

treatment to enhance dental esthetics by increasing crown lengths in the anterior segment.

Diode Laser: Gingivectomy and Labial Frenectomy

It is important to have a good understanding of biologic width prior to a gingivectomy procedure.[24,25] Some symptoms of biologic width violation include persistent gingival inflammation, recurrent pocket depths, and tissue recession.[24] Biologic width is a term that was coined by Cohen,[23] and is defined as the combined heights of the connective tissue attachment and epithelial attachment. In 1961, Garguilo et al.[26] reported the average connective tissue height was 1.07mm and the average epithelial attachment was 0.97mm, leading to an average biologic width of 2.04mm. The average depth of the facial gingival sulcus was 0.69mm, thus the average total gingival height above the bone was found to be approximately 2.73mm (*Fig. 22*). Kois[27] rounded this value up to 3mm and called it the biologic zone (*Fig. 22*). Maintaining a biologic zone of 3mm is an important factor in maintaining a healthy dentogingival complex.

For the present patient, the 3mm reserved for maintaining the biologic zone was subtracted from the 5mm bone sounding depth, revealing 2mm of gingival width could be safely removed with laser

Fig. 23:
Pre-treatment (left) and post-treatment (right) lower facial photographs. The upper two views are a comparison of full smile before and after treatment. The lower two photos area similar comparison with the lips closed. See text for details.

gingivectomy.[28] As an additional procedure, the area of attachment for an impinging maxillary midline frenum was also removed with the diode laser, and the wound healed by secondary intention.

The word "*LASER*" is an acronym which stands for Light Amplification of Stimulated Radiation Emission. Dental devices are generally classified as superficial and deep penetrating lasers.[29] Diode lasers deeply penetrate the tissue and are well absorbed by hemoglobin, thereby producing a layer of coagulation within the soft tissues (*hemostasis*) that controls bleeding. Diode lasers are usually preferred for dental soft tissue revision because of their precise cutting and coagulation ability. For orthodontic gingival hypertrophy, diode laser gingivectomy is reported to provide earlier healing and greater improvement in gingival health compared to scalpel surgery.[30,31] Pre-treatment and post-treatment comparison of gingival exposure when smiling is documented in Fig. 23.

Posterior and Anterior Bite Turbos

For the present patient, the use of posterior bite turbos opened the bite to permit correction of buccal crossbite for the upper left premolars. The subsequent anterior bite turbos (*BTs*) were installed on the lingual surfaces on the maxillary central incisors for correction of her deep bite. Because of the large overjet, anterior BTs were bonded more gingivally. BTs should not be used on endodontically treated teeth because the latter are more susceptible to fracture. Upright or lingually-tipped maxillary incisors may require a correction in the axial inclination before installing BTs. Anterior BTs serve as vertical stops in occlusion at the desired vertical dimension of occlusion (*VDO*). Spontaneous eruption of the posterior dentition to the desired occlusal plane, consistent with the treatment VDO, was the primary mechanism for overbite correction. However, the vertical load associated with anterior BTs may result in intrusion of the upper and lower incisors.[32-34]

Class II Elastics

Class II elastics tend to retract the maxillary arch and extrude the maxillary anterior segment while rotating the plane of occlusion posteriorly (*clockwise*). The lower dentition compensates by posterior rotation of the mandible, opening of the VDO, extrusion of the posterior teeth, and increased axial

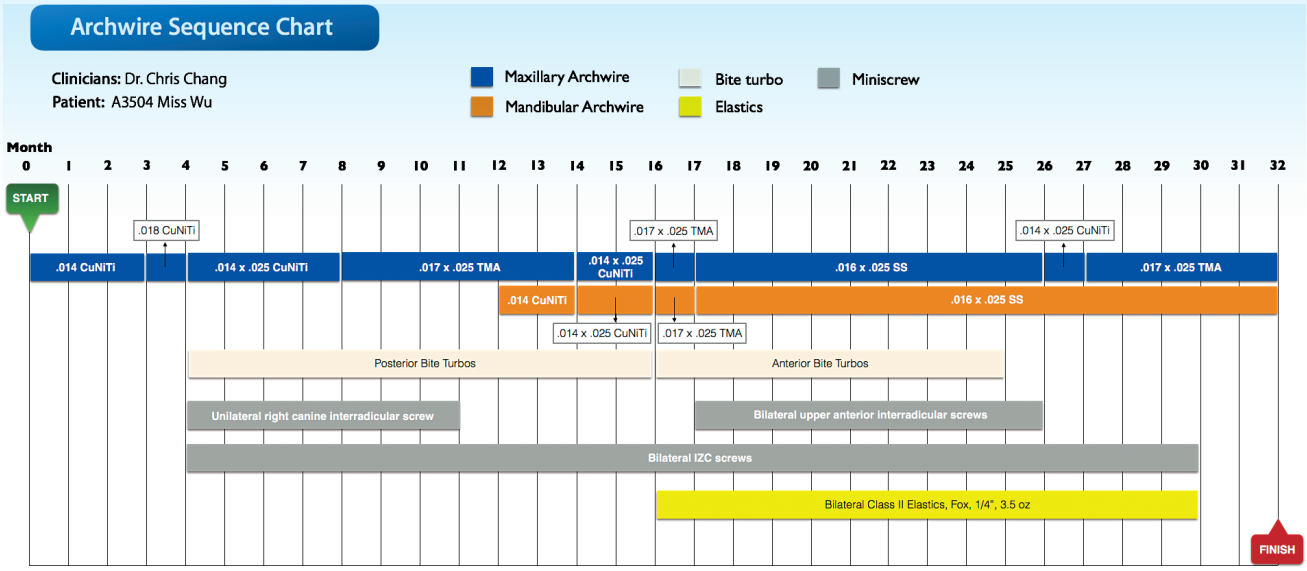


Table 3: Archwire sequence chart summarizes the sequential mechanics over the course of active treatment. See text for details.

inclination of the incisors. With respect to anterior dental segments, Class II elastics produce two predictable side effects: uprighting of the maxillary incisors and flaring of the mandibular incisors.[35]

To resist the incisal tipping effects of Class II elastics, higher torque brackets are indicated in the maxillary anterior and lower torque brackets are prescribed for the mandibular anterior.[36,37] However, for the present patient, standard torque brackets were placed in both arches. This approach worked well for the lower arch because L1 to SN° improved from 102° to 97°. Unfortunately, the expected flaring effect of the intrusive force, anchored by the maxillary anterior miniscrews (*Fig. 12*), was inadequate to counteract the side effects of the Class II elastics, so the axial inclination the upper incisors decreased (*U1 to SN° from 96° to 90°*). In retrospect, this problem was preventable as follows: 1. use higher torque brackets on the maxillary incisors, 2. progress to larger rectangular archwires to more completely express torque (*Table 3*), and/or 3. place palatal root torque in the anterior segment of the maxillary rectangular archwire.

Inadequate torque control of the maxillary incisors prevented the complete correction of the Class II posterior segments (*Fig. 15*). This problem resulted in deduction of 10 additional points on the CRE score. The patient was adequately treated to ABO standards as evidenced by an overall CRE score of 25, but if there was adequate overjet for a complete Class II correction, the score would have been a truly outstanding 15.

Conclusions

When treating complex malocclusions, bone screws provide effective anchorage in the maxillary anterior as well as the posterior regions of both arches.

Recovery and alignment of an impacted maxillary canine is best accomplished with a simplified open window technique, in combination with miniscrew anchorage, to successfully guide the impacted canine into its correct anatomical position. A Class II malocclusion with gummy smile was efficiently corrected with bilateral IZC bone screws and maxillary anterior miniscrews, but decreased axial inclination of the maxillary incisors prevented complete correction of the Class II buccal segments.

Acknowledgment

Thanks to Dr. Rungsi Thavarungkul for the beautiful illustrations. Thanks to Doctors Chris Chang, Angle Lee, Charlene Chang, Ashley Huang, and Lomia Lee for their mentorship and assistance with data collection.

References

1. Cangialosi TJ, Riolo ML, Owens SE Jr, Dykhouse VJ, Moffitt AH, Grubb JE, Greco PM, English JD, James RD. The ABO discrepancy index: a measure of case complexity. Am J Orthod Dentofacial Orthop 2004;125(3):270-8.
2. Kokich VG. Preorthodontic uncovering and autonomous eruption of palatally impacted maxillary canines. Semin Orthod 2010;16:205-211.
3. Casko JS, Vaden JL, Kokich VG, Damone J, James RD, Cangialosi TJ, Riolo ML, Owens SE Jr, Bills ED. Objective grading system for dental casts and panoramic radiographs. American Board of Orthodontics. Am J Orthod Dentofacial Orthop 1998;114(5):589-99.
4. Litsas G, Acar A. A review of early displaced maxillary canines: Etiology, diagnosis and interceptive treatment. Open Dent J 2011;5:39–47.
5. Ericson S, Kurol J. Early treatment of palatally erupting maxillary canines by extraction of the primary canines. Eur J Orthod 1988;10:283–95.
6. Mitchell L, editor. An Introduction to Orthodontics. 3rd ed. New York: Oxford University Press; 2007. pp. 147–56.
7. Jacoby H. The etiology of maxillary canine impactions. Am J Orthod 1983;84:125–32.
8. Richardson G. A review of impacted permanent maxillary cuspids-diagnosis and prevention. J Can Dent Assoc 2000;66:497–501.
9. Becker A, editor. The orthodontic treatment of impacted teeth. 2nd ed. Abingdon, Oxon, England: Informa Healthcare; 2007. pp. 1–228.
10. Peck S, Peck L, Kataja M. The palatally displaced canine as a dental anomaly of genetic origin. Angle Orthod 1994;64:249–56.
11. Shafer WG, Hine MK, Levy BM, editors. A textbook of oral pathology. 2nd ed. Philadelphia: WB Saunders; 1963. pp. 2–75.
12. Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. J Am Dent Assoc 2009;140:1485–93.
13. Alqerban A, Jacobs R, Fieuws S, Willems G. Comparison of two c one beam tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. Eur J Orthod 2011;33:93–102.
14. Ericson S, Kurol J. Radiographic assessment of maxillary canine eruption in children with clinical signs of eruption disturbance. Eur J Orthod 1986;8:133-140.
15. Hsu YL, Chang CH, Roberts WE. Canine-lateral incisor transposition: controlling root resorption with a bone-anchored t-loop retraction. Am J Orthod Dentofacial Orthop 2016;150:1039-50.
16. Chang CH, Su CW, Hsu YL, Roberts WE. Soft tissue considerations for the management of impactions. Int J Ortho Implantol 2011;24:50-9.
17. Becker A, Chaushu G, Chaushu S. Analysis of failure in the treatment of impacted maxillary canines. Am J of Orthod Dentofacial Orthop 2010;137(6):743-754.
18. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod Dentofacial Orthop 1970;57:132-144.
19. Yeh HY, Chang CH, Roberts WE. Implant-orthodontic combined treatment for gummy smile with multiple missing teeth. Int J Orthod Implantol 2013;32:16-32.
20. Wu H, Lin J, Zhou L, Bai D. Classification and craniofacia features of gummy smile in adolescents. J Craniofac Surg 2010;21:1474-1479.

21. Coslet JG, Vanarsdall R, Weisgold A. Diagnosis and classification of delayed passive eruption of the dentogingival junction in the adult. Alpha Omegan 1977 Dec;7(37):24-8.
22. Ezquerra F, Berrazueta MJ, Ruiz-Capillas A, Arregui JS. New approach to the gummy smile. Plast Reconstr Surg 1999;104:1143-1150, discussion 51-2.
23. Cohen E. Atlas of cosmetic and reconstructive periodontal surgery. 3rd ed. Decker BC; 2007. p. 259.
24. Jorgic-Srdjak K, Plancak D, Maricevic T, Dragoo MR, Bosnjak A. Periodontal and prosthetic aspect of biological width part I: Violation of biologic width. Acta Stomatol Croat 2000;34:195–7.
25. Ingber JS, Rose LF, Coslet JG. The "biologic width"—a concept in periodontics and restorative dentistry. Alpha Omegan 1977;70:62–5.
26. Gargiulo AW, Wentz FM, Orban B. Dimensions and relations of the dentogingival junction in humans. J Periodontol 1961;32:261-7.
27. Kois JC. New paradigms for anterior tooth preparation. Rationale and technique. Oral health 1998;88(4):19-22, 25-17, 29-30.
28. Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics: part 2. Soft tissue laser technology and cosmetic gingival contouring. Am J Orthod Dentofac Orthop 2005;127:85-90.
29. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. National Journal of Maxillofacial Surgery 2012;3(2):124-132.
30. To A, Rabie AB, Wong RW, McGrath CP. The adjunct effectiveness of diode laser gingivectomy in maintaining periodontal health during orthodontic treatment. The Angle Orthod 2013 Jan;83(1):43-47.
31. Ize-Iyamu IN, Saheeb BD, Edetanlen BE. Comparing the 810nm diode laser with conventional surgery in orthodontic soft tissue procedures. Ghana Medical Journal 2013;47(3):107-111.
32. Thavarungkul R. Correcting deep-bite with fixed bite ramps. News & Trends in Orthodontics 2009;16:68-71.
33. Lin SL, Chang CH, Roberts WE. Mutilated class II division 2 malocclusion: implant-orthodontic treatment utilizing flapless implant surgery and platelet-rich fibrin. Int J Orthod Implantol 2014;33:22-45.
34. Liu CW, Chang CH, Roberts WE. Class II deep bite malocclusion with posteriorly-inclined incisors. Int J Orthod Implantol 2012;25:32-42.
35. Janson G, Sathler R, Fernandes TMF, Branco NCC, de Freitas MR. Correction of Class II malocclusion with Class II elastics: A systematic review. American J of Orthod and Dentofacial Orthop 2013;143(3):383-392.
36. Kozlowski J. Honing Damon system mechanics for the ultimate in efficiency and excellence. Clin Impressions 2008;16:23-28.
37. Pitts T. Begin with the end in mind: bracket placement and early elastics protocols for smile arc protection. Clin Impressions 2009;17:4-13.

Discrepancy Index Worksheet

TOTAL D.I. SCORE 38

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 = 4

OVERBITE

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

Total = 5

ANTERIOR OPEN BITE

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

Total = 0

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 0

CROWDING (only one arch)

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

Total = 0

OCCLUSION

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

Total = 6

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 0

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 4

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = 4 pts

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

Each degree > 6° 1 x 1 pt. = 1

SN-MP

≥ 38° = 2 pts

Each degree > 38° 1 x 2 pts. = 2

≤ 26° = 1 pt.

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

1 to MP ≥ 99° = 1 pt.

Each degree > 99° 3 x 1 pt. = 3

Total = 13

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)	1 x 2 pts. =	2
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	2
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	_____ x 2 pts. =	_____

Identify:

Total = 6

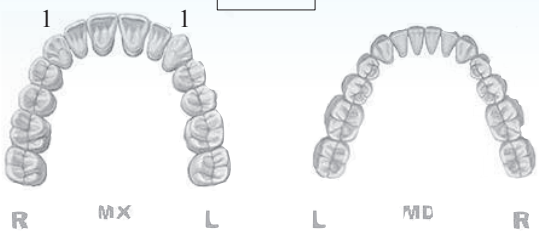
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 25

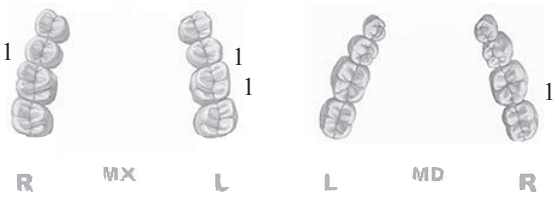
Alignment/Rotations

2



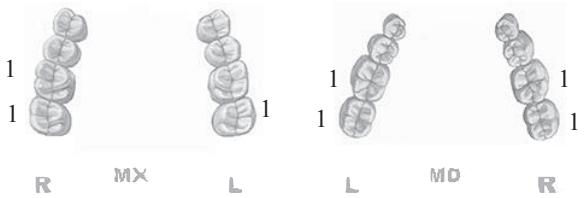
Marginal Ridges

4



Buccolingual Inclination

7

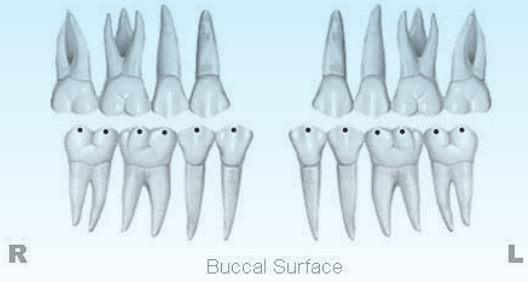


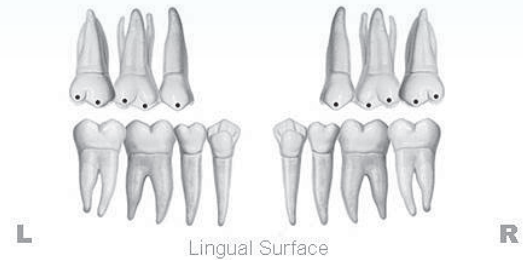
Overjet

2

Occlusal Contacts

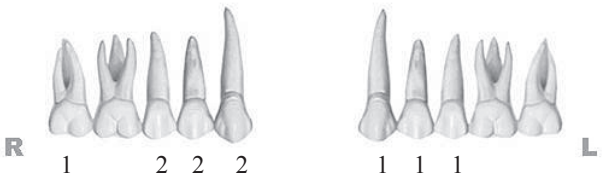
0





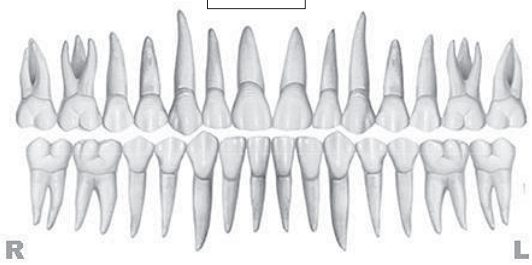
Occlusal Relationships

10



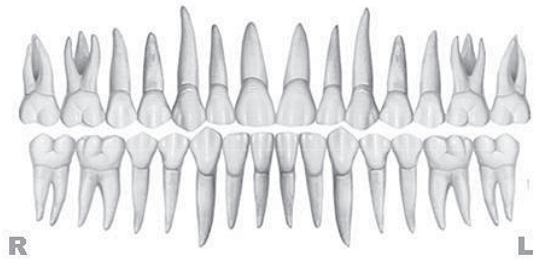
Interproximal Contacts

0



Root Angulation

0



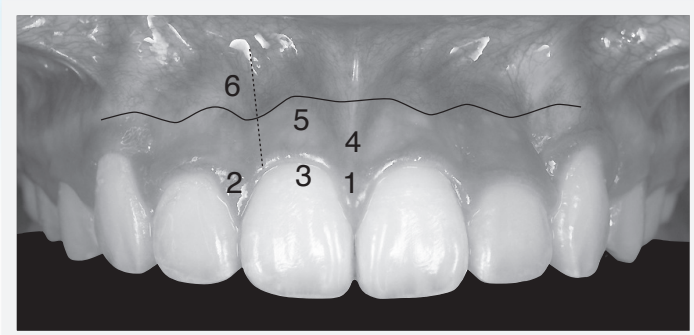
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 2

1. Pink Esthetic Score

Total = 2

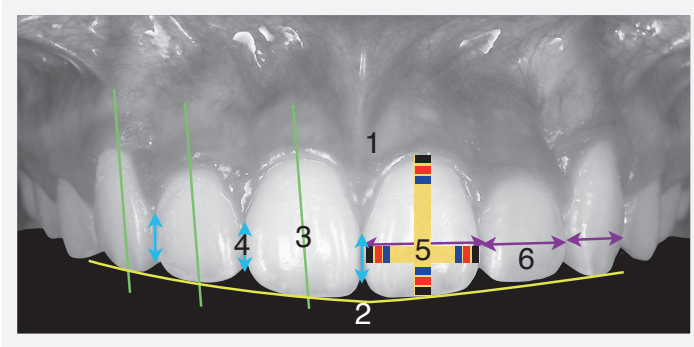


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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