

Canine Substitution Treatment of Class III Malocclusion, Crossbite with a Congenitally Missing Upper Incisor and a Peg Lateral Incisor

History: Upper right lateral incisor (UR2) is congenitally missing, and upper left lateral incisor (UL2) is peg-shaped.

Diagnosis: A 30-year-old male presented with increased facial height (58.5%), and a markedly increased mandibular plane (SN-MP 49°), but a normal facial profile (13°). Intraoral examination revealed an asymmetric Class III malocclusion, lingual crossbite of the upper right first molar (UR6), anterior crossbite from canine to canine (UR3-UL3), missing UR2, peg-shaped UL2, and upper midline deviation 4mm to the left. The ABO Discrepancy Index (DI) was 50 points.

Treatment: The peg-shaped UL2, and both lower first premolars (LR4, LL4) were extracted. A full fixed passive self-ligation (PSL) Damon Q® appliance was bonded on all permanent teeth. Four bite turbos were bonded on lower arch: LR6, LR3, LR1, and LL6. The anterior crossbite was corrected with Class III elastics, and the maxillary anterior spaces were closed in the upper arch to achieve bilateral canine substitution. Torque control of the U3s was accomplished with specific bracket selection and torquing auxiliary springs. Increasing the lower facial height to correct the anterior crossbite increased the facial convexity, but the patient maintained lip competence.

Outcome: This very difficult malocclusion (DI 50) was treated in 34 months to an acceptable result: ABO Cast-Radiograph Evaluation (CRE) 29 points, and Pink & White Esthetic Score 4. (*J Digital Orthod* 2020;57:52-67)

Key words:

Canine substitution, missing lateral incisor, crossbite, bite turbos, early light short elastics (ELSE), torquing auxiliary spring, peg lateral incisor

Diagnosis and Etiology

A 30-year-old male presented for orthodontic consultation to evaluate his “protrusive chin,” but the problem appeared to be a protrusive lower lip. There were no contributing medical history nor known habits. Facial evaluation showed a long convex face (Fig. 1), and the occlusion was Class III with an anterior crossbite (Fig. 2). Radiographic evaluation documented a very steep mandibular plane, and impacted lower third molars (Fig. 3). In the frontal plane, facial structures were relatively symmetric, but the occlusal plane was canted inferiorly on the right side. There was asymmetric condylar translation (Fig. 4), but were no signs nor symptoms of temporomandibular joint dysfunction. Intraoral examination revealed an asymmetric Class III malocclusion (more severe on the left) with a maxillary midline that was deviated 4mm to the left. The right maxillary lateral incisor (UR2) was peg-shaped, and the contralateral lateral incisor (UL2) was congenitally missing. In addition, crossbites were noted for the upper right first molar and the entire maxillary anterior segment (Fig. 1).

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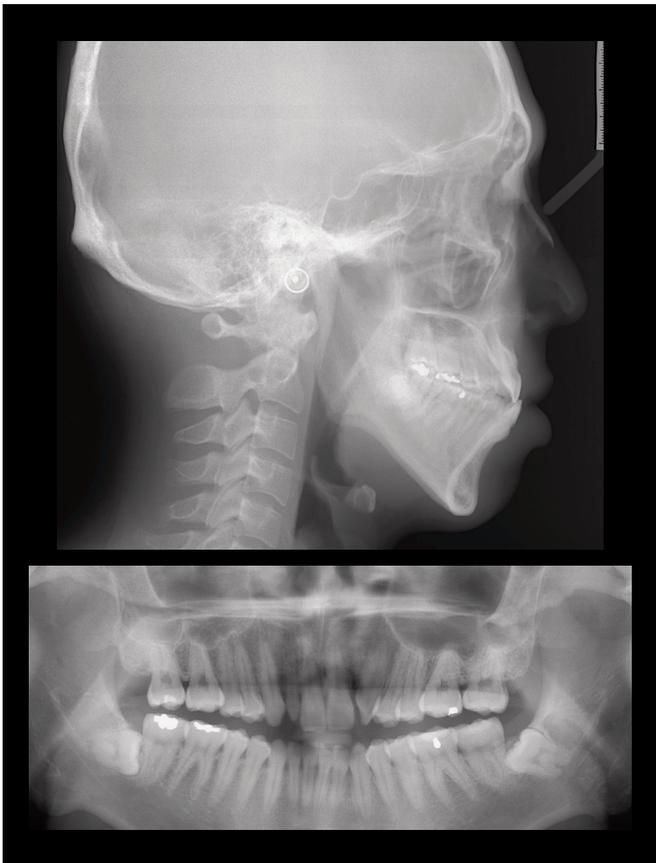
Cephalometric analysis (Table 1) revealed excessive facial height ($Na-ANS-Gn$ 58.5%) with a normal facial profile, but lower lip protrusion was excessive to the E-Line (5mm). Bimaxillary retrusion (SNA 79°, SNB 75°), high mandibular plane angle ($SN-MP$ 49°, FMA 41°), and retrusive maxillary incisors (97°) were associated with a skeletally retrusive mandible (ANB 4°). The panoramic radiograph showed that the mandibular 3rd molars were impacted (Fig. 3). The American Board of Orthodontics (ABO) Discrepancy Index (DI) was 50 points, as shown in the supplementary Discrepancy Index (Worksheet 1).



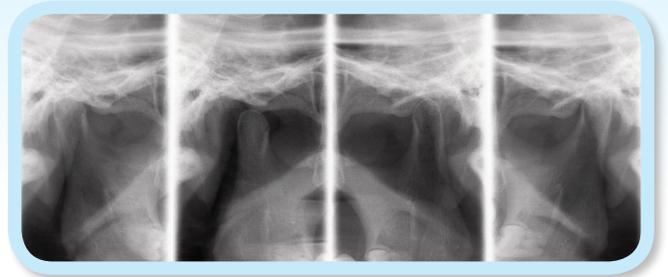
■ Fig. 1: Pre-treatment facial and intraoral photographs



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



■ Fig. 3: Pre-treatment panoramic and cephalometric radiographs



■ Fig. 4: Radiographs of the mandibular condyles in the closed position are shown bilaterally in the left and right images, respectively. The corresponding open mouth positions are shown in the center left and center right images, respectively. Although the excursions are asymmetric, there were no signs or symptoms of temporomandibular disorder.

CEPHALOMETRIC SUMMARY

SKELETAL ANALYSIS

	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	79°	79°	0°
SNB° (80°)	75°	74°	1°
ANB° (2°)	4°	5°	1°
SN-MP° (32°)	49°	51°	2°
FMA° (25°)	41°	43°	2°

DENTAL ANALYSIS

U1 To NA mm (4 mm)	2 mm	0 mm	2 mm
U1 To SN° (110°)	97°	95.5°	1.5°
L1 To NB mm (4 mm)	11 mm	6 mm	5 mm
L1 To MP° (90°)	87°	82°	5°

FACIAL ANALYSIS

E-LINE UL (2-3 mm)	-1 mm	0 mm	1 mm
E-LINE LL (1-2 mm)	5 mm	1 mm	4 mm
Convexity: G-Sn-Pg' (13°)	13°	16°	3°
%FH: Na-ANS-Gn (53%)	58.5%	58%	0.5%

■ Table 1: Cephalometric summary

Specific Objectives of Treatment

1. Retract the lower dentition to correct the anterior crossbite.
2. Extract the UR2 and close edentulous spaces to achieve bilateral canine substitution.
3. Achieve ideal overjet and overbite relationships.
4. Correct intermaxillary sagittal and frontal discrepancies.
5. Finish with a cast radiograph score of no more than 30 points.

Treatment Plan

Plan A: (Fig. 5)

- Optimize upper lateral incisor spaces with preprosthetic orthodontics.
- Extract the upper left peg-shaped lateral incisor.
- Restore both upper lateral incisors with implant-supported prostheses.
- Restore the lower left central incisor with composite resin.

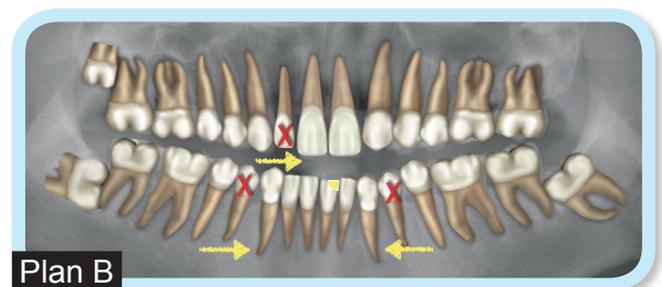
Plan B: (Fig. 6)

- Extract the upper right peg lateral incisor and both lower first premolars.
- Reshape upper canines to simulate lateral incisors.
- Restore the lower left central incisor with composite resin.



■ Fig. 5: Treatment Plan A

Extract the peg-shaped lateral incisor, correct the anterior crossbite, open space for implants, and restore both maxillary lateral incisors with implant-supported prostheses. Restore the fractured lower left central incisor with composite resin.



■ Fig. 6: Treatment Plan B

Extract upper right peg lateral incisor, extract both lower first premolars, and substitute the upper canines for the lateral incisors. Restore lower left central incisor with composite resin. See text for details.

After carefully considering both options, the patient chose canine substitution instead of implant-supported prostheses.

Appliances and Treatment Progress

After the peg lateral (UR2) and lower first premolars (LR4, LR5) were extracted, a 0.022-in slot, passive self-ligating (PSL) Damon Q® bracket system (Ormco, Glendora, CA) was installed on both arches. Standard torque brackets were used except for high torque brackets on the lower incisors. The archwire

sequence for both the upper and lower archwires was: 0.014-in CuNiTi, 0.014x0.025-in CuNiTi, 0.017x0.025-in TMA, and 0.016x0.025-in SS.

Fuji II® Type II glass ionomer cement (GC America, Alsip, IL) was used to build bite turbos on the lingual surfaces of the LR3 and LR1, as well as the occlusal surfaces of both lower first molars (Fig. 7) to facilitate anterior crossbite correction. A tongue depressor was provided with instructions to apply light and steady pressure in a labial direction to move the upper central incisors out of crossbite. Early light short elastics (Parrot 5/16" 2-oz.) were applied bilaterally from the upper first molars to the lower canines to correct the Class III molar relationship (Fig. 7).

In the 6th month of treatment, a progress panoramic radiograph revealed axial inclination problems

for the UR3, UR2 and UR1 (Fig. 8). Brackets were rebonded accordingly.

In the 9th month, an expanded 0.017x0.025-in TMA archwire was placed on the upper arch and a 0.014x0.025-in CuNiTi was inserted in the lower arch. Power chains and power tubes were used for closing

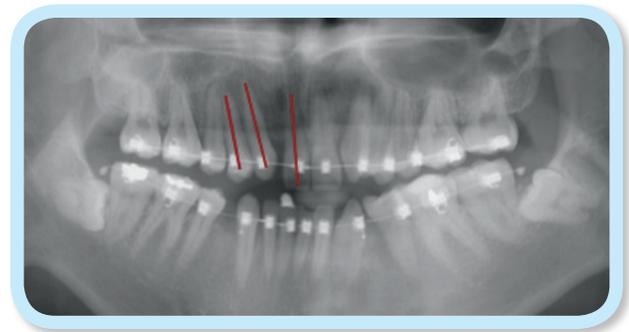


Fig. 8: A progress panoramic film revealed second order axial inclination problems: UR4, UR3, and UR1. Brackets were repositioned. See text for details.

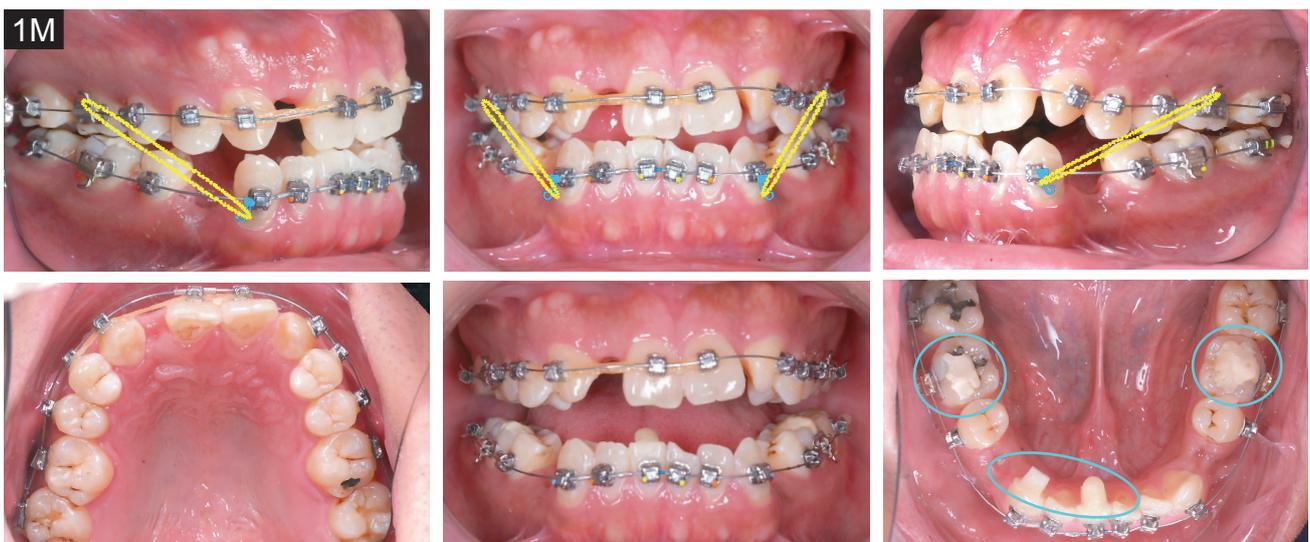


Fig. 7: Crossbite correction - resin bite turbos (blue ovals) were bonded on the lingual surface of the LR3 and LR1 and on the occlusal surfaces of the LR6 and LL6 (lower right image). Early light short elastics (yellow) were applied bilaterally from upper first molars to lower canines. See text for details.

the upper anterior spaces. In the 10th month, the Class III elastics were stopped once the overjet was corrected.

In the 12th month, the lower archwire was changed to 0.016x0.022-in SS to stabilize the arch-form as the premolar extraction spaces were closed. A figure-eight ligature maintained firm contact between the six lower anterior teeth. The bracket on the lower right second molar was rebonded. Seventeen months (17M) into treatment, torquing springs were applied to the substituted canines to deliver lingual root torque (Fig. 9). They were removed at 18-27 months when adequate axial inclinations were achieved. From 23-28 months, detailing was performed with progressive wire-bending. Brackets were repositioned on the maxillary central incisors. Both substituted canines were reshaped to simulate lateral incisors.

After 34 months of active treatment, all appliances

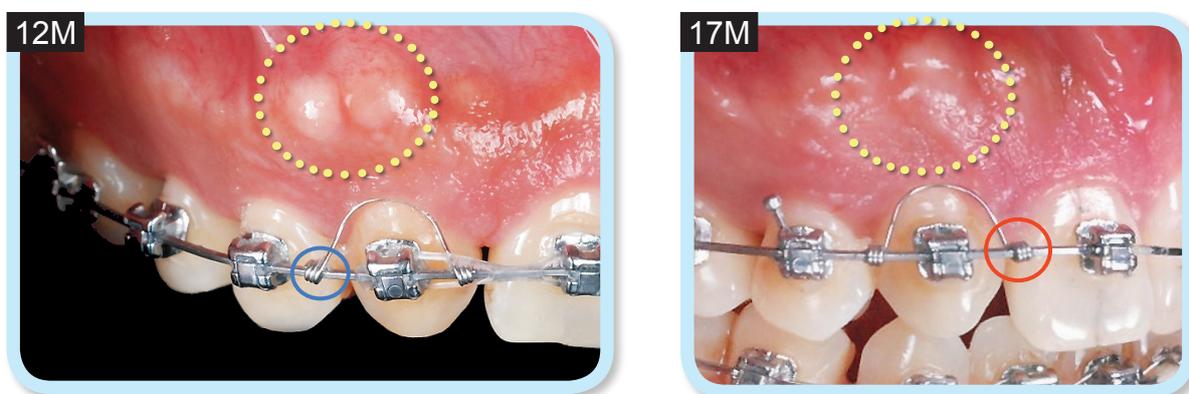
were removed and teeth in the maxillary anterior segment were restored with composite resin to optimize dental esthetics.

Retention

After the fixed appliances were removed, upper and lower clear overlay retainers were delivered with directions specifying full-time wear for the first six months, and then nights only afterwards. Instructions on home care and maintenance of the retainers were also provided.

Treatment Results

Facial esthetics were substantially improved by correction of the lower lip protrusion, and the smile line was optimized by improving the cant of the occlusal plane (Fig. 10). ABO Cast-Radiograph Evaluation (CRE) score was 29 points. The major CRE discrepancy were marginal ridges, buccal-lingual

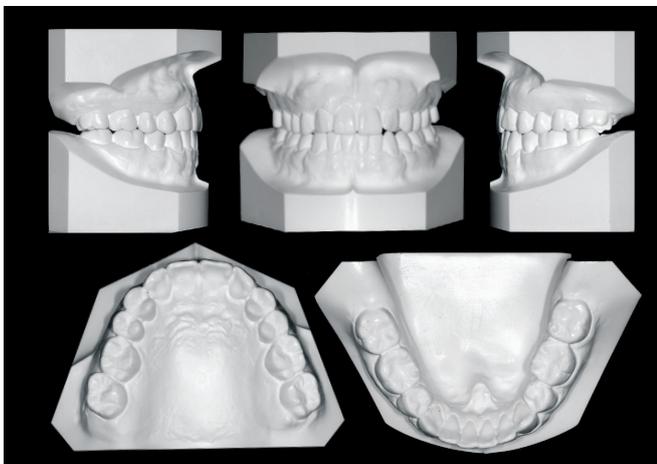


■ Fig. 9:

At twelve months (12M) into treatment, a torquing spring was placed on canines bilaterally to decrease root prominence (yellow dotted oval on the left). Note the spring was incorrectly positioned (blue oval). At seventeen months (17) into treatment, note the corrected position of the torquing spring with the arm under the main archwire (red oval). After five months of torque application, root prominence is improved (yellow dotted oval on the right). See text for details.



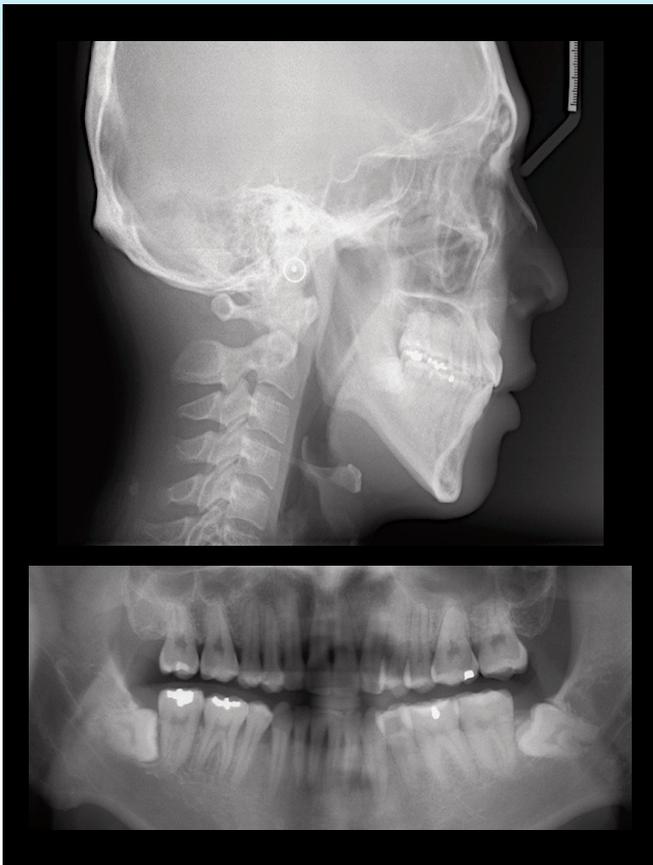
■ Fig. 10: Post-treatment facial and intraoral photographs



■ Fig. 11: Post-treatment study models (casts)

molar relationships, and overjet (*Worksheet 2*). Both anterior and posterior crossbites were resolved, and the molar relationships were Class I (*Fig. 11*). The post-treatment panoramic and cephalometric radiographs are shown in *Fig. 12*. Lip balance was improved, and lip competence was maintained despite a 3° increase in facial convexity (*Fig. 13, Table 1*).

The post-treatment cephalometric analysis was consistent with a Class II skeletal pattern ($ANB\ 5^\circ$), high mandibular plane angle ($SN-MP\ 51^\circ$, $FMA\ 44^\circ$), and increased lower facial height (58%) (*Table 1*). Superimposed cephalometric tracings showed retraction of the upper and lower incisors, as well

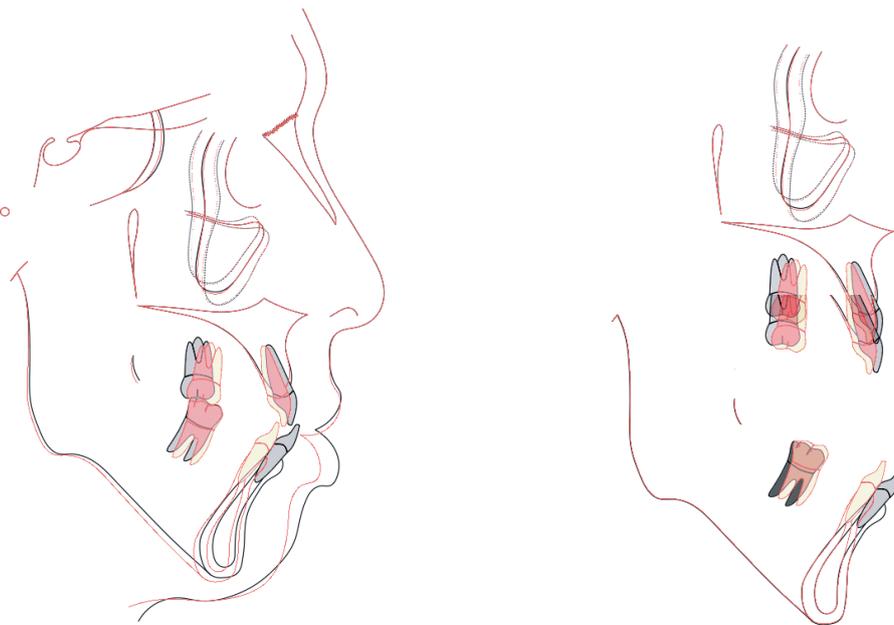


■ Fig. 12: Post-treatment panoramic and cephalometric radiographs

as anterior movement and extrusion of the lower molars. The mandible was rotated clockwise (*posteriorly*), and the lower lip was retracted (Fig. 13). The patient was quite satisfied with the result.

Discussion

According to epidemiological studies,¹ maxillary lateral incisors show the highest genetic variance in the dentition. The most common anomaly is a unilateral undersized (*often peg-shaped*) maxillary lateral incisor. Less commonly the condition is bilateral and may be associated with a contralateral congenitally absent lateral.² Agenesis prevalence for maxillary laterals is 2-9% over a variety of different ethnic groups; the data is similar for the mandibular second premolars (~3%). However, the congenital absence of third molars is much more prevalent (25-35%).³



■ Fig. 13:

Pre-treatment (black) and post-treatment (red) cephalometric tracings are superimposed on the anterior cranial base (left) to show an improved facial profile. Maxillary superimposition (upper right) documents protraction and extrusion of upper molars. Mandibular superimposition (lower right) shows incisor retraction and molar protraction.

Treatment of Peg Lateral Incisors

If the root is well formed, a peg lateral incisor can be restored with a porcelain crown or sometimes a veneer. Porcelain restorations are the most common treatment for peg lateral incisors because they require little or no restorative preparation of the tooth. If interproximal space is adequate, a porcelain restoration is bonded over a tapered peg lateral to restore normal form and function.⁴

Treatment of Missing Lateral Incisors

In achieving optimal esthetics and function, a coordinated, interdisciplinary approach is often necessary.⁵ Treatment may involve canine substitution, a tooth-supported restoration or an implant-supported prosthesis.²⁻⁶ The present malocclusion with maxillary lateral incisor deficiencies (Fig. 14) was complicated by an anterior crossbite and Class III molar relationship (Fig. 2).



■ **Fig. 14:** A periapical radiograph shows the peg lateral (UR2) and the missing UL2. There was inadequate space for the prosthetic restoration of the maxillary lateral incisors. See text for details.

Canine substitution was deemed the best and comprehensive treatment option for the patient.²

Canine Substitution

When restoring the esthetic zone (*maxillary anterior segment when smiling*),³⁻⁵ it is important to consider the type of malocclusion, crowding/spacing, intermaxillary tooth size relationships, canine positions, shape/color of canines, and maxillary lip length.⁴ Furthermore, a detailed assessment of tooth form and the supporting gingiva is indicated: worn incisal edges, shape of individual teeth, incisal contact relationship, contours of gingival margins, and probability of black triangles when the dentition is ideally aligned. The correction of all applicable factors should be simulated with a wax or digital set-up prior to initiating orthodontic treatment. The decision to reshape teeth and/or to add tooth structure should be carefully evaluated in relation to the ideal width-to-length ratios of the Golden Proportion.⁵

1. Indications for Canine Substitution

a. Malocclusion:

Two malocclusion patterns are particularly amenable to canine substitution: 1. Angle Class II with no crowding in the mandibular arch which can be finished in a Class II occlusion; and 2. Angle Class I with crowding in the mandibular arch that requires extraction of premolars (Fig. 15). For these situations, canine-protected occlusion is not usually a priority, so anterior group function in all excursions is a good

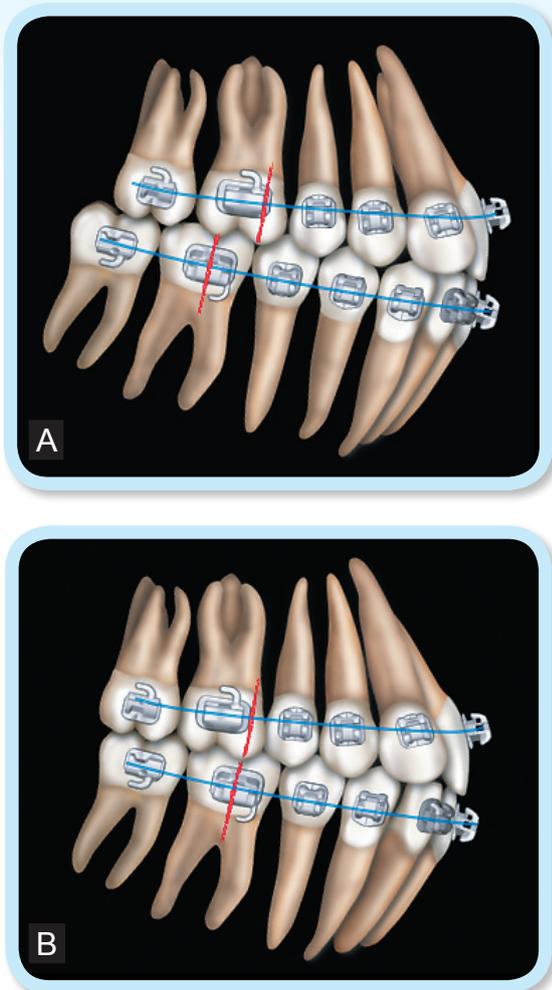


Fig. 15:
 (A) Angle Class II malocclusion with no crowding in the mandibular arch
 (B) Angle Class I malocclusion with crowding in the lower arch that requires extractions.

option. Nordquist and McNeill⁷ found no difference in occlusal function or periodontal status between canine-protected and group function occlusion.

b. Profile:

Kokich⁵ feels a straight profile is the most favorable for canine substitution in Caucasians, but a mildly

convex profile is also acceptable. The protrusive profile and less prominent nose that is typical of Asians are favorable factors for canine substitution because retraction results in a more ideal lip protrusion.⁸ On the other hand, a convex profile, retrusive mandible, and deficient chin prominence are unfavorable characteristics for canine substitution (Fig. 3). Correcting the anterior crossbite by opening the bite with bite turbos is usually a risky procedure for patients with a long face, but fortunately the patient was able to maintain lip competence despite a 3° increase in facial convexity (Figs. 12 and 13, Table 1).

c. Canine size and shape:

In comparison to the adjacent canine, the lateral incisor has a flat labial surface, and narrower dimensions at the cemento-enamel junction (CEJ) for both mesio-distal and bucco-lingual width.⁷ To simulate a maxillary lateral incisor, the outline form of the crown must be reduced at the cusp tip, as well as in mesio-distal width and facio-lingual depth. Furthermore, resin restoration of the outline extensions is required for the mesio-incisal and disto-incisal line angles (Fig. 16). According to Thordarson and Zachrisson,⁶ tooth sensitivity may persist for 1-3 days after crown⁷ reduction, but there is no long-term sensitivity if the high-speed reduction is performed with copious water spray.^{9,10}

d. Soft issue (lip level):

Patients with a high lip line when smiling are challenging for effective management of the

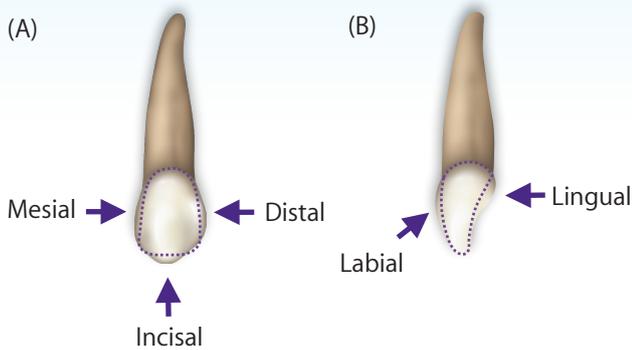


Fig. 16: The suggested outline form for a canine substituting for a lateral incisor is shown by the purple dotted line in the frontal (A) and profile (B) views. See text for details.

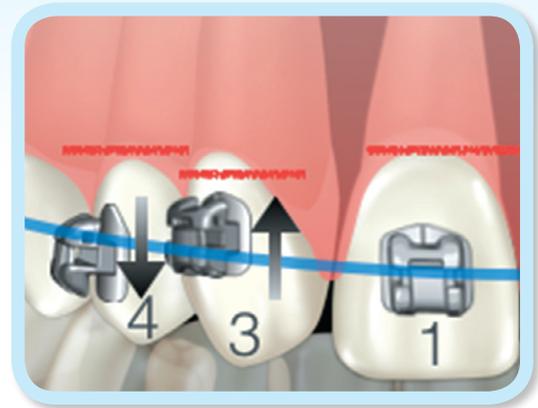


Fig. 17: Bracket position adjustments are shown to assist in achieving the preferred high-low-high gingival margin profile that mimics natural soft tissue margins. See text for details.

maxillary anterior esthetic zone. The periodontal support is especially important: control of gingivitis, soft tissue contours, and root prominence. The present patient (Fig. 10) has the opposite problem: a relatively low lip line. Thus, detailed coordination of upper to lower arch alignment is a high priority, because inadequate maxillary incisor exposure is an increasingly important issue for aging adults, particularly men.¹¹

2. Bonding Position

Restoring the natural contours of the gingival margins is particularly important for maxillary canine substitution (Fig. 16). Optimal esthetics requires a more incisive gingival margin compared to the adjacent central incisor and first premolar. The incisor to canine high-low-high gingival margin principle is best achieved with coordinated orthodontics and restorative procedures. The canine can be intruded by a more incisal bracket position (Fig. 17). Crown

length is decreased, while the buccolingual surfaces are recontoured with crown reshaping, and the line angles are restored with composite resin (Fig. 16). In addition, the adjacent premolar is masked to simulate a canine by intrusion to improve the gingival emersion profile. An additional important step is to lengthen the labial surface with composite resin to achieve group function.

3. Bracket/Torque Selection

A high torque bracket (Table 2) is recommended for lingual root torque to simulate the natural labial inclination of a lateral incisor.⁹ A torquing spring is also helpful if additional lingual root torque is needed to decrease the root prominence of the canine. In contrast, buccal root torque is needed to increase the first premolar root prominence.⁷ However, these mechanics must be applied judiciously to avoid alveolar dehiscence and gingival recession. For mesially substituted first

Torque	U1	U2	U3	U4	U5
High	22	13	11		
Std	15	6	7	-11	-11
Low	2	-5	-9		

■ Table 2: Torque value of Damon Q® brackets.

premolars, the preferred buccal crown torque is relatively perpendicular. A standard first premolar bracket is preferred because it has more negative torque (-11°). Furthermore, the buccal crown torque compensates for the intrusion of 1st premolars (Table 2).⁸ If additional torque compensation is required for a specific tooth, it is best achieved with a torquing auxiliary (Fig. 9).

4. Interdisciplinary Treatment

When the canine is darker in comparison to the adjacent central incisor and first premolar, a selective tooth whitening procedure is indicated. If that conservative approach is inadequate, it may be necessary to place porcelain veneer or crown restorations to achieve harmonious esthetics.

Conclusions

Canine substitution is an effective long-term solution for selected patients. The initial examination and the follow-up diagnosis are critical for the success of this comprehensive interdisciplinary treatment. Important considerations include:



- (1) Straight or mildly convex facial profile for Caucasians, or a protrusive profile in Asians.
- (2) Angle Class I or II malocclusion with crowding in the lower arch.
- (3) Mimic natural esthetics with careful attention to dental and soft tissue morphology.
- (4) Torquing spring auxiliaries are helpful for correction of labial contour and/or root prominence.
- (5) Veneer prostheses may be necessary to achieve optimal results for demanding patients.

Acknowledgment

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 50

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 = 16

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 = 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 = 1

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

Total = 2

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 1

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB $\geq 6^\circ$ or $\leq -2^\circ$ = 4 pts.

Each degree $< -2^\circ$ x 1 pt. =

Each degree $> 6^\circ$ x 1 pt. =

SN-MP

$\geq 38^\circ$ = 2 pts.

Each degree $> 38^\circ$ 11 x 2 pts. = 22

$\leq 26^\circ$ = 1 pt.

Each degree $< 26^\circ$ x 1 pt. =

1 to MP $\geq 99^\circ$ = 1 pt.

Each degree $> 99^\circ$ x 1 pt. =

Total = 24

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

Identify: Anomalous morphology UR peg lateral

Total = 6

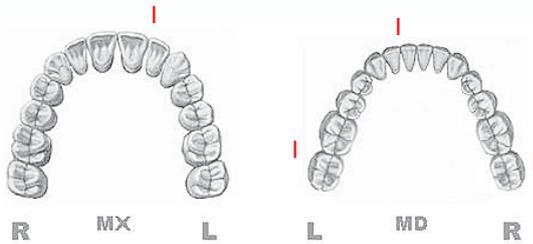
Cast-Radiograph Evaluation

Total CRE Score

29

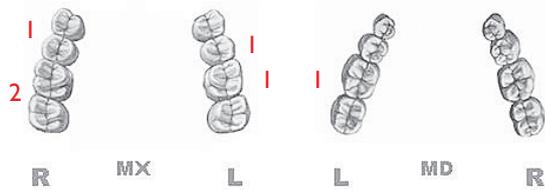
Alignment/Rotations

4



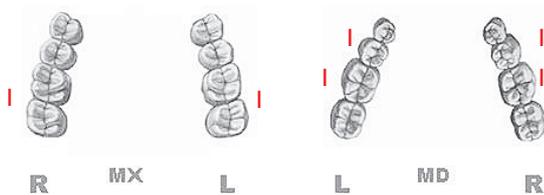
Marginal Ridges

6



Buccolingual Inclination

6



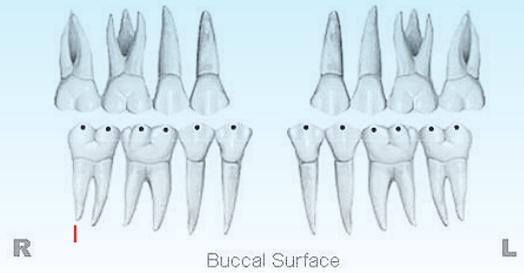
Overjet

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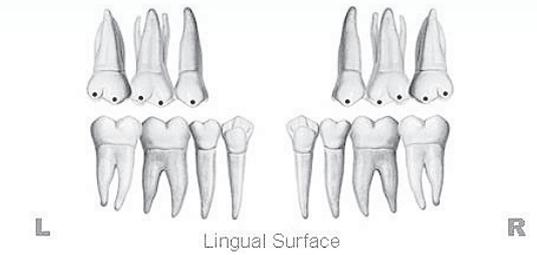


Occlusal Contacts

1



Buccal Surface



Lingual Surface

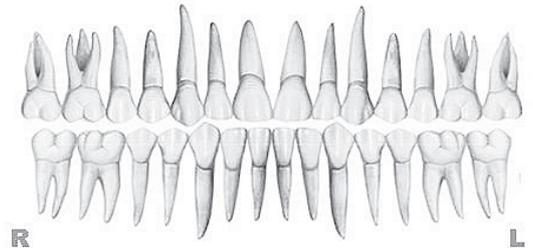
Occlusal Relationships

4



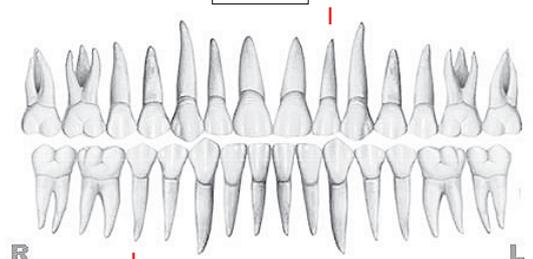
Interproximal Contacts

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Root Angulation

2

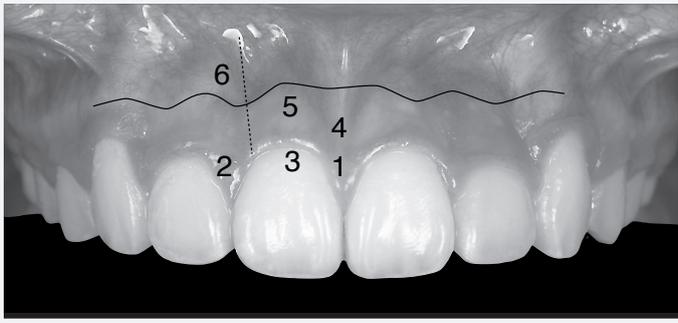


INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 4

1. Pink Esthetic Score

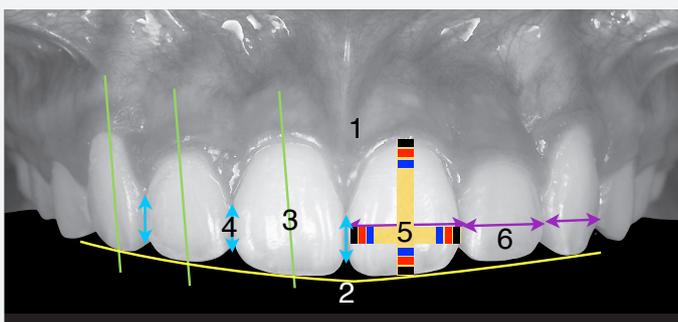


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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

Total = 1

2. White Esthetic Score (for Micro-esthetics)



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

Total = 3