Premolar Substitution for a Missing Maxillary Canine

Abstract

History: *A 19-year-old female presented with a chief complaint (CC) of missing maxillary left canine and crowding.*

Diagnosis: *A skeletal Class I (SNA 78˚, SNB 76˚, ANB 2˚) relationship was associated with a mandibular plane angle (SN-MP 31˚) that was within normal limits (WNL). This Class I malocclusion had an overjet of 2mm at the upper right canine (UR3), a missing upper left canine (UL3), and horizontal fractures (root and crown) of upper left lateral incisor (UL2). The Discrepancy Index (DI) was 9 for this unusual malocclusion.*

Treatment: *Translate the upper left first premolar (UL4) anteriorly to substitute for the missing UL3. The Damon Q® passive self ligating (PSL) system was used to align both arches. At the end of treatment, a diode laser was used for a midline frenectomy and selective gingivectomy in the maxillary anterior region to achieve better esthetics.*

Outcomes: *After 23 months of active treatment, the space for the missing UL3 was successfully substituted by the UL4. The Cast-Radiograph Evaluation (CRE) was 14, and the IBOI Pink & White esthetic score was 5.*

Discussion: *The most important advantage for tooth substitution in the maxillary anterior esthetic zone is permanence and biological compatibility. To achieve optimal esthetics, careful detailing is required during orthodontic treatment in addition to follow-up soft tissue and dental modifications. Compatible crown torque for all teeth in the segment is coupled with new techniques and materials in esthetic dentistry. The primary objective is to restore natural tooth shapes and sizes. In addition, it is important to provide symmetric gingival contours for all dental units, as well as to secure optimal occlusion with cuspid guidance or group function.*

Conclusions: *Interdisciplinary cooperation among orthodontists and other dental specialists is critical for achieving high quality treatment outcomes for premolar substitution to simulate a cuspid. (J Digital Orthod 2021;61:28-44)*

Key words:
Missing left maxillary canine, premolar substitution, canine guidance, group function, frenectomy, laser gingivectomy

Introduction

Management of a unilateral missing maxillary canine is a challenging task in dentistry.[1-12] Orthodontic space closure for dental substitution is an attractive option, but soft tissue and tooth modification are usually necessary for an optimal outcome. In contrast, prosthetic solutions are expensive, and longterm esthetics may be problematic. Due to its shape and position in the arch, the permanent canine is crucial for both functional occlusion and dentofacial esthetics. There are three treatment options for replacing a missing canine: premolar substitution, a tooth-supported pontic (*fixed prosthesis*), or an implant-supported crown. Specific criteria must be addressed. The preference for most patients is a minimally invasive option that achieves optimal esthetics and function. The orthodontist plays a key role by positioning teeth in ideal restorative positions, i.e., preprosthetic alignment.[1-12]

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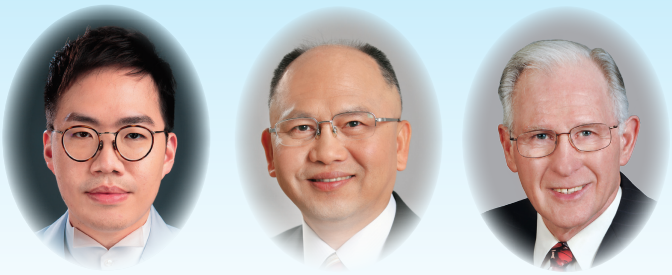

The nomenclature for this report is a modified Palmer notation. Upper (*U*) and lower (*L*) arches, as well as the right (*R*) and left (*L*) sides, define four oral quadrants: UR, RL, LR, and LL. Teeth are numbered 1-8 from the midline in each quadrant, e.g., a lower right first molar is LR6.

History and Etiology

A 19yr-2mo-old female sought orthodontic consultation to evaluate a fractured lateral incisor (*UL2*) and missing maxillary left canine (*UL3*) (*Figs. 1 and 2*). Contributing history was a car accident in 2015. Clinical examination revealed an acceptable

Fig. 1: Pre-treatment facial and intraoral photographs

facial profile. Overbite was 2mm. Overjet was 1-2mm at the incisal edges of the rotated upper central incisors (*Figs. 1 and 2*). Crowding was 6 and 4mm for the upper and lower arches respectively. The sagittal relationship of occlusion was Class I (*Figs. 1 and 2*). Panoramic and cephalometric radiographs provided pretreatment documentation (*Figs. 3 and 4; Table 1*).

Diagnosis

Skeletal:

- Class I relationship (*SNA 78˚, SNB 76˚, ANB 2˚*)
- Normal mandibular plane angle (*SN-MP 31˚, FMA 24˚*)

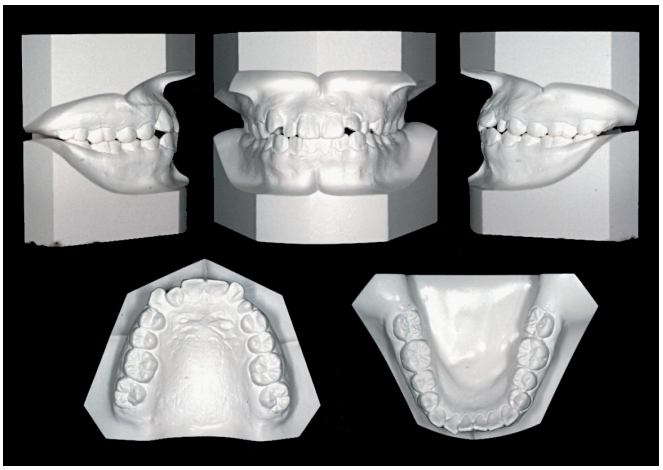

Fig. 2: Pre-treatment dental models (casts)

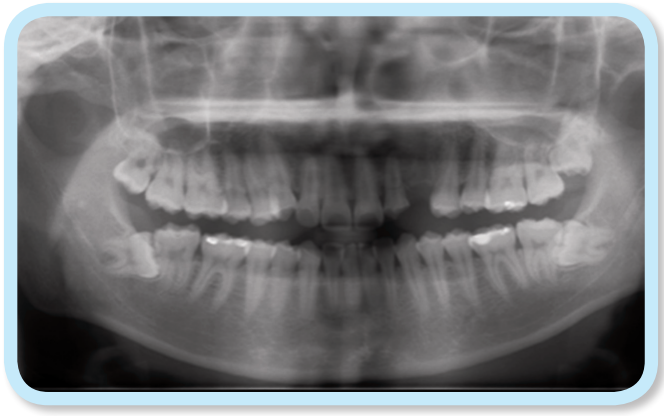

Fig. 3: Pre-treatment panoramic radiograph

Fig. 4: Pre-treatment lateral cephalometric radiograph

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA˚ (82°)	78˚	79˚	1˚
SNB˚ (80°)	76˚	77˚	1˚
ANB˚ (2°)	2˚	2˚	0˚
SN-MP˚ (32°)	31˚	31˚	0˚
FMA˚ (25°)	24˚	24˚	0˚
DENTAL ANALYSIS			
U1 To NA mm (4mm)	5	2	3
U1 To SN˚ (104°)	110˚	101˚	9˚
L1 To NB mm (4mm)	5	1	4
L1 To MP˚ (90°)	92˚	81˚	11˚
FACIAL ANALYSIS			
E-LINE UL (-1mm)	-2	-4	2
E-LINE LL (0mm)	-1	-3	2
%FH: Na-ANS-Gn (53%)	54%	54%	0
Convexity: G-Sn-Pg' (13°)	9˚	10˚	1˚

Table 1: Cephalometric summary

Dental:

- Class I malocclusion
- Overjet/Overbite were both 2mm
- Missing UL3
- Horizontal fractures of the UL2, both the crown and the root

Facial:

- U/L lip position to the E-line was -2mm/-1mm

The American Board of Orthodontics Discrepancy Index (*DI*) score was 9.

Treatment Objectives

Maxilla (all three planes)**:**

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

Mandible (all three planes)**:**

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

Maxillary Dentition:

- A-P: *Slight retraction of incisors*
- Vertical: *Maintain*
- Inter-molar Width: *Decreased width as molars are protracted anteriorly*

Mandibular Dentition:

- A-P: *Retract incisors*
- Vertical: *Maintain*
- Inter-molar Width: *Decrease as molars are protracted forward*
- Inter-cuspid Width: *Maintain*

Facial Esthetics: *Maintain*

Treatment Plan

The overall objectives were to restore the missing UL3, retract the lips, and close interproximal spaces. Several options were considered:

1. Extract UR4, LL4, and LR4, and substitute the UL4 for the missing UL3.

2. Align and restore the missing UL3 with an implant-supported prosthesis.

3. Conventional fixed prosthesis to restore the UL3, utilizing the UL2 and UL4 as abutments

Option 1 was to create space in the other three quadrants by extracting UR4, LL4, and LR4. Utilize differential space closure in all four quadrants to substitute the UL4 for the missing UL3. Correct rotations and close all spaces to retract the lips. Reshape the UL4 as needed to simulate a UL3. This option is a minimally invasive approach to achieve optimal esthetics and function. ***Option 2*** requires less orthodontics, so the treatment time is less, but an implant-supported prosthesis is expensive and may result in a longterm esthetic compromise particularly if there is any remaining growth or occlusal adaptation. ***Option 3*** is non-extraction preprosthetic alignment for a conventional 3-unit bridge. The disadvantage for this approach is

extensive abutment preparation, i.e., a loss of 60-70% of crown structure for the abutments which may lead to endodontic and/or abutment fracture problems long-term.

After a careful discussion of the three treatment plans, the patient selected ***Option 1*** because of the potential for the most ideal dentofacial result. Furthermore, this alternative was the least expensive overall because it was less likely to result in longterm esthetic problems, and no special maintenance was required.

Treatment Progress

Extraction of the three first premolars (*UR4, LL4, and LR4*) was performed at the beginning of the treatment to provide space for initial dental alignment. A self-ligating fixed appliance (*Damon Q®, Ormco Corporation, Brea, CA*) was bonded on all upper teeth, and a 0.014-in CuNiTi archwire was engaged. A high-torque bracket was chosen for the UR3 in case of loss of torque during space closure. Standard-torque brackets were chosen for upper central and lateral incisors (*Fig. 5*).

Since the UL2 was fractured, tooth movement was minimized. To prevent interference with the lower brackets, bite turbos were placed on the lower first molars. A 0.018-in CuNiTi archwire was inserted to the maxillary arch. High-torque brackets were selected for lower canines, and standard-torque brackets for lower central and lateral incisors. A 0.014-in CuNiTi lower archwire was inserted (*Fig. 6*). During this period, early alignment of the upper and lower arches was achieved with progressive 0.014x0.025-in CuNiTi and 0.017x0.025-in TMA archwires. After thirteen months of treatment, posterior bite turbos were removed, and anterior bite turbos were placed on the palatal surface of the upper central incisors. In the 16th month of treatment, brackets on UR1, UL1, LL5 were repositioned to correct axial angulations. The UL4 was rebonded to adjust the gingival margin to simulate a canine. In the 20th month of treatment, a more rigid archwire 0.016x0.025-in SS was used for final space closure. After 23 months of active treatment, all appliances were removed, and two fixed retainers were delivered: a maxillary anterior 2-2 and a lingual mandibular 3-3. Removable clear overlay retainers were provided to maintain both arches.

To improve esthetics, a frenectomy and selective gingivectomy were performed with a diode laser.[6-8] The desired soft tissue margins were defined for the upper four incisors, right canine, and substituted left premolar (*Fig. 7*). Post-treatment records were collected: casts and photographs plus panoramic and lateral cephalometric radiographs (*Figs. 8-11*).

Results Achieved

Maxilla (all three planes)**:**

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

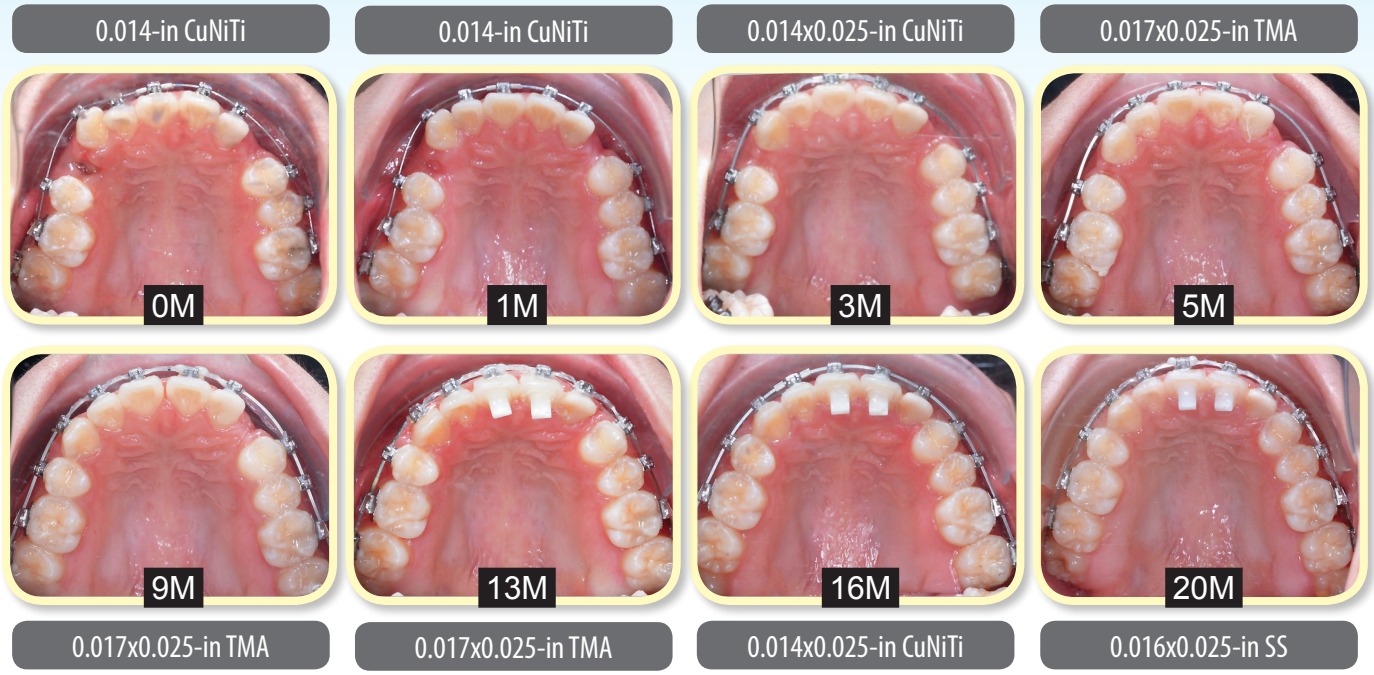

Fig. 5:

A progressive series of maxillary occlusal photographs document treatment progress in months (M) and the maxillary archwire progression from the start of treatment (0M) to twenty months (20M).

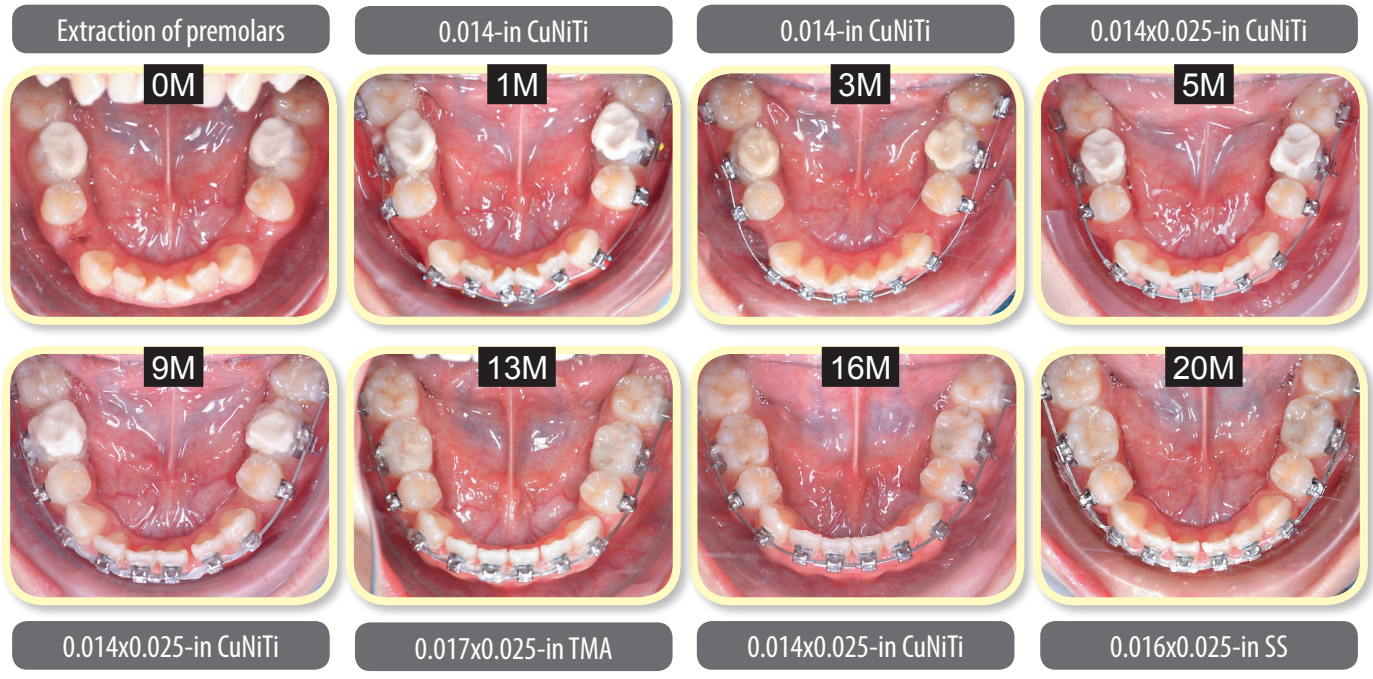

Fig. 6:

A progressive series of mandibular occlusal photographs document treatment progress in months (M) and the mandibular archwire progression from the start of treatment (0M) to twenty months (20M).

Fig. 7:
Frenectomy and gingivectomy in the maxillary anterior segment is shown in a progressive series of frontal intraoral photographs. The pre-treatment view is shown on the upper right. Bone sounding was performed for all anterior teeth and the volume of keratinized gingiva was determined. A maxillary midline frenectomy was performed (lower right). See text for details.

Mandible (all three planes)**:**

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

Maxillary Dentition:

- A-P: *Retraction of incisors; Protraction of molars*
- Vertical: *Maintained*
- Inter-molar Width: *Decreased*

Mandibular Dentition:

- A-P: *Retraction of incisors; Protraction of molars*
- Vertical: *Maintained*
- Inter-molar/Inter-canine Width: *Decreased/ Increased*

Facial Esthetics:

- Upper and lower lip: *No change in upper or lower lip protrusion*

Final Evaluation of Treatment

Superimposition of pre-treatment and post-treatment cephalometric tracings (*Fig. 12*) revealed no change in lip prominence, but the upper and lower incisors were uprighted, retracted, and intruded. U1-SN, U1-NA, L1-MP, and L1-NB were substantially decreased (*Table 1*). Extraction space was utilized to correct crowding and protract molars in both arches, but lip prominence was maintained. The mandible grew downward and forward (*Fig. 12*).

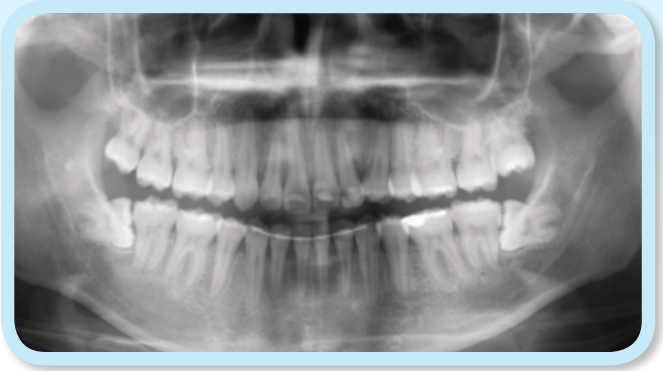

Fig. 8: Post-treatment panoramic radiograph

Fig. 9: Post-treatment lateral cephalometric radiograph

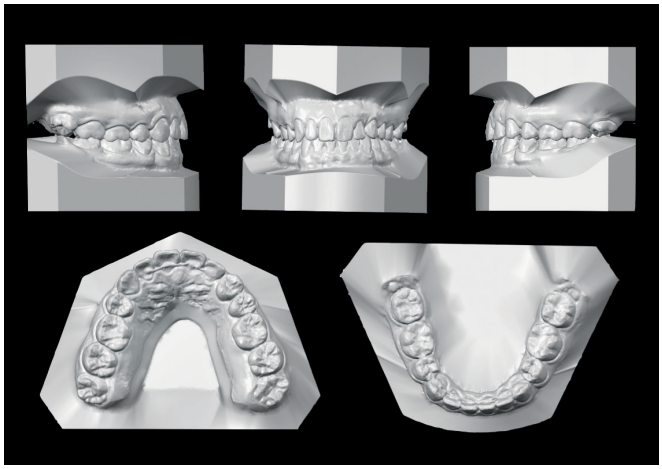

Fig. 10: Post-treatment dental models (casts)

The Cast-Radiograph Evaluation (*CRE*) score was 14 points. The principal residual discrepancies were anterior overjet, root alignment, and occlusal relationships. Bilateral horizontal impaction of lower third molars was an indication for extraction of all four third molars. Total active treatment time was 23 months to achieve optimal alignment. A diode laser was used for a maxillary midline frenectomy plus a modest gingivectomy in the maxillary anterior region. Post-treatment facial and intraoral photographs are shown in Fig. 11. The fractured UL2 was restored, but the gingival margin of the crown was recessed, consistent with excessive axial inclination of the root. The tooth was vital and there was no evidence of root resorption (*Fig. 8*).

Discussion

There are usually three options for replacing a missing canine: premolar substitution, tooth-supported fixed prosthesis, or an implant-supported prosthesis. Selecting the appropriate option depends on the malocclusion, specific space requirements, tooth-size relationship, size of the edentulous space, and the morphology of the contralateral canine.[1-3]

Orthodontic space closure to achieve premolar substitution is a good biologic solution, but the outcome may fail to have a natural appearance and achieve functional disclusion during lateral excursions of the mandible. Furthermore, retention of space closure may be difficult.[4]

When smiling, the contour of the gingival margins of the six maxillary anterior teeth (*esthetic zone*) plays an important role in dentofacial esthetics. The gingival

Fig. 11: Post-treatment facial photographs and intra-oral photographs document the correction after 23 months of active treatment.

margins for the central incisor, lateral incisor, and canine should have a high-low-high relationship.[1-8] More specifically, the gingival margin for central incisors should be on the same level and positioned more apically compared to the adjacent lateral incisors. The gingival margin for the adjacent canine should be at about the same level as the central incisor. For optimal dentofacial esthetics, the gingival margins should correspond to the cementoenamel junction (*CEJ*) for each tooth, be symmetric, and have a healthy gingival papilla in each interdental embrasure.[5]

Orthodontic intrusion and extrusion are common strategies for changing the clinical exposure of a tooth crown, but ultimately the clinical crown is determined by the level of a healthy epithelial attachment. To achieve the desired height of the gingival margin, it is usually necessary to intrude a mesially substituted first premolar.[6-8] However, optimal esthetics and function for simulating a canine usually requires adjustments of crown morphology for the substituted premolar. Crown lengthening procedures may be needed to achieve the desired gingival margin, but that option is not

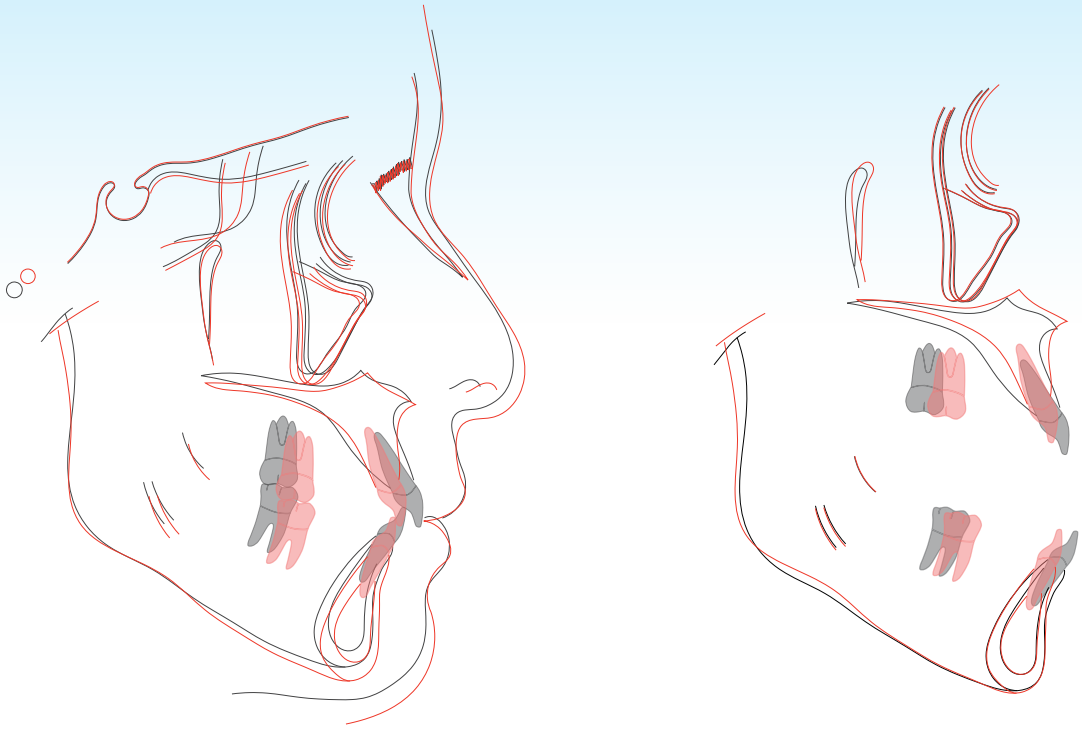

Fig. 12:
Initial (black) and final (red) cephalometric tracings are superimposed on the anterior cranial base (left), the skeletal structures of the maxilla (upper right), and the mandible (lower right).

always predictable. Typical problems may be loss of periodontal attachment, exposure of the CEJ, and denuded root surfaces (*sensitivity*).

Canine Shape

In the maxillary arch, the mesiodistal dimension for the first premolar is narrower than for the canine (*Table 2*). Reshaping of the palatal cusp as well as bonding and tinting may be required to effectively simulate a canine. Additional esthetic bonding is required to form a canine-like cusp tip.

Inclination and Root Eminence

A substituted first premolar usually requires intrusion, followed by restoration with composite

Fig. 13:
A drawing of an upper canine is superimposed on the adjacent first premolar to demonstrate the more prominent root and cervical enamel curvature of the canine (blue). For a first premolar to effectively simulate a cuspid, three morphologic changes are needed: 1. add resin at the gingival margin (blue area), 2. lengthen the buccal cusp, and 3. reduce the palatal cusp. See text for details.

resin or a porcelain veneer (*Fig. 13*). Intrusion of a maxillary premolar may not achieve adequate root prominence (*alveolar eminence*). Labial root torque may be required for more root prominence, as well as to avoid unesthetic exposure of the lingual cusp when smiling. In any event, the premolar should be properly aligned prior to modification of crown morphology.

Angulation and Mesiodistal Position

Compared to a premolar, the mesial surface of a canine is longer, and the contact point is closer to the incisal tip. Moreover, the long axis of canine is 17˚, and the premolar is 9˚ (*Table 2*), so the angulation of the premolar bracket requires adjustment. Once optimal pre-restorative alignment is achieved, restorative details can be adjusted with recontouring and esthetic bonding.

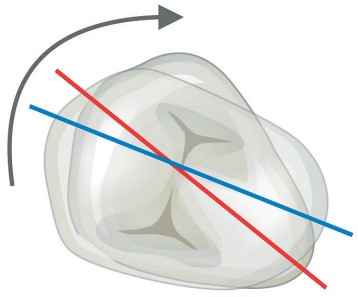

Fig. 14:
To present a more canine-like appearance, a first premolar requires slight rotation of the mid-frontal plane (blue line) to the mesial (red line).

Rotation

The mesial line angle of the first premolar is more prominent than for a canine. To simulate a more canine-like appearance, the first premolar is rotated slightly to the mesial by distally positioning the bracket on the crown (*Fig. 14*).

Bracket Selection

Buccal crown torque for a mesially substituted first premolar should be relatively perpendicular. Intrusion of the premolar increases the buccal crown torque. To resist this undesirable side effect, a pretorqued first premolar bracket is preferred because it has more negative torque (*-7˚*) than the canine bracket (*0˚*). In effect, the usual negative torque in a premolar bracket compensates for the positive torque that is a side effect of intrusion.

Occlusal Function

A cuspid-protected, functional occlusion is difficult to achieve with orthodontics, but it is a desirable goal.[10,11] More realistically, it is necessary to reduce the palatal cusp height and rotate the premolar mesially to establish contact with the mandibular cuspid on the mesial ridge of the buccal cusp. Some clinicians fear that canine substitution exposes a premolar to excessive functional loads. Long-term studies of periodontal condition and occlusal function from 2-25 (*mean 9.7*) years after treatment have failed to demonstrate any significant problems.[10] Group function is usually the optimal occlusion pattern for canine substituted premolars.[10-12]

Maxillary	Central Incisor	Lateral Incisor	Canine	1st Premolar	2nd Premolar	1st Molar	2nd Molar
Angulation (mesiodistal)	2˚	7˚	17˚	9˚	5˚	10˚	8˚
Inclination (facioligual)	28˚	26˚	16˚	5˚	6˚	8˚	10˚
Crown Size (Mesiodistal)	8.5	6.5	7.5	7	7	10	9

Adapted from Andrews and Wheeler

Table 2: Angulation, inclination, and crown size

Horizontal Root Fracture

The lateral incisor with a fractured crown (*UL2*) reportedly had a root fracture that was well healed prior to treatment (*Fig. 3*). Horizontal root fractures reflect severe trauma, such as an automobile accident or sports injury.[13] Compared with other dental impact injuries, the incidence is relatively low, ranging from 0.5 to 7%.[14-17] Healing sequelae following horizontal root fracture have been described:[15,18,19]

1. healing with calcified tissue;
2. healing with interproximal connective tissue;
3. healing with interproximal bone and connective tissue
4. interproximal inflammatory tissue without healing

Some case reports describe pulp vitality after spontaneous healing.[14] It is recommended that all teeth with horizontal root fractures be followed for at least 2 years prior to initiating orthodontic movement. A similar corroborating case report was published by Hovland et al.[20]

Premolar Substitution

The most obvious advantage for space closure to achieve premolar substitution is the permanence and biological compatibility of the finished result. However, there may be esthetic and stability problems that require careful detailing throughout orthodontic treatment, as well as finishing to achieve optimal positioning and crown torque.[2,5] Coupling orthodontic substitution with new esthetic techniques and materials can achieve natural tooth shapes, sizes, and gingival contours.[4,8] Securing an optimal occlusion with cuspid guidance or group function is consistent with long-term stability of the orthodontic treatment.[7,8]

Conclusions

Prospective interdisciplinary cooperation between orthodontists and other dental specialists is critical for obtaining and maintaining a high quality outcome for premolar substitution to simulate a canine.

Fig. 15: Facial and intraoral photographs at 3-year follow-up document the current condition of the patient.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 9

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 = 0

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 = 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 = 0

OTHER (See Instructions)

Supernumerary teeth	_____	x 1 pt. =	_____
Ankylosis of perm. teeth	_____	x 2 pts. =	_____
Anomalous morphology	_____	x 2 pts. =	_____
Impaction (except 3rd molars)	_____	x 2 pts. =	_____
Midline discrepancy (≥3mm)		@ 2 pts. =	_____
Missing teeth (except 3rd molars)	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	2	x 2 pts. =	4

Identify: Protrusive lower lip

Total = 5

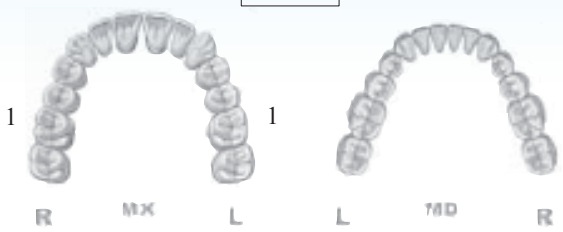
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 14

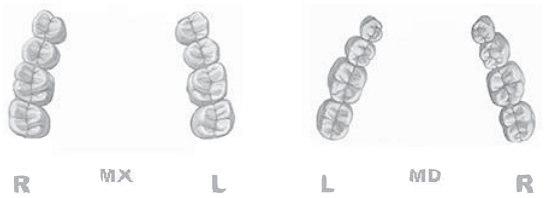
Alignment/Rotations

2



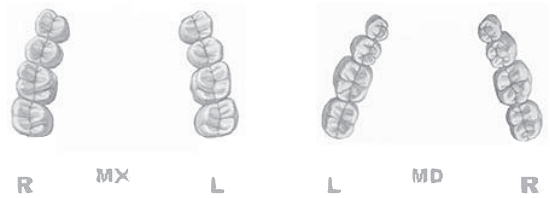
Marginal Ridges

0



Buccolingual Inclination

0

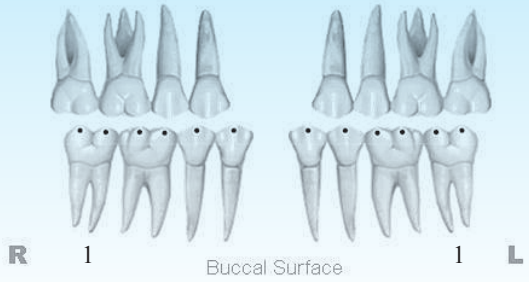


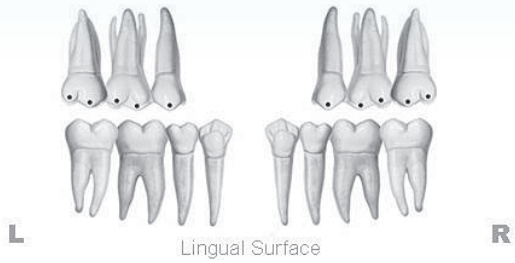
Overjet

4

Occlusal Contacts

2



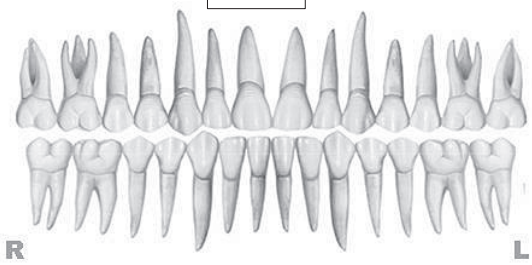


Occlusal Relationships

3

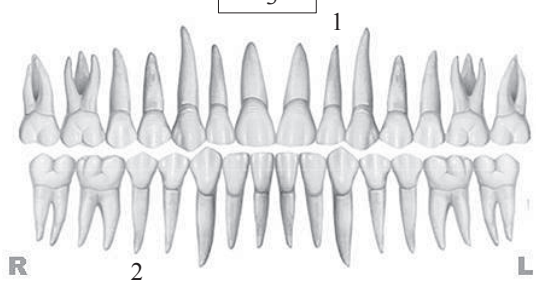
Interproximal Contacts

0



Root Angulation

3



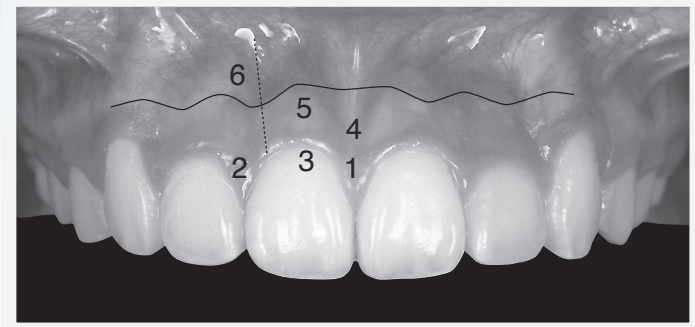
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

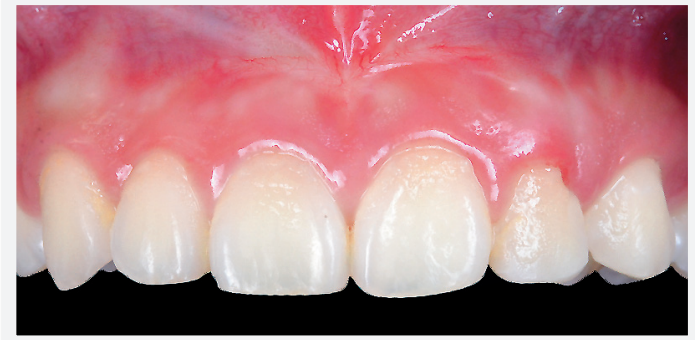
Total Score: = 5

1. Pink Esthetic Score

Total = 1



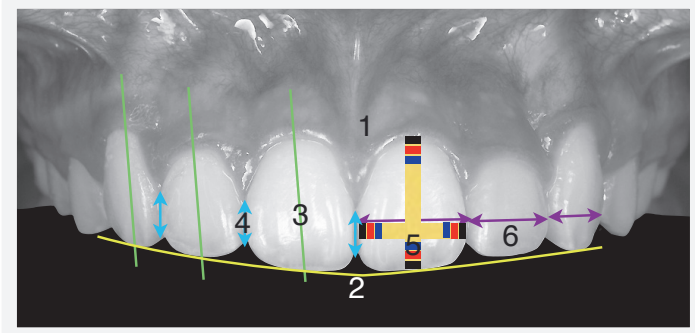
1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2



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 = 4



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