Recovery of an Inverted Maxillary Central Incisor Impaction with a Dilacerated Root

Abstract

Introduction: *A 19 year- 4 month male presented with a chief complaint (CC) of poor dental and facial esthetics.*

Diagnosis: *Increased facial convexity (16˚) and lower facial height (59%) were associated with a steep mandibular plane (FMA 31˚), retrusive maxilla (SNA 80.5˚) and mandible (77˚), plus an intermaxillary base discrepancy (ANB 3.5˚). Moderate anterior crowding was noted in both arches, and molar relationships were Class I. The UR1 was missing, contributing to a 4mm midline deviation and full anterior crossbite. Radiographic images documented complete inversion of the UR1, with a dilacerated root conforming to palatal contour distal to the root of the UR2. The Discrepancy Index (DI) was 28.*

Etiology: *Severe impaction of the UL1 was apparently due to a deviated path of eruption which may have related to improper development of the tooth, and/or limited space in the arch due to traumatic injury of the primary dentition.*

Treatment: *Standard torque, passive self-ligating (PSL) brackets were bonded upside down on the upper anterior teeth to prevent labial flaring, when the UR1 space was opened. Low torque brackets were bonded upside down on the lower incisors to prevent lingual tipping with Class III elastics. Two infra-zygomatic (IZC) bone screws were placed buccal to the second molars (IZC 7) to retract the entire maxillary arch. Surgical exposure of the UR1 was performed following 12 months of space opening. A UR1 replica was produced with a 3D printer using the cone-beam computed tomography (CBCT) image. The replica was used clinically to plan the staged path for traction. A slow traction procedure, with regular periodontal maintenance, was performed to avoid a premature perforation of the labial alveolar plate. A rectangular archwire and Warren torquing spring were used to upright the UR1.*

Results: *Facial esthetics and symmetry were improved, but moderate root resorption was noted for all four maxillary incisors. This challenging malocclusion with an inverted UR1 (DI = 28) was treated in 60 months to an excellent outcome, as evidenced by a Cast-Radiography Evaluation (CRE) score of 17, and Pink & White (P&W) dental esthetic score of 5. The UR1 was recovered and aligned in a satisfactory position, which required only removable retention.*

Conclusion: *Despite root dilaceration of more than 90˚ in the sagittal plane, and a horizontal rotation of the impaction to impinge on the roots of the UR2, the UR1 was recovered and optimally aligned. Complex interdisciplinary care required a long treatment time (60 mo), but resulted in an excellent outcome. CBCT images and 3D printed replicas were valuable for diagnosis and recovery of the complex impaction. (J Digital Orthod 2019;53:4-25)*

Key words:
Inverted impacted maxillary central incisor, root dilaceration, IZC bone screws, anterior crossbite, CBCT, three dimensional printing, self-ligation appliance, 3D printed replica

History and Etiology

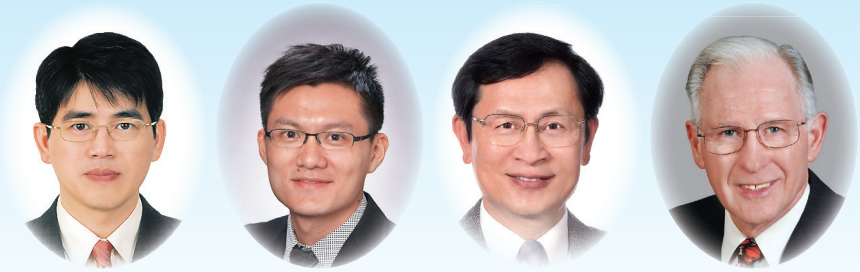
Dental nomenclature for this report is a modified Palmer notation: upper right (*UR*) and left (*UL*), and lower right (*LR*) and left (*LL*) quadrants. Teeth in each quadrant are numbered from 1-8 relative to the midline. A 19 year 4 month male presented with a convex lateral profile, anterior crossbite, impacted UR1, and the maxillary midline shift was 4mm to the right (*Figs. 1 and 2*). Cephalometric, panoramic, and anterior-posterior

Dr. Yu-Hsin Huang,
Lecturer, Beethoven Orthodontic Course (Left)

Dr. Po-Jan Kuo,
Periodontist, Jing-Jong Lin Orthodontic Clinic (Center Left)

Dr. John Jin-Jong Lin,
Examiner of IJOI, Director of Jin-Jong Lin Orthodontic Clinic (Center Right)

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



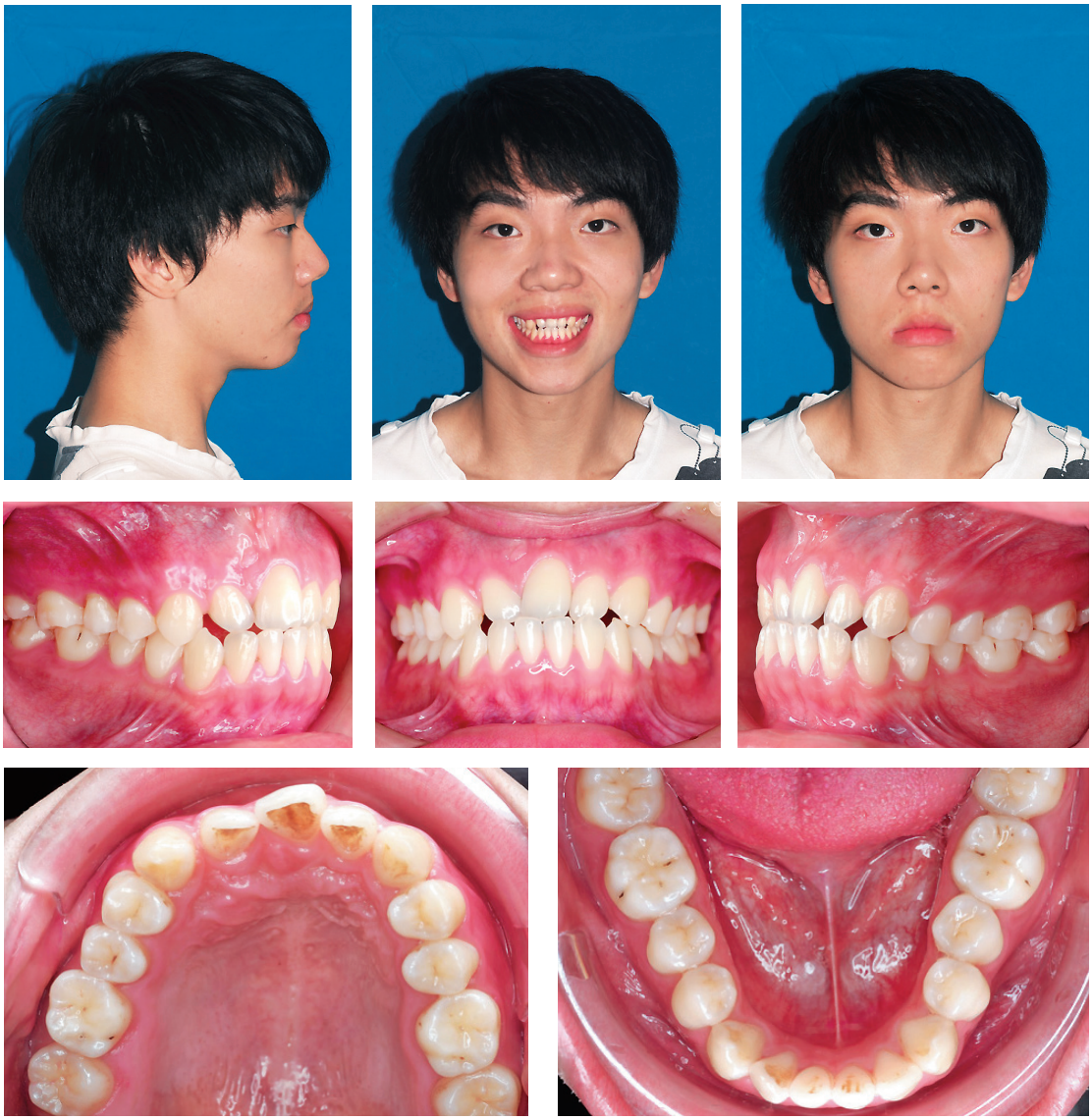


Fig. 1: Pre-treatment facial and intraoral photographs

radiographs of the head (*Figs. 3-5*) revealed that the UR1 was a complex, inverted impaction with a dilacerated root. There was no history of significant trauma, dental problems, or medical disorders. The etiology appeared to be a deviated path of eruption of the UR1 followed by root formation in a distolingual direction that encroached on the cortical plate of the palate, resulting in a horizontal impaction lingual to the UR2. Recognizing the severity of the problem, the patient's dentist referred him to an interdisciplinary team: orthodontist, periodontist and radiologist.

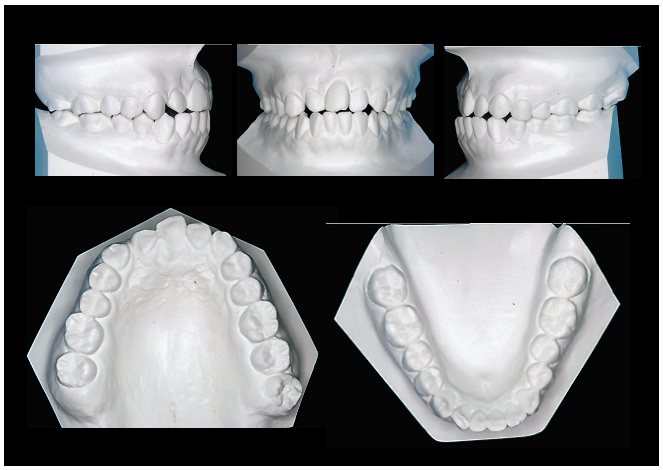


Fig. 2: Pre-treatment dental models (casts)

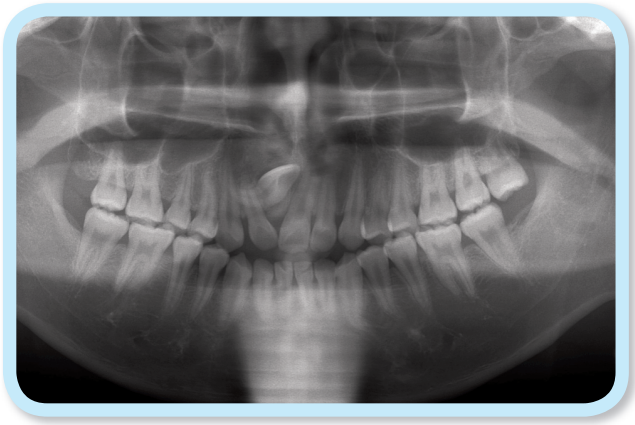


Fig. 3:
Pre-treatment panoramic radiograph shows the impacted UR1 with a dilacerated root superimposed under the UR2 root.

Fig. 4:
Pre-treatment cephalometric radiograph in centric occlusion reveals an anterior crossbite with an inverted maxillary central incisor impaction.

Fig. 5:
Pre-treatment posterior-anterior (P-A) radiograph of the head.

Diagnosis

Facial:

- Facial Height: *Increased (59%) with tapered facial form*
- Protrusion: *Relatively protrusive lower lip (3mm to the E-Line)*
- Symmetry: *Maxillary dental midline 4mm to the right, occlusal plane cant (Fig. 1)*
- Smile Line: *Upper lip has an asymmetric elevation on the right side consistent with the occlusal cant (2mm inferior on the patient's right side).*

Skeletal:

- Intermaxillary Relationship: *Retrusive (SNA 80.5˚, SNB 77˚, ANB 3.5˚)*
- Mandibular Plane: *Excessive (SN-MP 38˚, FMA 31˚)*
- Vertical Dimension of Occlusion (*VDO*): *Excessive Na-ANS-Gn (59%)*
- Symmetry: *Within normal limits (WNL)*

Dental:

- Classification: *Class I bilaterally*
- Overbite: *1mm*
- Overjet: *-2mm*
- Missing / Unerupted / Impacted: *UR1 inverted with severe root dilaceration and positioned palatally to the UR2*
- Symmetry: *Upper midline deviated 4mm to the right*

The American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*) was 28 as documented in to the subsequent worksheet.

Specific Objectives of Treatment

The treatment objectives were: 1. correct the anterior crossbite and asymmetric dental arches, 2. open space for the impacted UR1, 3. extrude, upright and rotate the inverted UR1 into occlusion, 4. coincide the upper dental midline from the right to facial midline.

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: *Maintain*
- Vertical: *Maintain*
- Inter-molar / Inter-canine Width: *Maintain/Expand*

Mandibular Dentition:

- A - P: *Retract*
- Vertical: *Maintain*
- Inter-molar / Inter-canine Width: *Maintain*

Facial Esthetics:

- Correct protrusive lower lip

Treatment Alternatives

The 3-Ring Diagnosis for assessing anterior crossbite is helpful for evaluating skeletal discrepancies.[1,2]

Extraction of the UR1 impaction simplifies dental alignment in the upper arch, but extraction and enamel stripping is indicated in the lower anterior region to correct the overjet and overbite. In addition, periodontal crown lengthening and esthetic restorations and/or implant surgery may be required to adequately restore esthetics and function. A nonextraction treatment plan to recover an inverted impaction (*UR1*) is complicated, and will require an extended duration of active treatment, but it would probably be the most esthetic outcome. In this context, three treatment options are considered (*Fig. 6*):

1. **Option 1** (*Plan A*): Extract the impacted UR1, UL1 and both lower first premolars (*LR4, LL4*). Differential closure of the extraction spaces achieves Class II canine and Class I molar relationships. Apply interdisciplinary periodontal surgery and restoration procedures as indicated.

2. **Option 2** (*Plan B*): Extract the UR1 and retract both upper buccal segments with anchorage provided by infra-zygomatic crest (*IZC*) bone screws. Open space to install an osseointegrated implant to restore the UR1. Perform bone and soft tissue augmentation as needed for an optimal outcome.[3,4]

3. **Option 3** (*Plan C*): Open space for the impaction while retracting both maxillary buccal segments with IZC bone screw anchorage. Uncover the UR1 and bond attachments to upright and rotate the impaction into an optimal occlusion. This approach results in a Class I occlusion, but the severely dilacerated root of the UR1 may penetrate the labial alveolar plate.

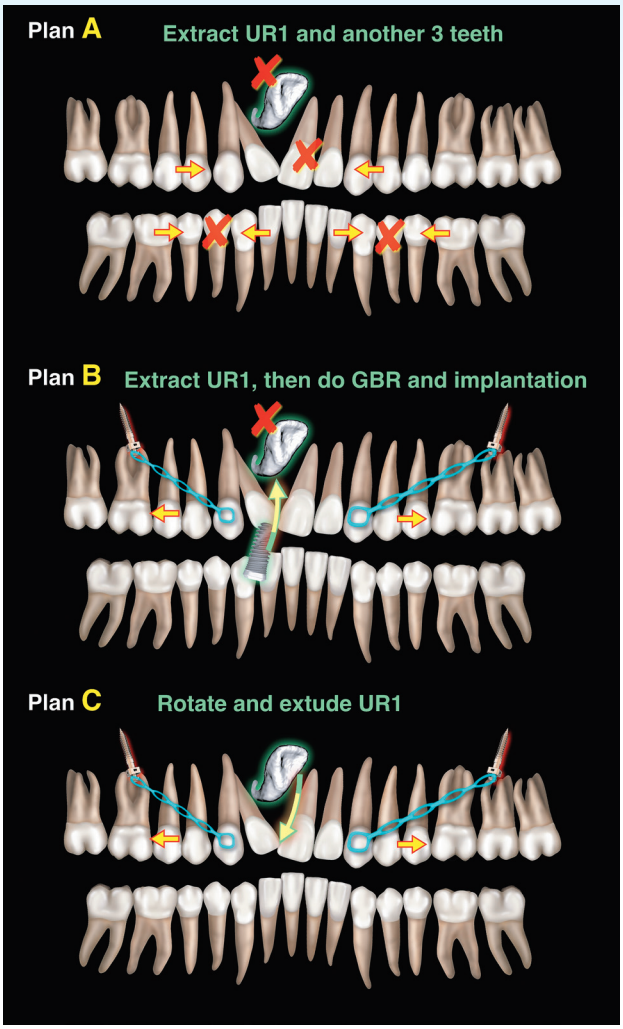


Fig. 6:
A three-part diagram shows three treatment approaches: Plan A is Option 1, Plan B is Option 2, and Plan C is Option 3. See text for details.

Rationale: Extracting 4 teeth as specified in Option 1 would correct dental crowding, reduce facial protrusion, and retract the lips, probably resulting in favorable lip protrusion to the E-line. However, the Class II canine relationships and substitution of lateral for central incisors are

esthetic compromises that require considerable periodontal and restorative rehabilitation for an optimal outcome. Option 2 avoids the long and uncertain recovery process for the challenging impaction, but favorable longterm outcomes are unpredictable for an implant-supported prosthesis replacing a single maxillary incisor. Complicated bone augmentation and implant surgery for the expected atrophic ridge are unlikely to match the natural periodontium of the adjacent UL1. An additional challenge is the longterm aging of the patient because osseointegrated implants do not move physiologically like natural teeth.[3-5] Correcting the position of an implant-supported prosthesis may require surgical repositioning with a segmental osteotomy and osseodistraction.[6] The last treatment option (*Plan C*) preserves all the teeth except the UR8. Although the inverted UR1 has an extremely dilacerated root, the crown of the incisor is ideal for alignment in the arch. Furthermore extruding and rotating the UR1 into position naturally generates periodontium to match the adjacent teeth.

3D Imaging and Replica: CBCT images and a replica produced with a 3D printer were valuable procedures for determining that a recovery procedure was practical. Based on imaging confirmation of a well-formed crown for the UR1 impaction, a plan was formulated for a staged rotation in two planes, that was associated with extrusion of the impaction into occlusion. Despite the well discussed technical challenges and long treatment time, the patient preferred the recovery and alignment of the UR1 impaction (*Option 3*) because that approach was most likely to produce the most desirable esthetics and function.

Treatment Progress

A 0.022-in slot Damon Q® passive self-ligating (*PSL*) appliance (*Ormco, Glendora, CA*) was installed on all permanent teeth, and 0.014-in copper-nickel-titanium (*CuNiTi*) wires were placed in both arches. Standard-torque brackets were bonded upside down on the upper anterior teeth to prevent excessive flaring as the UR1 space was opened (*Fig. 7*). Inverted low torque brackets were bonded on the lower anterior teeth (*Fig. 8*) to prevent lingual tipping as they were retracted with Class III elastics (*Fox 1/4-in, 3.5-oz*). Space was opened for the UR1 (*Fig. 9*). Elastic chains were placed from the maxillary canines to the

Fig. 7:
The initial mechanics for the selected treatment Option 3 (Plan C) included an open coil spring, IZC-7 bone screws, elastic chains and Class III elastics. See text for details.

IZC screws to prevent anterior flaring as the space was opened.

In the 5th month, upper left posterior segment retraction failed to keep pace with the contralateral side. CBCT images revealed that retraction of the UL7 roots was blocked by the IZC bone screw (*Fig. 10*). The screw was repositioned and upper left segment retraction was continued. One month later, the arch wires were changed to 0.018-in CuNiTi in the upper and 0.014x0.025-in CuNiTi in the lower. Class III elastics (*Fox 1/4-in, 3.5-oz*) from U6s to L3s was combined elastic chains from the bone screws to U4s. After one month, arch wires were changed to 0.014x0.025-in CuNiTi in the upper and wire, the lower archwire was upgraded to a 0.018x0.025-in CuNiTi in the lower. Diagonal elastics were utilized as needed to achieve a Class I canine relationship.

Fig. 8:
The self-ligation brackets were bonded upside down. See text for details.

In the 9th month of treatment, smaller diameter archwires (*0.014x0.025-in CuNiTi*) were placed in both arches to accommodate the repositioned brackets on UR2 UL3 LL3 LR1 and LR3. The UR2 bracket was specifically oriented to incline the root distally to create adequate space for UR1 rotation and extrusion. Three months later, the UR1 was exposed, a bracket was bonded on the enamel surface, and an elastic chain was connected to the archwire (*Fig. 11*). Following three months of traction, the incisal edge of the UR1 was sufficiently exposed to bond a bracket near the incisal edge on the labial

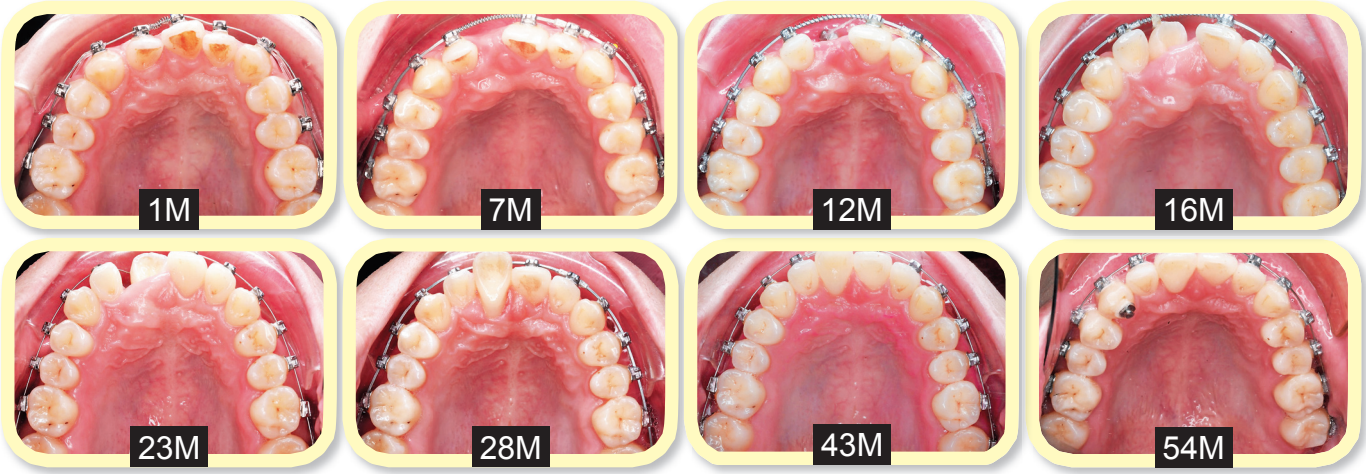


Fig. 9: A progressive series of occlusal photographs show treatment progress from 1-54 months (1M-54M). See text for details.

surface. The line of traction force was adjusted so the dilacerated root of UR1 rotated mesially to unlock the root from the palatal surface of the UR2. The rotational plane for the UR1 was carefully monitored with CBCT imaging. The replica of the impaction produced with a 3D printer (*Fig. 12*) was used to plan the mechanics. In the 18th month of active treatment, a gum boil-like lesion was noted in the vestibule above the UR1. Fortunately, the lesion was submucosal scar tissue and not a penetrating root tip. The scar tissue was removed without compromising the vitality of the UR1.

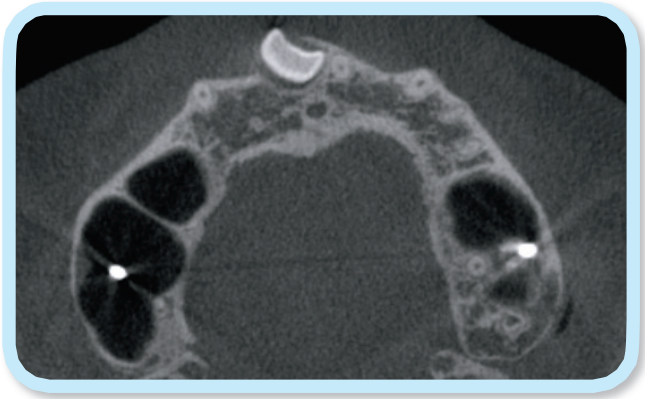


Fig. 10:
A horizontal cut from a CBCT image shows the crown of the impaction and two IZC screws that are near or within the maxillary sinus. See text for details.

To apply a more horizontal force with a chain of elastics, a long hook was crimped mesial to the coil spring in the edentulous site on a new stiffer archwire (*0.016x0.025-in SS*). In the 20th month of treatment, the dilacerated root of UR1 was still lodged behind the UR2 root so two buttons were bonded near the incisal surface of the UR1, and a chain of elastics was activated to the archwire to apply a moment to the UR1 root in the frontal plane (*Fig. 13*).

After 23 months of treatment, the UR1 root was mesial to the UR2 root, so a PSL bracket was bonded on the UR1, and the entire upper arch was engaged with a light-force 0.013-in CuNiTi (*Fig. 14*). Three months later, the incisal edge of UR1 was

Fig. 11:
A progressive series of frontal intraoral photographs show UR1 extrusion, rotation and alignment from 12-31 months (12M-31M). See text for details.

Fig. 12:
Clinical evaluation of the UR1 position using a 3D printed replica. See text for details.

Fig. 13:
Extrusion and rotation mechanics adjusted to move the root of the UR1 past the root of the UL2. See text for details.

aligned, but there was palatal gingival recession that required labial root torque on the UR1 (*Fig. 9*). One month later, the IPR (*interproximal reduction*) was performed between the UR1 and UL1 to correct a black triangle, and the next month an upper 0.018x0.025-in CuNiTi archwire was placed.

In the 29th month of treatment, a smaller diameter upper archwire (*0.014x0.025-in CuNiTi*) was inserted. Two months later, a Warren torquing spring was activated for UR1 labial root torque (*Fig. 15*). In the 34th month of treatment, IPR was performed between

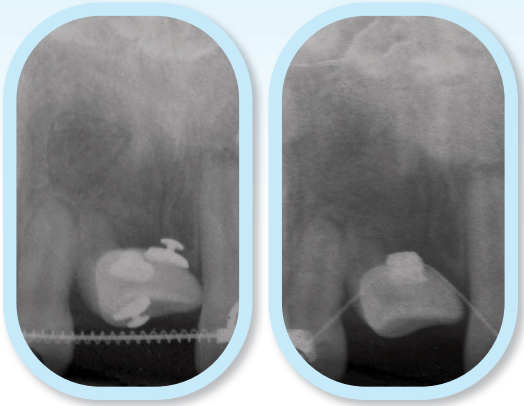


Fig. 14:
Left: After 23 months of treatment, a periapical radiograph shows the root of the UR1 is mesial to the root of the UR2. Right: A PSL bracket is bonded and UR1 and a light continuous archwire is engaged for alignment. See text for details.

LR1 and LR2, and a new UR1 Warren torquing spring was placed on the UR1. The following month an upper 0.018x0.025-in CuNiTi archwire was placed. The archwire was stepped up between the LR3-LL3, and Class III elastics (*Fox 1/4-in, 3.5-oz*) were resumed. One month later, an upper 0.018x0.025-in CuNiTi archwire was placed and the UR1 torquing spring was reactivated.

In the 43rd month of treatment, the UR1 bracket was removed to prevent further apical perforation of the UR1 root. After waiting 3 months for the perforation to heal, a bracket was bonded again on the UR1, and both arches were detailed. Class III, diagonal and cross elastics[7] were applied as needed in preparation for final detailing.[8] After 60 months of active treatment, the CC was resolved so all fixed appliances were removed, and retention was achieved with intermaxillary Hawley retainers (*Fig. 16*).

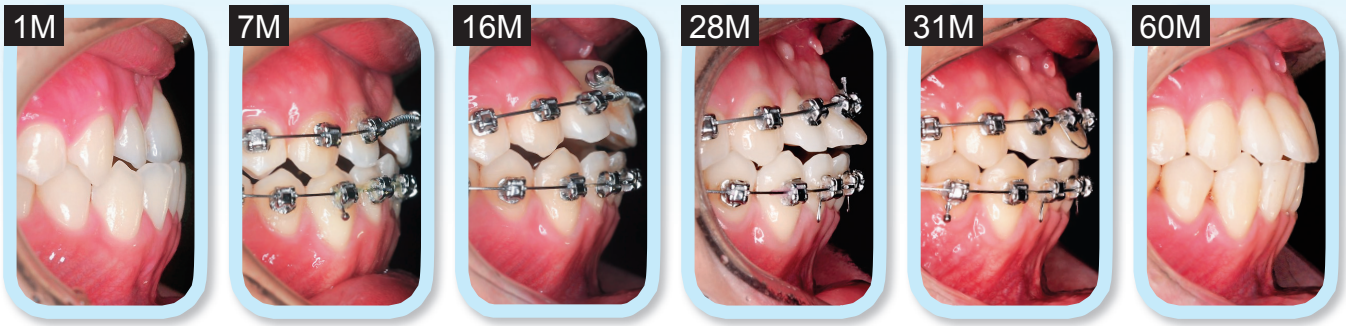


Fig. 15:
A series of intraoral lateral views showing the right incisal area document treatment progress from 1-31 months (1M-31M). See text for details.

Fig. 16:
Removable Hawley retainers were placed after the fixed appliances were removed. See text for details.

Results Achieved

The final results are documented in Figs. 17-21. Sixty months of active treatment resolved a severe malocclusion, complicated by a dilacerated UR1 impaction and anterior crossbite (*DI=28*), to an excellent outcome (*CRE of 17*), as shown in worksheet 2 at the end of this report. With the current non-extraction approach and IZC bone screw anchorage, the LFH (*VDO*) was unchanged, but there was facial improvement associated with a decrease in the FMA, SN-MP and SNB angles (*Table 1*). Maxillary arch expansion to correct anterior crossbite was consistent with a near ideal facial convexity (*G-Sn-Pg' 12°*), but the maxillary incisors were flared (*U1-SN 113°*). The specific treatment objectives[9] are outlined below:

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	80.5°	80°	0.5°
SNB° (80°)	77°	77.5°	0.5°
ANB° (2°)	3.5°	2.5°	1°
SN-MP° (32°)	38°	36°	2°
FMA° (25°)	31°	29°	2°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	4 mm	6 mm	2 mm
U1 To SN° (104°)	100.5°	113°	12.5°
L1 To NB mm (4 mm)	9 mm	8 mm	1 mm
L1 To MP° (90°)	94.5°	91.5°	3°
FACIAL ANALYSIS			
E-LINE UL (-1 mm)	-1 mm	-1.5 mm	0.5 mm
E-LINE LL (0 mm)	3 mm	2.5 mm	0.5 mm
%FH: Na-ANS-Gn (53%)	59%	59%	0%
Convexity: G-Sn-Pg' (13°)	16°	12°	4°

Table 1: Cephalometric summary

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

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

Maxillary Dentition

- A - P: *Flared incisors, slightly retracted molars*
- Vertical: *Incisors were maintained but molars were intruded*
- Inter-molar / Inter-canine Width: *Maintained / Increased*

Mandibular Dentition

- A - P: *Both incisors and molars were retracted.*
- Vertical: *Incisors were maintained but molars were slightly extruded.*
- Inter-molar / Inter-canine Width: *Maintained*

Facial Esthetics:

- Lip profile and facial convexity were improved (*Figs. 17, 20 and 21*)

Retention

Good stability was expected for the recovered UR1 impaction, so Hawley removable retainers were delivered for both arches. Full time wear was prescribed for the first 6 months and nights only thereafter (*Fig. 16*). The patient was instructed in proper home hygiene care and maintenance of the retainers.

Final Evaluation of Treatment

Near ideal overbite, overjet and Class I interdigitation were achieved as documented with a CRE of 17 points. The most prominent CRE deficiencies were alignment/rotations (*4 points*), marginal ridges (*5 points*) and buccolingual inclinations (*5 points*) (*Figs. 17 & 18*). The UR1 was aligned in a slightly more flared angulation than the adjacent incisors, consistent with controlling the tendency for the dilacerated root to penetrate labial cortical plate. Class III elastics tipped the lower molars distally. The pink and white (*P & W*) dental esthetic score was 5. See Worksheet 3 at the end of this report.[10]

Discussion

Impacted maxillary central incisors are a rare occurrence particularly in the absence of supernumerary teeth.[11,12] Despite its low prevalence, a missing upper central incisor often results in major occlusal and esthetic impairments such as midline deviation, asymmetric anterior maxillary esthetic zone, and anterior crossbite. These problems are readily recognized early in mixed dentition by patients and their parents, so treatment is usually attempted in growing individuals.[12,13] Prognosis for a successful recovery of an impacted UR1 or UL1 depends on the impaction's position, orientation, amount of root formation age, degree of root dilaceration, available space in the arch, and potential for root resorption of adjacent teeth.[14-18]

Fig. 17: Post-treatment facial and intraoral photographs

Fig. 18: Post-treatment dental models (casts)

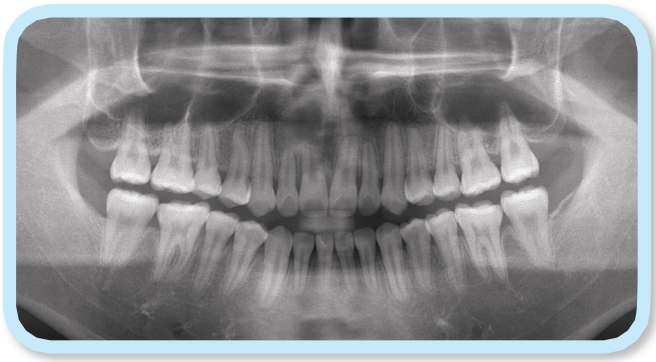


Fig. 19: Post-treatment panoramic radiograph

Fig. 20: Post-treatment cephalometric radiograph

In the early developmental stages, the permanent tooth germ of the maxillary incisor is situated palatal and superior to the apex of the primary incisor, so trauma to a young child's primary incisors is often an etiologic factor for impaction, but not dilaceration.[15,16] Intrusion or avulsion of primary teeth usually occurs before the age of four, long before the root formation of the succedaneous teeth. Other factors have been implicated in dilaceration such as root canal infection, scar tissue, developmental disorders, lack of space and the effect of anatomical structures (*dense bony walls*).[15-17] Dilacerated roots can curve in any direction, but for horizontally impacted maxillary central incisors the deviation is often anteriorly in the sagittal plane because the

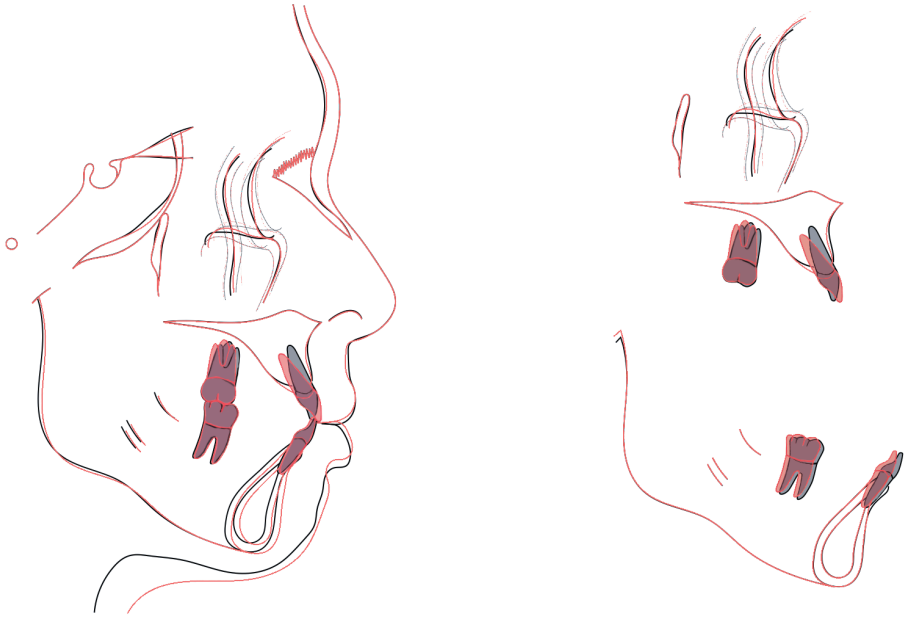


Fig. 21:
Superimposed cephalometric tracings from before treatment (black) and after treatment (red) are superimposed on the anterior cranial base (left), maxilla (upper right) and mandible (lower right). See text for tracings interpretation and treatment details.

developing root tip deviates superiorly when it engages the palatal plate of bone.[19-21]

Orthodontic treatment of the impacted maxillary central incisor should begin as soon as possible, hopefully before the root has completely formed.[13,17] It is rare to attempt to recover and align an inverted impaction of a maxillary central incisor with a dilacerated root in an adult. The curved root complicates the path for extruding the impaction, threatens the roots of adjacent teeth, and prolongs the treatment time.[12-16] Abnormal root shape particularly for spindly roots of severe dilaceration is a risk factor for root resorption.[18,19] CBCT images are essential for evaluating the potential for recovery of a complex impaction. Orthodontists may opt to extract the impaction rather than risk damage to other teeth and labial bone penetration. Even if a severely dilacerated impaction is recovered, root canal therapy and apicoectomy are likely.[20,21] For the current patient, the probability of apical root resorption was a positive prospect because loss of the root tip increased the probability of achieving optimal alignment of UR1.

For complex impactions, gingival health must be carefully maintained throughout the entire sequence of interdisciplinary treatment.[22] The application of IZC bone screws provides favorable 3D anchorage for elastic chains to restrict excessive incisal flaring.[2,23] Similar to the mandibular buccal shelf,[24] the IZC site lateral to the upper molars is advantageous for avoiding the roots of the molars, but there is also adequate space to reposition a bone screw if needed.

For the present patient, IZC bone screws were good anchorage for the well established simultaneous application of elastic chains and Class III elastics.[23,25] It is also possible to use two bone screws in an IZC site for varying anchorage needs (*Fig. 22*). If the roots

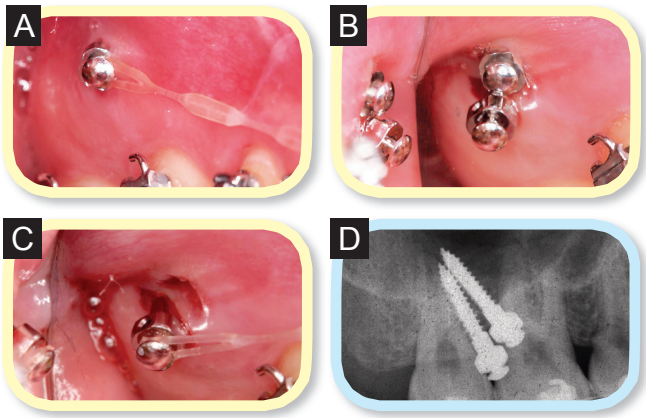


Fig. 22:
A: The head of the initial IZC bone screw was seated too deeply for Class III elastics engagement. B: A new screw was placed behind the original one. C: The new screw was placed more superficial than the original one. D: The head of the inferior screw was used as anchorage for Class III elastics.

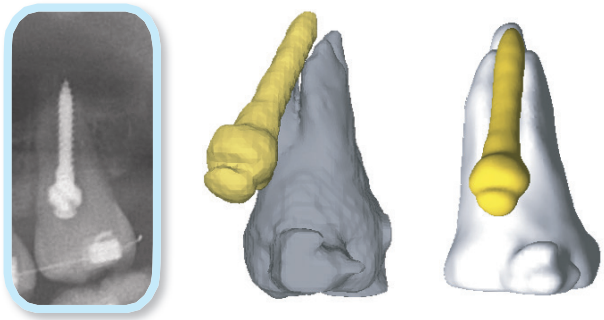


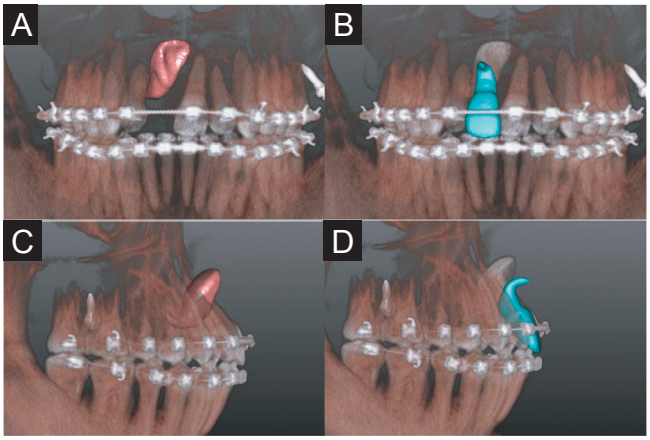
Fig. 23:
Left: The cropped panoramic image of left IZC screw fails to show the proximity of the screw and tooth root.
Center: A CBCT image shows the IZC bone screw is blocking the root from being retracted.
Right: A similar CBCT image shows the second molar mesial buccal root is mesial to the IZC bone screw.

of the molars strike the IZC bone screw during arch retraction,[26] it is necessary to replace the screw in an adjacent site (*Fig. 23*).

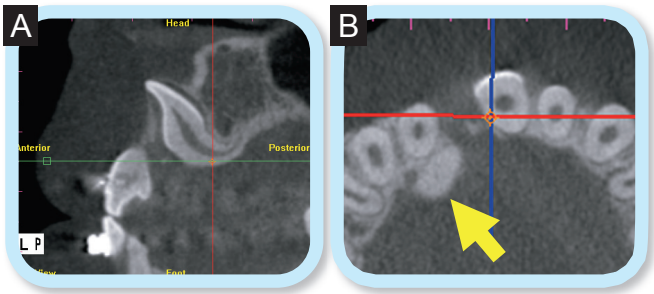
There are three common methods for recovering impactions: 1. soft tissue excision, 2. apically positioned flap, and 3. closed eruption technique.[27,28] For the present problem (*Fig. 24*) soft tissue excision was chosen because the impaction was too high for an apically positioned flap which has a relatively high risk for loss of periodontal attachment, gingival scarring and/or recession, and the closed eruption technique was not conducive to a staged traction procedure.[29,30]

The 3D replica of the impaction was useful for clinically guiding the extrusion, uprighting and rotation process (*Fig. 25*). CBCT imaging is precise for measuring arch retraction with IZC anchorage,[31] but the exact size of a complex impaction near adjacent teeth may be influenced by the voxel size and interference of surrounding structures.[32,33]

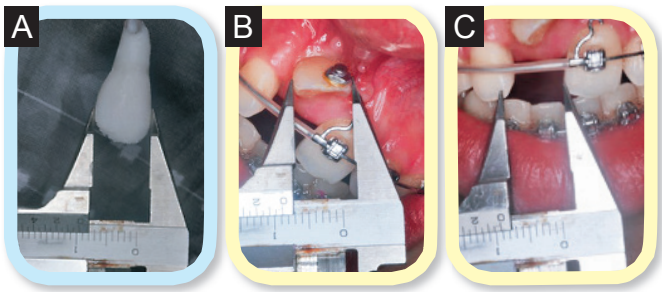
The calibration of data collected, as well as the clinician's expertise with CBCT software and imaging equipment, can influence accuracy.[32] The actual coronal mesiodistal width of UR1 was 8.85mm when clinically exposed compared to the width of replica which was 9.50mm (*Fig. 26*). Despite the loss of accuracy, the replica shape and size were acceptable



■ *Fig. 25:*
A series of three 3D animations the pretreatment position of the UR1 (red) in the frontal view (A) and sagittal view (B). The upper right animation (C) shows the aligned UR1 (blue) in the frontal plane. The lower right illustration (D) is the corresponding sagittal plane. (Courtesy of Dr. Sam Hsu)



■ *Fig. 24:*
A: A pretreatment CBCT image shows the severe dilaceration of the UR1 root in the sagittal plane. B: An axial view of the maxillary arch shows the dilacerated UR1 root is palatal to the root of the UR2 (arrow). See text for details.



■ *Fig. 26:*
A. Measurement of the replica in width. B. Width of the partially erupted impaction. C. Width of the space opened in the arch for UR1 alignment.

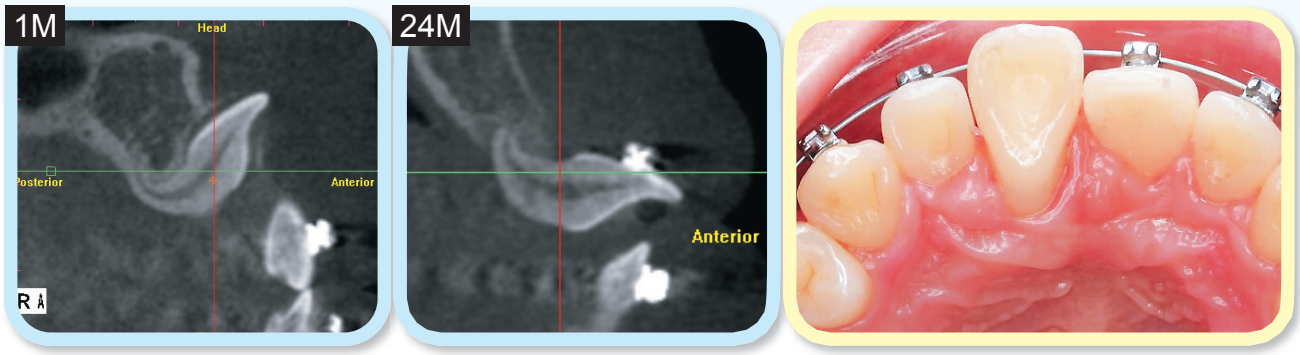


Fig. 27:
1M: The original position of the impacted UR1. 24M: The position of the rotated impaction after 24 months of treatment. The engagement of the thick palatal bone prevented the root from moving as far anteriorly as expected, which resulted in a palatal root dehiscence when the UR1 was aligned. See text for details.

for planning the complex eruption process relative to both soft and hard structure.[27,28]

Throughout the traction process, the periodontist performed regular soft tissue maintenance and provided advice on the pace of tooth movement. The major concern was to control the tendency for the root tip to penetrate the labial plate. Despite regular periodontal care, palatal dehiscence was noted on the UR1 (*Fig. 27*). A rectangular archwire and Warren torquing spring gently applied labial root torque.[34] A CBCT image was taken to monitor the final process of root movement. All of the maxillary incisors showed moderate root resorption. In retrospect, it may have been wise to delay bonding a bracket on the UR2 until after the infringement of the UR1 root was corrected (*Fig. 14*). This approach has proven effective for controlling root resorption on adjacent lateral incisors when maxillary canine impactions are recovered.[35] However, in this instance a decrease in the UR1 root length was beneficial for achieving adequate alignment without problematic labial plate penetration (*Figs. 28 and 29*).[36] Producing an accurate 3D replica[37-39] of complex impactions is useful for determining if recovery and alignment is practical. However, another important consideration

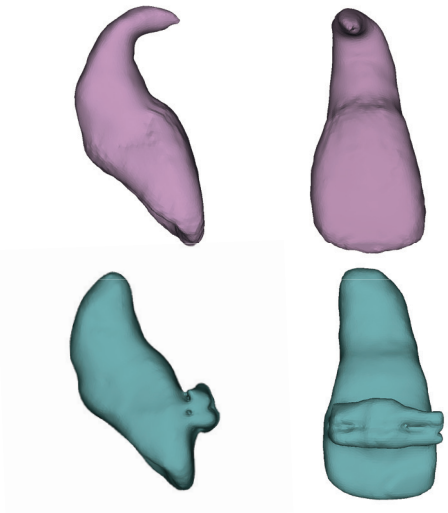


Fig. 28:
Comparison of replicas produced before (violet) and after (green) treatment show the extensive resorption of the UR1 root tip. That expression of root resorption contributed to the successful final alignment of the UR1. See text for details. (Images: courtesy of Dr. Po-Jan Kuo)

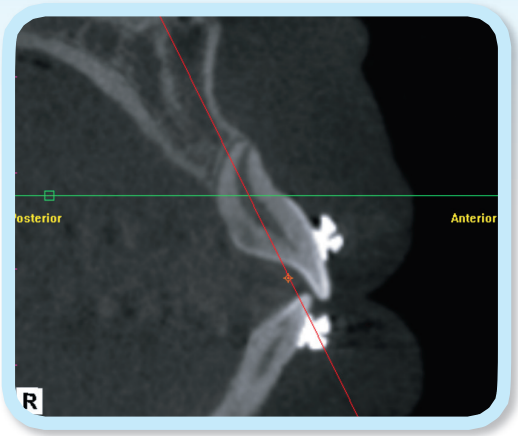


Fig. 29:
The blunted root apex allowed the UR1 to be aligned in a near ideal position.

is the anticipated root resorption of the long tapered end of a severely dilacerated root tip (*Figs. 27-29*).

Conclusions

Recovery of a complex impaction with a compromised shape and unfavorable position is problematic, particularly in an adult. It may be wise to extract the impaction, and compensate with additional extractions, differential space closure, and/or an implant-supported prosthesis. However, a missing maxillary central incisor is an esthetically sensitive problem that is difficult to camouflage with orthodontics and/or restorative dentistry. If the crown of the impaction is well-formed, recovery may be preferable because alignment generates

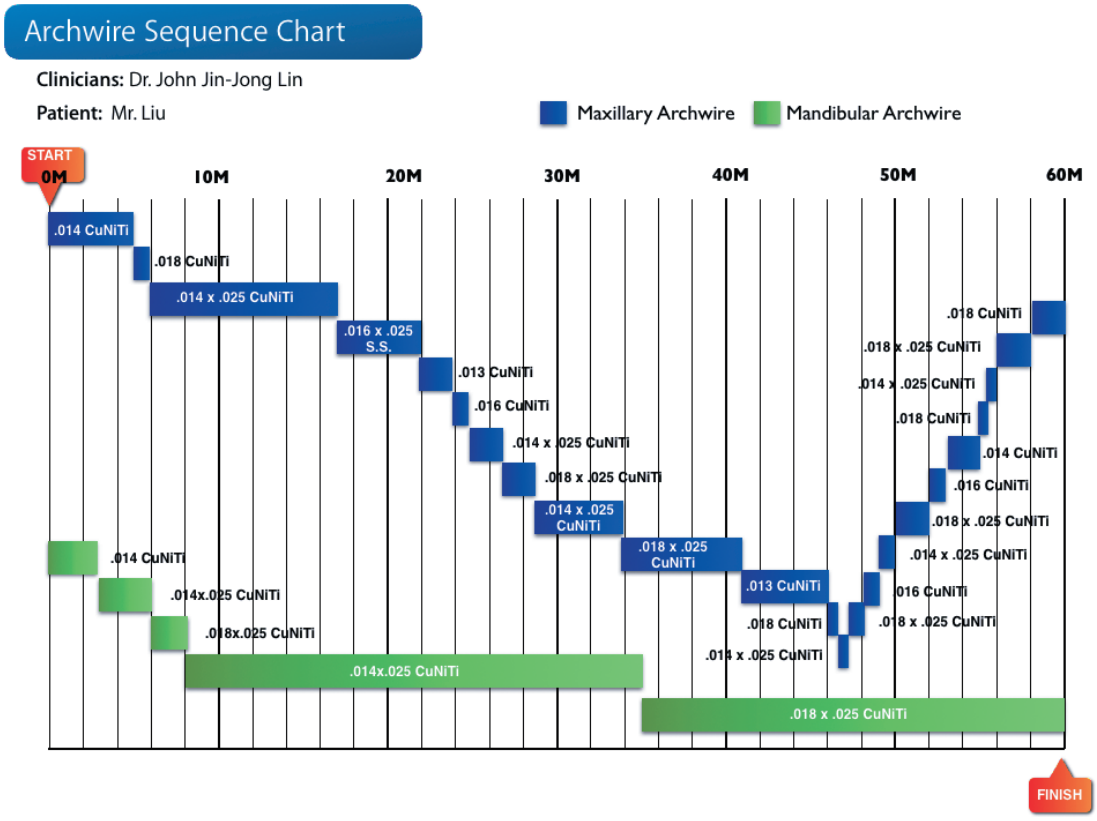


Table 2: Archwire sequence chart

periodontium to provide a more esthetic result. If the root is dilacerated and transposed, iatrogenic damage may occur during recovery, such as root resorption of adjacent teeth, penetration the labial plate of bone, and tooth devitalization. A careful CBCT assessment and a 3D printed replica of the impaction are helpful for determining if a complex alignment is practical. Even so, both the patient and the clinician must be prepared for a long and uncertain clinical course.

Acknowledgment

Thanks to Dr. Sam Hsu for providing 3D images and the UR1 replica, Mr. Paul Head for proofreading this article, and Dr. Rungsi Thavarungkul for the beautiful illustrations.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 28

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 = 7

OVERBITE

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

Total = 0

ANTERIOR OPEN BITE

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

Total = 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 = 7

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° 3.5° = 4 pts.

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

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

SN-MP 38°

≥ 38° = 2 pts.

Each degree > 38° _____ x 2 pts. = _____

≤ 26° = 1 pt.

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

1 to MP ≥ 99° 94.5° = 1 pt.

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

Total = 2

OTHER (See Instructions)

Supernumerary teeth	_____	x 1 pt. =	_____
Ankylosis of perm. teeth	_____	x 2 pts. =	_____
Anomalous morphology	_____	x 2 pts. =	_____
Impaction (except 3rd molars)	1	x 2 pts. =	2
Midline discrepancy (≥3mm)		@ 2 pts. =	2
Missing teeth (except 3rd molars)	_____	x 1 pts. =	_____
Missing teeth, congenital	_____	x 2 pts. =	_____
Spacing (4 or more, per arch)	_____	x 2 pts. =	_____
Spacing (Mx cent. diastema ≥ 2mm)		@ 2 pts. =	_____
Tooth transposition	1	x 2 pts. =	2
Skeletal asymmetry (nonsurgical tx)		@ 3 pts. =	_____
Addl. treatment complexities	3	x 2 pts. =	6

Identify: Extremely curved root of UR1
Inverted UR1
Nonextraction Tx for protrusive profile

Total = 12

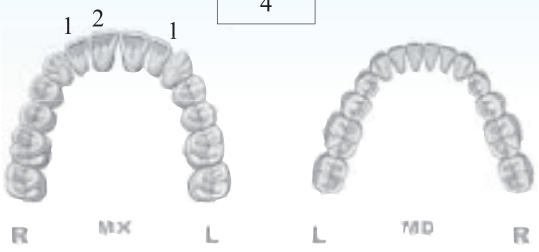
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 17

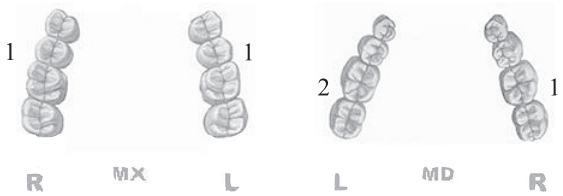
Alignment/Rotations

4



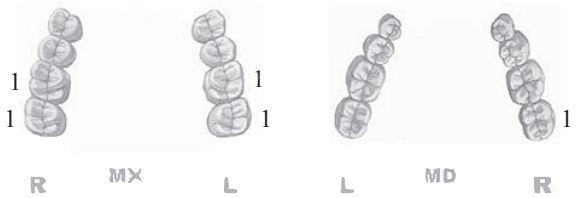
Marginal Ridges

5



Buccolingual Inclination

5

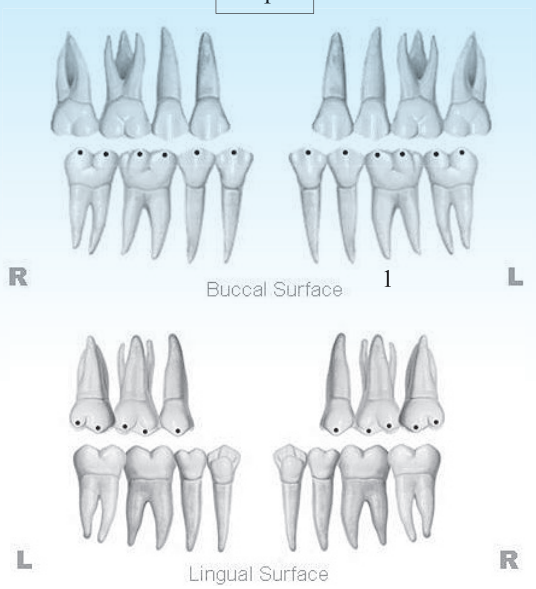


Overjet

1

Occlusal Contacts

1

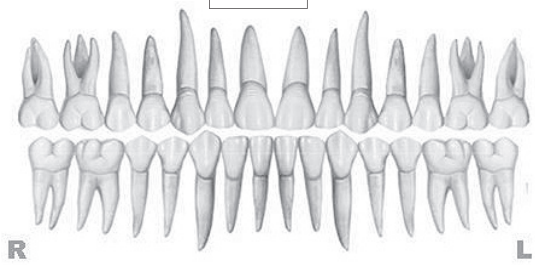


Occlusal Relationships

0

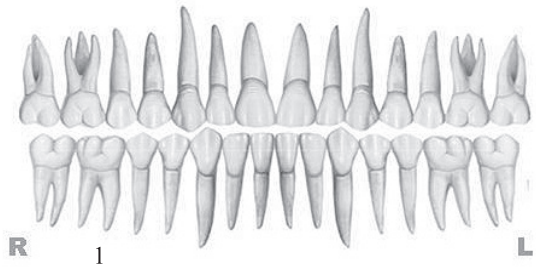
Interproximal Contacts

0



Root Angulation

1



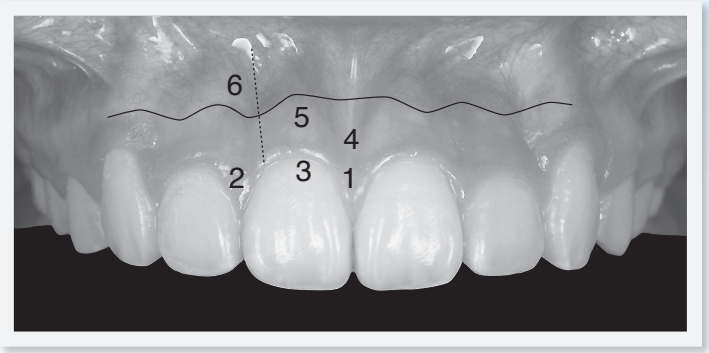
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score: = 5

1. Pink Esthetic Score

Total = 2

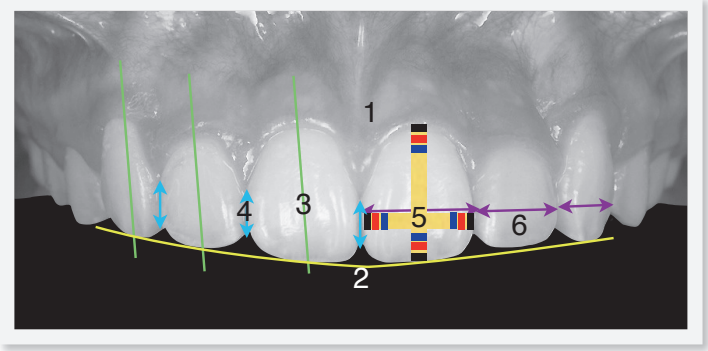


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

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 = 3



1. Midline	0	1	2
2. Incisor Curve	0	1	2
3. Axial Inclination (5°, 8°, 10°)	0	1	2
4. Contact Area (50%, 40%, 30%)	0	1	2
5. Tooth Proportion (1:0.8)	0	1	2
6. Tooth to Tooth Proportion	0	1	2

1. Midline	(0)	1	2
2. Incisor Curve	(0)	1	2
3. Axial Inclination (5°, 8°, 10°)	0	(1)	2
4. Contact Area (50%, 40%, 30%)	(0)	1	2
5. Tooth Proportion (1:0.8)	0	(1)	2
6. Tooth to Tooth Proportion	0	(1)	2