Molar Protraction Through Downward Extension of Maxillary Sinus in Patient with Central Diastema Caused by Small Lateral Incisors

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A 32-year-old male patient presented with upper central diastema resulting from upper bilateral small-sized lateral incisors. The patient also had a deep bite of dental origin. A relatively simple mechanotherapy with pre-adjusted edgewise appliances was applied. A favorable and stable result of the ideal overbite and overjet after the correction of central diastema. Besides the above primary complaints, the prolonged retained roots of upper left first molar caused difficulty for proper space closure since the maxillary sinus wall was downward extended. The lower sinus floor may impede the orthodontic movement, but was very likely to be overlooked. The upper left molars were finally mesialized to occlude with the lower molars in compromised axial inclination. *(Taiwanese Journal of Orthodontics. 32(1): 41-52, 2019, 2020)*

**Keywords:** upper central diastema; downward extension of maxillary sinus wall; maxillary molar protraction
degrees of molar tipping during intrusive or horizontal tooth movement as reported in the literature.\textsuperscript{3,4} This becomes relevant when planning for orthodontic space closure in the maxillary posterior region.

Different designs are available for the bodily mesialized movement of the upper molars.\textsuperscript{4,5} The space-closure mechanics include light forces with an accentuated curve or titanium-molybdenum alloy T-loop segmented arch mechanics to promote bodily tooth movement during protraction in the maxillary arch, although this goal is not always easily achieved.

In this case, after completion of the space closure, the teeth were occluded with its lower counterpart but the second molar tooth ended up with an enhanced mesial inclination of the tooth axis. It became a compromised occlusion.

### CASE REPORT

**Clinical Examination**

Initial intraoral examinations revealed dental and skeletal Class I malocclusion. The overbite and overjet were 5 and 3.5 mm, respectively. Patient’s upper central diastema was measured as 5 mm. The upper dental midline was deviated to his right side for about 2 mm relative to the facial midline (Figure 1).

The SN-FH in the cephalometric measurement was

![Initial orthodontic records before treatment.](image)

The face presented mild asymmetry with the chin deviated to the right side. In addition, no gummy smile and a straight profile were noticed in A-1, 2, and 3. The maxillary central diastema, which was 5 mm in width, and impinging deep bite were found in C. The canine relation was Class I in both sides. The molar relation was Class I at the right side (C-1). At the left side, there are retained roots in the first molar (C-4). Panoramic radiograph in D revealed that all of the 4 third molars were present and well aligned. Initial lateral cephalometric x-ray was presented in B.
near zero, indicating that the Nasion point of this patient was inferiorly positioned than the normal (Table 1). All the readings involved with Nasion were needed to carefully reconsidered for their clinical interpretation. The measurements of SNA, SNB, Ar-S-N, Y-axis, mandibular plane angle, and gonial angle were appeared to be within the normal range after the re-evaluation.

The facial proportion as indicated in the PFH/AFH ratio, UAFH/LAHF ratio, and LAFH values, suggested normal and balance (Table 1).

The lateral cephalometric analysis ruled out the skeletal components of the patient’s deep bite. The deep bite was found to be mainly from dental origin. The patient had a normal ANB and mandibular plan angle. His upper incisors were upright and slightly elongated, and his lower posterior teeth were a mildly undererupted. The patient had protrusive upper and lower incisors with a small inter-incisor angle.

A frontal cephalometric radiographic evaluation was useful in revealing that the bi-zygomatic width was only slightly larger than the normal value (Figure 2). Therefore, the patient had a normal facial width in the transverse

| Table 1. Summary of cephalometric measurement in the different stages of treatment, including initial, finishing and follow-up. |
|---|---|---|---|
| Reference | Mean | initial | finish | Follow up |
| SN-FH | 5.9 | 1 | 1 | 1 |
| S-N(mm) | 75 | 77 | 77 | 77 |
| Ar-S-N | 122.6 | 113 | 114 | 114 |
| MAX_MAND(A-P) | 84.9 | 85 | 85 | 85 |
| SNA | 81.4 | 83 | 83 | 83 |
| SNB | 3.5 | 2 | 2 | 2 |
| ANB | 97.7 | 95 | 95 | 95 |
| Mx. Length(Ar-A)(mm) | 112.3 | 104 | 104 | 104 |
| Md. Length(Ar-B)(mm) | 14.6 | 10 | 9 | 9 |
| A-Mx. Diff.(mm) | 0.9 | -2 | -2 | -2 |
| A-NVert.(mm) | -4.2 | -7 | -9 | -9 |
| Growth & VERTICAL | 0.67 | 0.70 | 0.71 | 0.71 |
| PFH/AFH ratio | 0.83 | 0.69 | 0.7 | 0.7 |
| UAFH/LAFH ratio | 76.4 | 76 | 76 | 76 |
| Y-axis | 68.2 | 62 | 63 | 62 |
| SN-MP | 30.9 | 25 | 25 | 25 |
| PP-MP | 22.2 | 22 | 22 | 22 |
| Upper Gonial Angle | 49.8 | 46 | 46 | 46 |
| Lower Gonial angle | 74.1 | 65 | 67 | 66 |
| Dentition (A-P) | Initial | finish | Follow up |
| U1-SN | 106.3 | 105 | 108 | 110 |
| U1-NA | 21.3 | 18 | 24 | 23 |
| U1-NA(mm) | 3.9 | 3 | 4 | 5 |
| L1-MP | 93.5 | 102 | 108 | 107 |
| L1-Apog(mm) | 3.6 | 3 | 6 | 5 |
| L1-NB | 25.8 | 30 | 40 | 38 |
| L1-NB(mm) | 6.6 | 6 | 7 | 7 |
| Pog-NB(mm) | 2.1 | 1 | 2 | 2 |
| U1-L1 | 129.4 | 128 | 115 | 120 |
| Dentition (Vert) | | | | |
| sn-as | 26.4 | 30 | 30 | 30 |
| U1-PP | 31.5 | 34 | 32 | 31 |
| U6-PP | 26.6 | 25 | 26 | 24 |
| Is-me | 59.1 | 55 | 55 | 55 |
| L1-MP | 44.2 | 44 | 43 | 43 |
| L6-MP | 34.9 | 36 | 38 | 38 |
| SOFT TISSUE | | | | |
| NLA | 99.1 | 85 | 85 | 85 |
| Upper lip -Eline(mm) | 2.0 | 0 | 0 | -1 |
| Lower lip -Eline(mm) | 2.8 | 1 | 0 | -1 |
| als-snVert(mm) | -0.1 | 2 | 1 | 1 |
| ul-snVert(mm) | 4.5 | 4 | 2 | 2 |
| ll-snVert(mm) | 0.7 | 2.5 | -1 | -1 |
| lls-snVert(mm) | -8.3 | -13 | -14 | -14 |
| pog-snVert(mm) | -8.3 | -14 | -15 | -15 |
The bizygomatic arch width (ZZ) and bigonial width (GoGo) were both slightly larger than the normal value. The absolute values of CO-AG, CO-MSR, and AG-MSR are larger on the left side, thereby indicating a morphological asymmetry of the mandible. The patient’s mandible was shifted slightly to his right side and there was mild skeletal asymmetry.

Diagnosis
1. Skeletal Class I malocclusion with normal vertical and transverse dimensions.
2. Upper central diastema, anterior dental deep bite, Class I canine in left side, Class I canine and Class I molar relationship in the right side, Left upper first molar residual roots with poor prognosis.
3. Small-sized upper lateral incisors with reduced MD dimension.
4. Upright upper anterior teeth, over-eruption of both upper and lower incisors along with proclined and
mild crowded lower anterior teeth.

5. Downward extension of maxillary sinus floor in the region of upper left first molar.

**Treatment Planning**

1. Extraction of the residual roots of upper left first molar. Full mouth-fixed pre-adjusted edgewise orthodontic appliances are applied. There will be no need for orthognathic surgery and temporary anchorage devices.

2. Leveling of the upper dentition would be adequate to intrude the incisors and extrude the posterior teeth at the same time to correct the deep bite.

3. By space redistribution and resin augmentation, the upper lateral incisors will gain proper M-D dimensions and well prepared for the esthetic dental management later.

4. Due to the upper left side maxillary sinus extension, the protraction of upper left second molars will be performed with large sized stainless-steel arch wires to avoid the mesial inclination of the tooth axis.

5. The wrap-around removable Hawley retainers will be applied. The restoration or prosthesis of upper lateral incisors is essential for retaining the stability of the central diastema.

**Treatment Progress**

Orthodontic treatment was initiated immediately after the extraction of residual roots of upper left first molar tooth. The bracket system 0.022 slot OPA-K (Tomy company, Japan) was employed for this process. The dentition leveling was performed with 0.014-inch NiTi wires followed by 0.018-inch NiTi wires (Figure 3).

Two restorative options of lateral incisors were...

![Figure 3](image_url)

*Figure 3. Treatment progress after 14 months of treatment.*

Upper and lower arches were well aligned after 14 months of active orthodontic treatment (A, B, and C). Thereafter, the remaining space closure at upper arch was performed. Due to the lack of an antagonist tooth, the lower third molar was over-erupted as observed in D. Lingual buttons and power chains were used to correct the distal-out rotation of upper right second molar tooth. Power chain was used for closure the extraction space of left upper first molar as noted in E.
provided to the patient, a resin build-up of the lateral incisor or veneer prosthesis. The patient chose to have a resin build-up.

Reciprocal space closure with power chains and open coil spring were applied for space distribution of upper lateral incisors (Figure 4). Segmental open coil spring was inserted to create spaces at the proximal areas of bilateral upper lateral incisors for size augmentation and tooth reshaping.

Extraction of these two retained roots of upper left first molar was performed before the leveling stage of treatment. The space was gradually closed by sliding mechanics (Figure 5). Figure 5C indicated that the protraction of left upper second molars was time consuming. The left upper second molar was moved forward to contact the second premolar with a mesially inclined tooth axis.

At the end of active treatment, the upper central diastema and the deep bite were both corrected. The upper lateral incisors were temporarily restored to have proper the M-D dimension. Satisfactory dental interdigitating was accomplished.

**Treatment Result**

The lip posture became balanced. Upper and lower dentitions were well-aligned with the coincidence of upper and lower dental midlines. Bilateral Class I canine and molar relationship were achieved (Figure 6). The root parallelism was favorable in the panoramic radiograph except in the upper left second molar (Figure 6). There was no significant apical root resorption.

The space between two upper central incisors was closed. The small-sized upper laterals were reshaped with resin augmentation to achieve a better Bolton’s ratio. Overbite and overjet were both 2 mm. Good dental inter-digitation was accomplished. Class I molar relationship in the left side was compromised with the mesial inclination of substituting the upper second molar. Lower left third molar, which was found elongated, should have been removed in initiation of treatment as the patient was informed.

![Figure 4. Re-distribution of existing space among the upper anterior teeth.](image-url)

The space between upper incisors was 5 mm to begin with. After 14 months, this space had been redistributed to 2-mm wide spaces at the distal surface of lateral incisors on the both sides. At the end of orthodontic treatment, a 2-mm space was held at the distal side of both lateral incisors (B), and the patient had resins build-up of both teeth one mouth thereafter (C). After five years of follow-up, a stable alignment with no space between 2 central incisors (D).
Figure 5. Upper molar roots encountered sinus cortical bone during protraction.
A. The mesial retained root caused less alveolar bone loss than the distal one. The alveolar crest level was tilted. It was lower in the distal surface of second premolar and higher in the mesial surface of second molar.
B. The sinus floor extended more severely near the root of the left upper second molar. At 14 months, the subsequent protraction movement failed to proceed since the mesial root of second molar touched the sinus lining.
C. The protraction continued. The substituting teeth was mesial inclined to close the extraction space. The second molar tilting was about 15 degrees.

Figure 6. Completion of active orthodontic treatment.
Upper and lower dentitions were moved forward, and the upper left second molar was moved forward 9 mm to substitute the missing first molar (Figure 7, Table 1). There was an increase in the upper intercanine width by 2 mm. The vertical dimension including the mandibular plane angle and anterior facial height were maintained after treatment. Stable occlusion was noted after 5-year follow-up examination (Table 1, Figure 8, 9).

**Figure 7.** Cephalometric tracings, regional superimposition, and occlusogram.
Overall and regional cephalometric superimpositions were demonstrated. Black line, pre-treatment; red line, post-treatment; green line, follow-up. The anterior teeth were intruded and posterior teeth were extruded to achieve the deep bite correction. In the occlusogram, the forward movement of the dentition during treatment was illustrated. The left second molar was moved 9 mm forward to substitute the upper left first molar.
Figure 8. Comparison of lateral cephalometric radiographs. The lateral profile was not changed obviously. The labial-mental fold slightly decreased and lower lip became harmonized.

Figure 9. The smile arc was improved after treatment.
**DISCUSSION**

**Modification and interpretation of the cephalometric data concerning the low position of Nasion point**

The most commonly used horizontal planes in cephalometric analysis are SN and FH. The patient has a small value of SN-FH angle; the measurement was 1 degree, while the norm is around 7 degrees. This is due to patient’s prominent frontal sinus and the inferior position of point Nasion (Table 1).

Schudy pointed out that if the SN and FH planes were about parallel, using SN-MP could be misleading and not able to reflect the true relation within the denture area. It is worth notice in the present case, if clinicians made a diagnosis that he had low mandibular plane angle with deep bite, the presumption of difficult bite opening might prefer surgical intervention on this case.

For this case, the SN-MP angle was 25 degrees before treatment without SN-FH calibration. The diagnosis of low MP could mislead the treatment mechanics. On the other hand, when use FH-MP (Frankfort horizontal to mandibular plane angle, or FMA of Tweed triangle) instead, 25 degrees could be normal. Thus, the deep bite was dental origin rather than skeletal features. The orthodontic correction with proper biomechanics should have good prognosis.

**Skeletal components of a deep bite**

The horizontal planes used in lateral cephalogram, including the Frankfort horizontal, palatal, occlusal and mandibular plane, could be nearly parallel to each other in extreme deep bite. To check whether this case has a skeletal deep bite, clinicians can use the readings of SN-FH, SN-MP, and PP-MP. The above two items SN-MP, and PP-MP were measured more than twenty degrees, the length of the mandibular corpus was smaller than norm. The gonial angle was smaller than normal value but the mandible did not rotate too upward to decrease the LAFH, which was normal. It is concluded that this patient has dental deep bite from over erupted upper and lower incisors (Table1).

The overbite correction was achieved by extrusion of molars and intrusion of anterior teeth by using continuous arch leveling. The increased lower incisor flaring and decreased inter-incisal angle have also contributed to bite opening. The upper and lower incisors were both labial proclined after treatment with reduced U1-L1 angle (Table 1). The patient had good posterior support and anterior guidance.

**Upper central diastema and deep bite**

Upper central diastema can be one of the occlusal factors to cause dental deep bite. Abraham and Kamath reported that the reduced sized lateral incisors will permit the distal movement of the central incisors and create a central diastema to further deepen the bite. The incidence of upper central diastema in the permanent dentition was from 1.6% to 25%, varies from different races. People from oriental and middle east have higher prevalence.

The deep bite with a central diastema is usually prone to relapse if not properly manage. The deep bite must be corrected prior to midline space close. The steep curve of Spee was leveled also reduce the overbite. The spaces at the distal side of two lateral incisors were created before finishing. Post-orthodontic esthetic dentistry for these two upper lateral incisors was prime important, the normalization of MD dimensions of lateral incisors is essential for preventing the relapse of diastema and bite deepening.

**Molar protraction through the extended sinus floor**

The maxillary sinus, located in the body of the maxilla, is the largest and the first of the paranasal sinuses to develop. Its floor is near the alveolar process of the maxilla. Like a cortical bone, the floor of the maxillary sinus is a layer of compact bone lined with the periosteum.

The size of the maxillary sinus is variable in its extension in adults. Its floor extends between adjacent
teeth or individual roots in about half of the population, creating elevations in the antral surface or protrusions of root apices into the sinus.

Most roots that protrude into the sinus are enveloped by a thin cortical layer with perforations in 14% to 28% of the cases. 

It was pointed out by Kwak et al. that the distance from the root apex to the inferior sinus wall is the shortest at the second molar area. When tooth roots protrude into the maxillary sinus, they can cause moderate apical root resorption and greater tipping during intrusive or horizontal movement of teeth across the sinus floor.

Park et al. demonstrated that the morphology of the sinus will not influence the speed of tooth movement through the sinus. However, Wehrbein reported a correlation between the sinus depth and the degree of dental tipping adjacent to the extraction site. The same report pointed out the fact that the more vertical extended the sinus, the greater axial tipping of the teeth.

In animal experiment with mice, Kuroda et al. found no root resorption on tooth that was moved through the cortical wall of the sinus. This case also failed to find any discernible root resorption.

In this case, the mesial retained root of upper left first molar was shorter but lack of inflammatory sign, the distal retained root had ongoing chronic periodontitis and apical resorption (Figure 5A). This might be the reason why more downward extension of the maxillary sinus had been induced at distal residual root area.

During space closure, the protraction slowed down as the traction force persisted when mesial buccal root of left upper second molar encountered the sinus wall. The crown portion of upper left second molar kept moving forward and the root movement did not catch up. Finally it became mesially tilted to occlude with lower first molar. The final tooth axis of the upper left second molar was about 15 degrees. According to Andrews (1972), the normal angulation of first molar should be 5 degrees.

Similar results were also reported in other literatures. Protraction mechanics would require careful planning and accurate execution of the force systems to achieve bodily tooth movement. Bond the bracket with exaggerate angulation for mesial down and distal up for overcorrection was suggested. Using the power chain on the arch wires with accentuated curve of Spee was also described in other reports.

In five-years follow up records, the dental alignment remained stable (Figure 5C).

**Tooth extraction is a risk factor for maxillary sinus floor extension**

It was also suggested that the delay extraction of retained dental roots could cause the local inflammation and afterward extension of the maxillary sinus floor. The amount of maxillary sinus extension was greater after the extraction of teeth with an infected root of molars. Greater sinus expansion was observed after the removal of teeth related to periapical lesions.

**Alternative treatment option of concerning the dental implant**

The prediction of the successful rate to protract the molars over the cortical plate of the sinus floor is not clear. Preparation of the extraction site for dental implant insertion is another solution. When this option was chosen, the left upper first molar had been substituted with dental implant, the over-eruption of left lower third molar could be prevented.

**CONCLUSION**

1. SN and FH plane parallelism is commonly seen. The diagnosis of facial pattern should be cautious by other supplementary cephalometric measurements.
2. The prognosis of closure the upper central diastema should be discriminated by the existing skeletal factors involved in etiology.
3. Sinus extension problem should not be ignored or overlooked, especially when prolonged retention of residual roots was present.
REFERENCES