

Maxillary Space Closure Using Aligners and Palatal Mini-Implants in Patients with Congenitally Missing Lateral Incisors

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The etiology of hypodontia may include congenital absence of lateral incisors or second premolars, significant ectopic displacement of maxillary canines, or dentoalveolar trauma resulting in anterior tooth loss. Congenital absence of maxillary lateral incisors is relatively common, with a prevalence of .8-2%,¹ representing 20% of all congenitally missing teeth.²

Treatment of patients with congenitally missing maxillary lateral incisors generally involves either space closure, often with canine substitution, or space opening for subsequent prosthetic replacement. The selected approach will affect the patient's final esthetics, periodontal health, and occlusal function.² Single-tooth osseointegrated implants in the maxillary anterior region are likely to create esthetic complications from infrapositioning due to continued facial growth and eruption of the adjacent teeth.^{3,4} Mesial space closure or protraction of the maxillary posterior teeth is often the treatment of choice, as long as it can be completed during the growth period. According to the Angle Society of Europe, space closure should be considered especially in patients with increased maxillary tooth display, such as those with vertical maxillary excess.⁵ Canine substitution for a congenitally missing maxillary lateral incisor can be

readily accomplished with a satisfactory esthetic outcome, which can be further enhanced by tooth recontouring and positioning, bleaching, and the use of porcelain veneers.⁶⁻⁸ Some patients may be satisfied with the orthodontic results and elect not to proceed with recontouring, intrusion of first premolars, or subsequent restorations.

Although an increasing number of orthodontic patients are seeking “invisible” or “esthetic” treatment with clear aligners, bodily tooth movement can be difficult to achieve in cases requiring space closure to address the congenital absence of one or both maxillary incisors. Bodily movement of as much as 2.5mm has been reported in distalization cases, but this requires a high level of patient compliance with extended wear of adjunctive intermaxillary elastics.⁹⁻¹¹ Potential side effects of Class III elastics must also be considered in terms of TMD or distal shifting of the lower anchor teeth



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and consequent retrusion of the mandibular incisors. This could be a severe problem in situations calling for unilateral Class III elastics, with possible side effects including a lower midline shift, maxillary arch rotation and yaw discrepancy, and transverse occlusal canting.

Anchorage for Upper Arch Mesialization

Anchorage requirements are increased when a congenitally missing tooth is more anteriorly positioned within the maxillary arch. Protraction facemask therapy and Class III elastics have been used to augment anchorage, but both require excellent patient compliance and may result in the side effects described above.

Mini-implants now offer a means of achieving more reliable anchorage.¹²⁻¹⁴ Although buccal mini-implants can be positioned in the intended path of tooth movement for optimal force application, placing mini-implants in the anterior palate allows all teeth to be moved without interference.^{15,16} Furthermore, the anterior palate has high bone quality and a thin attached mucosa, permitting larger and more stable mini-implants to be placed with minimal risk of tooth or root injury and a reported success rate of 95-98%.¹⁷⁻²¹ In the area immediately distal to the third palatal ruga, referred to as the T-Zone,²² two adjacent mini-implants can be positioned in a sagittal (median) or transverse (paramedian) direction.²³ A paramedian insertion will place the screws away from the incisive canals and the suture, but a median insertion

has the advantages of greater bone quantity and less risk of incisor root injury during insertion.²⁴ Because the bone volume is reduced in the lateral and posterior areas of the palate,^{25,26} only a median insertion is recommended in posterior locations.

The Mesialslider* appliance is a mechanism that allows the use of sliding mechanics anchored by mini-implants in the anterior palate.^{23,27,28} This enables mesialization or protraction of the maxillary molars to close unilateral or bilateral dental

TABLE 1
CASE 1 CEPHALOMETRIC ANALYSIS

	Pre-treatment	Post-Treatment
NSBa	121.8°	123.1°
NL-NSL	1.7°	3.0°
ML-NSL	27.8°	25.1°
ML-NL	26.1°	22.1°
SNA	85.2°	87.0°
SNB	79.8°	83.4°
ANB	5.3°	3.7°
Wits appraisal	+4.7mm	+0.7mm
U1-NL	98.0°	104.6°
L1-ML	95.7°	92.8°
U1-L1	140.2°	140.5°
Overjet	3.9mm	3.7mm
Overbite	3.5mm	1.8mm

*PSM North America Inc., Indio, CA; www.psm-na.us.

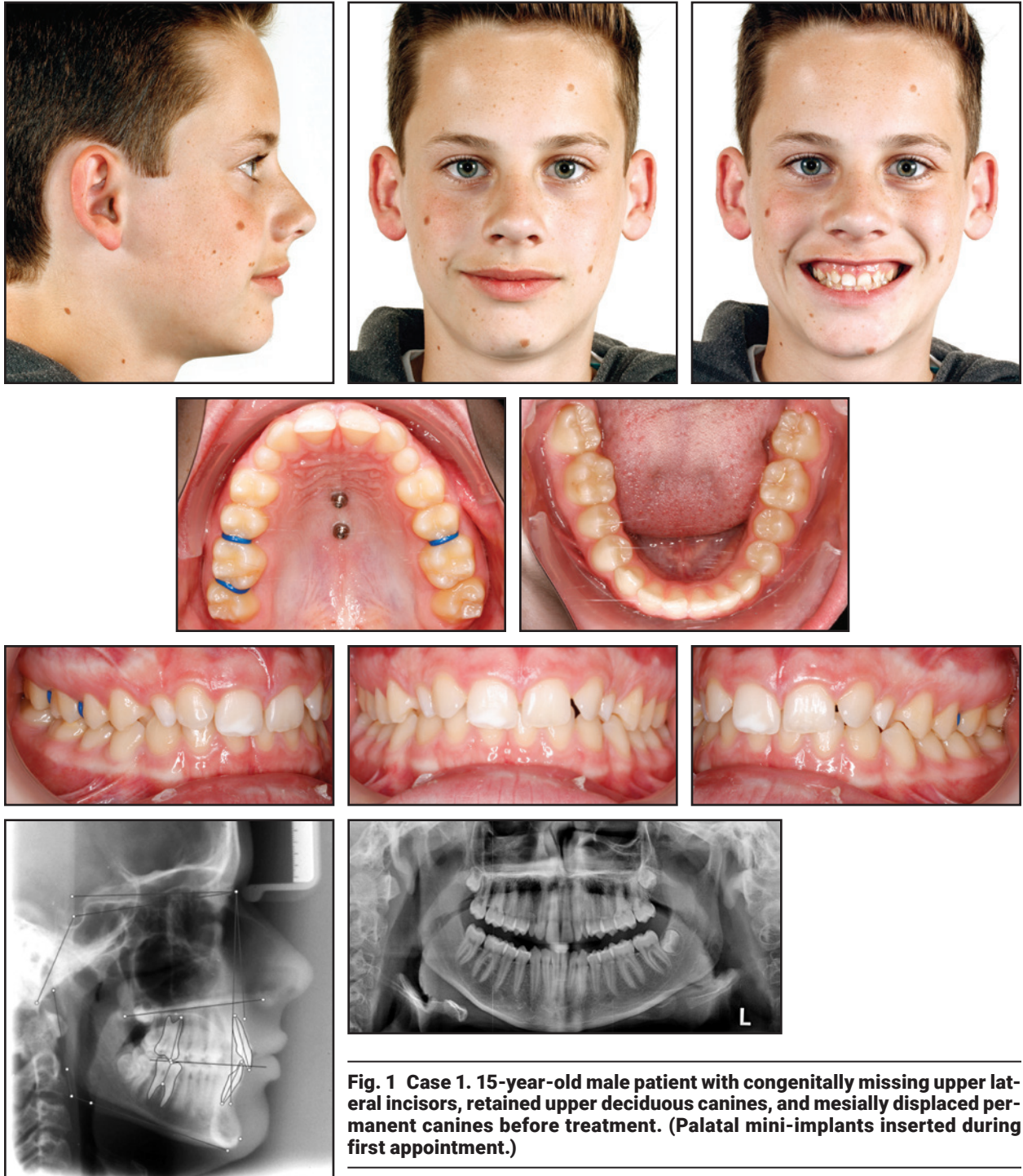


Fig. 1 Case 1. 15-year-old male patient with congenitally missing upper lateral incisors, retained upper deciduous canines, and mesially displaced permanent canines before treatment. (Palatal mini-implants inserted during first appointment.)

*PSM North America Inc., Indio, CA; www.psm-na.us.

spacing, without the need for additional buccal brackets.²⁹ By changing the angulation of the guiding wire framework, vertical control can be added for situations such as open-bite correction with simultaneous molar intrusion and protraction.³⁰ Contralateral distalization is possible with the Mesial-Distalslider.^{31,32} Another version, the T-Mesialslider, uses a combination of direct and indirect palatal anchorage.^{33,34} The conventional Mesialslider and the T-Mesialslider are attached only to the molars; an alternative configuration, the B-Mesialslider, also connects to the premolars through bonded tubes.³⁵

Recent developments in computer-aided de-

sign and manufacturing (CAD/CAM) techniques include insertion guides that enable placement of palatal temporary anchorage devices (TADs) and a TAD-borne slider in a single appointment.³⁶ Moreover, these TAD-borne appliances can be metal-printed using selective laser-melting procedures.³⁷

The Mesialslider can be combined simultaneously or consecutively with customized aligner treatment, as described in the following two cases.

Case 1: Two-Stage Protocol

A 15-year-old male presented with congenitally missing maxillary lateral incisors (Fig. 1). The

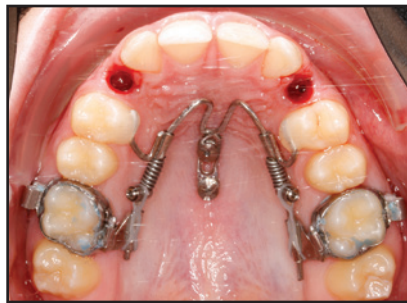


Fig. 2 Case 1. Mesialslider* affixed to two palatal mini-implants. (Deciduous canines extracted at same appointment.)



Fig. 3 Case 1. After seven months of treatment.



maxillary permanent canines had drifted mesially, adjacent to the central incisors, while the deciduous canines were retained between the permanent canines and the first premolars.

After being presented with several options, the patient and parents provided informed consent to proceed with aligner treatment involving space closure.

Two Benefit* mini-implants (2mm × 9mm anterior and 2mm × 7mm posterior) were inserted about 5mm apart in the midline of the anterior palate at the third palatal ruga, in the T-Zone.^{22,24} While the Mesialslider can be adapted directly in the mouth without any laboratory construction, this device was adapted on a plaster cast, using impression caps and laboratory analogs, to reduce chair-time (Fig. 2). To improve stability, the mini-implants were coupled by a Beneplate* with a 1.1mm stainless steel wire,²³ which was secured to the implant heads with small fixation screws. The Mesialslider was connected to tubes bonded on the

palatal surfaces of the upper first premolars and conventional palatal sheaths on the first-molar bands. To take advantage of the regional acceleratory phenomenon during space closure, the deciduous canines were not extracted until the appliance placement appointment. The 240g nickel titanium mesialization springs were then activated.

After seven months, significant mesial movement of the maxillary premolars and molars was observed (Fig. 3). Another five months later, all spaces were closed (Fig. 4). The Mesialslider appliance was removed, and impressions were taken for Invisalign** clear aligners. A thermoformed splint was delivered for nighttime wear while the aligners were being fabricated.

During the second stage of treatment, aligners were changed every two weeks (Fig. 5). With the initial 17 sets of trays and adjunctive intermaxillary

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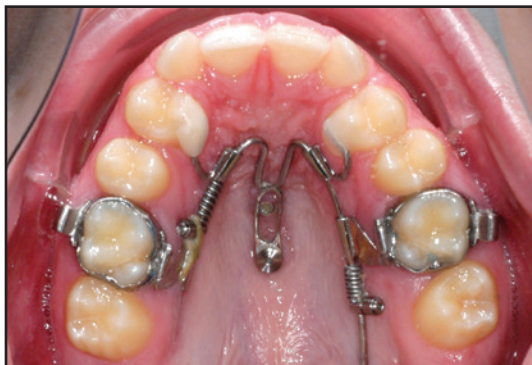


Fig. 4 Case 1. After 12 months of treatment, with all spaces closed.



Fig. 5 Case 1. After 17 months of treatment.

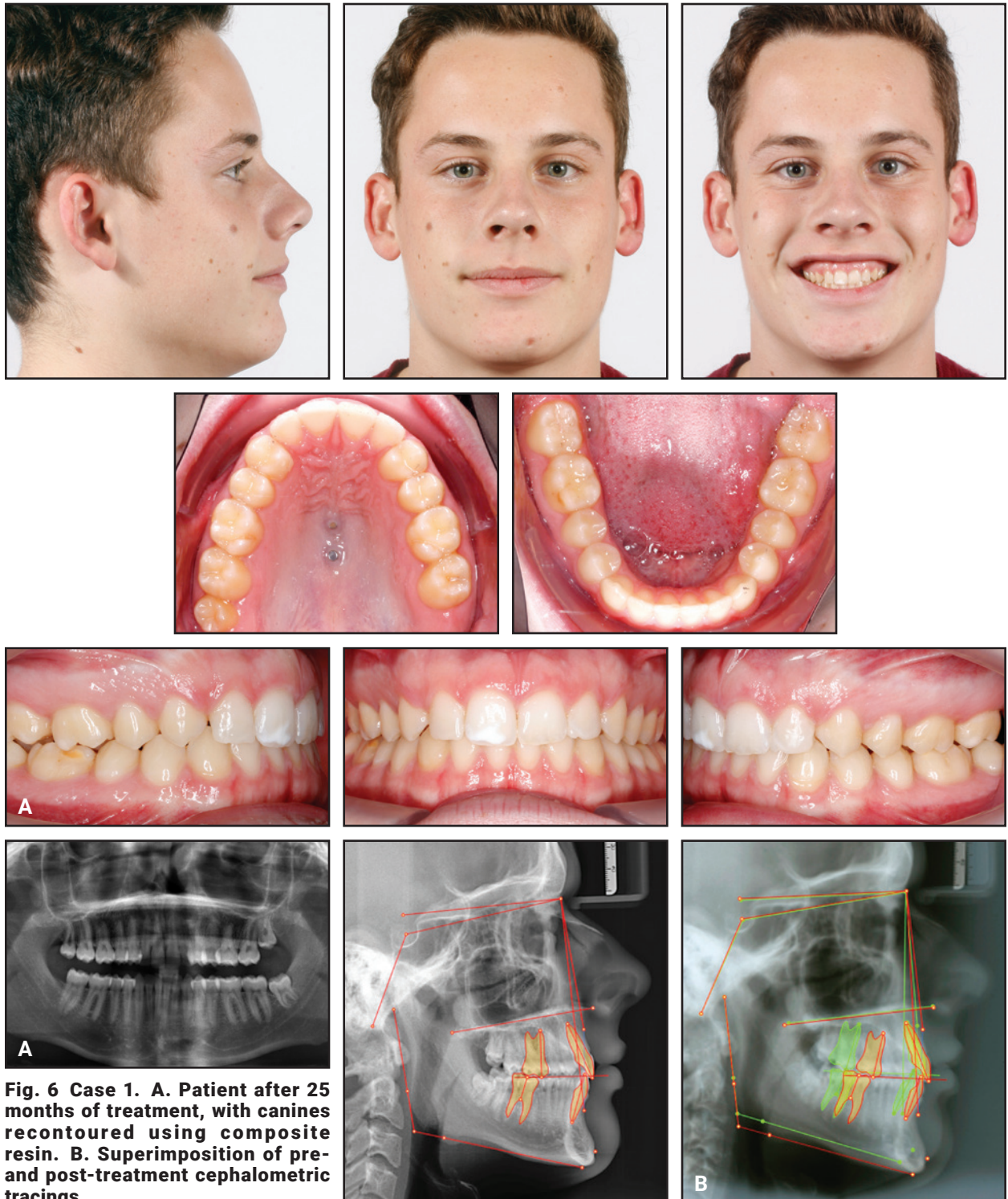


Fig. 6 Case 1. A. Patient after 25 months of treatment, with canines recontoured using composite resin. B. Superimposition of pre- and post-treatment cephalometric tracings.

Fig. 7 Case 1. Patient one year after treatment.



elastics, the maxillary incisors were uprighted and the occlusion was finished. Refinement required 10 additional sets of aligners.

After a total 25 months of treatment, the maxillary canines were recontoured with composite resin (Fig. 6). Removable vacuformed retainers were delivered.

Radiographs and intraoral photographs confirmed the bodily mesialization, and cephalometric superimpositions demonstrated significant molar protraction (Table 1). The results remained stable one year after treatment (Fig. 7).

Case 2: One-Stage Protocol

A 19-year-old female presented with a congenitally missing right lateral incisor (Fig. 8). The maxillary right canine had drifted mesially, leaving substantial space between the canine and the first premolar.

The patient specifically requested “invisible” orthodontic treatment for space closure.

As in Case 1, two mini-implants (2mm × 9mm anterior and 2mm × 7mm posterior) were inserted in the anterior palate. A Mesialslider was attached to bonded tubes on the palatal surfaces of the upper first molars and the upper right first premolar, but the 240g nickel titanium mesialization

**TABLE 2
CASE 2 CEPHALOMETRIC ANALYSIS**

	Pre-treatment	Post-Treatment
NSBa	128.7°	130.4°
NL-NSL	2.5°	3.4°
ML-NSL	23.1°	23.9°
ML-NL	20.5°	20.5°
SNA	86.4°	85.4°
SNB	83.0°	82.3°
ANB	3.4°	3.2°
Wits appraisal	+1.3mm	+1.2mm
U1-NL	111.3°	109.2°
L1-ML	99.5°	97.4°
U1-L1	128.5°	132.8°
Overjet	4.4mm	4.4mm
Overbite	1.3mm	1.5mm

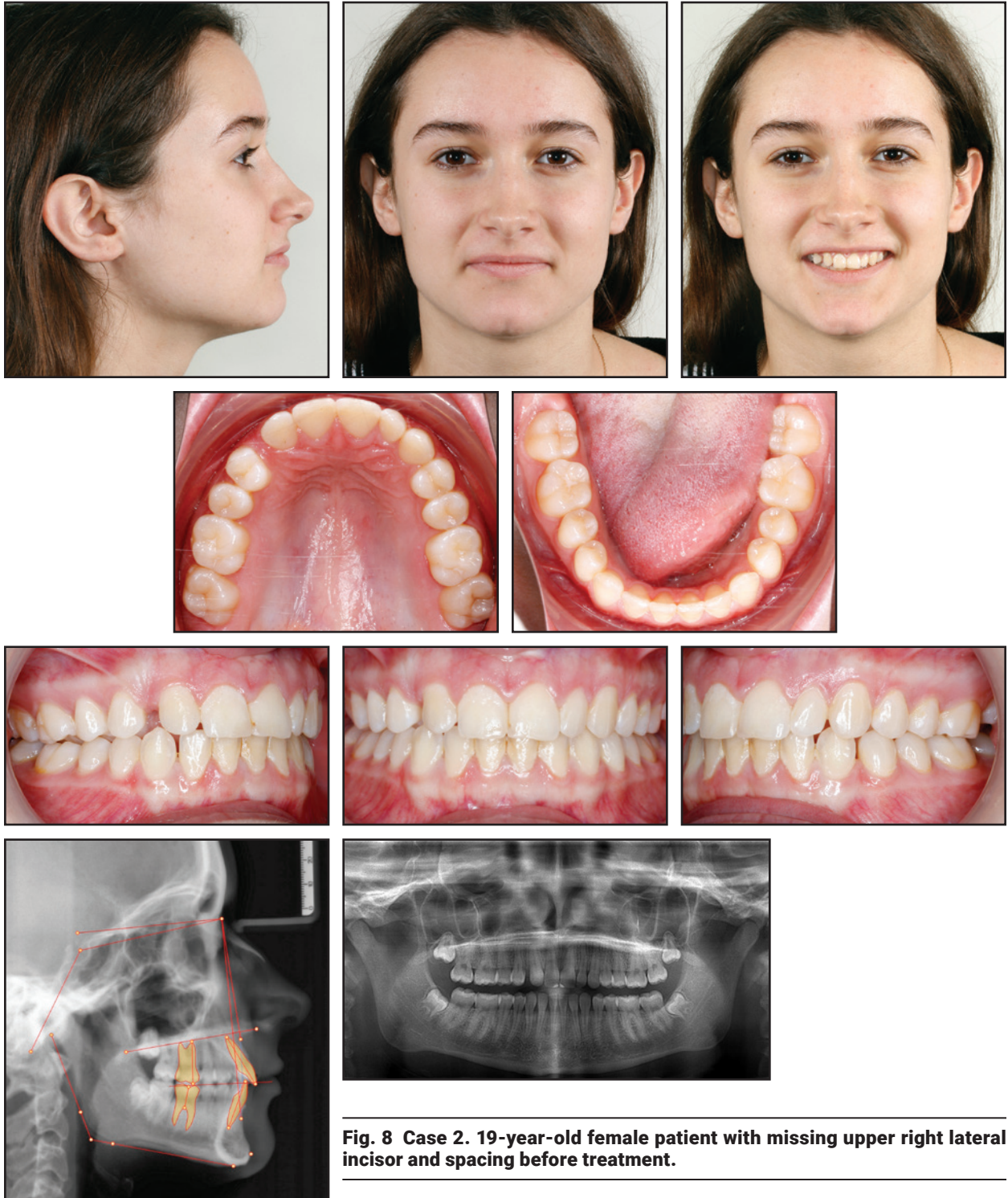
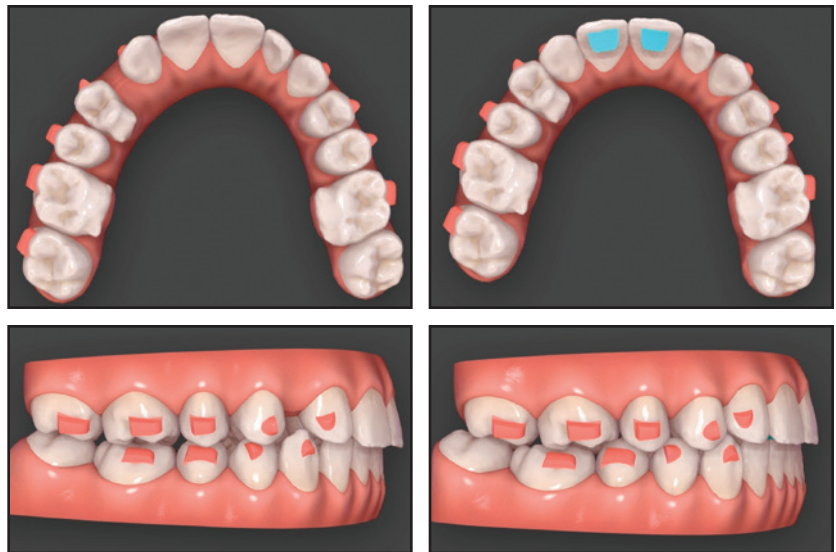


Fig. 8 Case 2. 19-year-old female patient with missing upper right lateral incisor and spacing before treatment.



Fig. 9 Case 2. Passive Mesialslider in place.

Fig. 10 Case 2. ClinCheck treatment plan for bodily mesial movement of teeth, avoiding rotations and up-righting movements.**



spring was not activated at this stage (Fig. 9).

An intraoral scan was taken for prescription and fabrication of Invisalign aligners (Fig. 10). Sequential mesialization of the premolars and molars was planned, allowing for maximum retentive surface contact of the aligners with the teeth being moved.

As soon as the aligners were delivered, the Mesialslider was activated by compressing the mesialization spring. The patient was instructed to change aligners every four days. Mesial movement of the upper right first premolar was noted after four months of treatment (Fig. 11). Two months later, with the first premolar anteriorly repositioned,

a closing spring was added for mesialization of the upper right first molar (Fig. 12). Spaces were almost completely closed after eight months of treatment (Fig. 13).

Total treatment time was 10 months, involving 70 sets of aligners and no refinement stage (Fig. 14). A removable maxillary retainer was delivered, and a 3-3 lingual mandibular retainer was bonded. For esthetic purposes, the upper right canine was reduced interproximally (.5mm distally and .5mm mesially) during treatment and

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Fig. 11 Case 2. After four months of treatment, showing proper aligner fit.

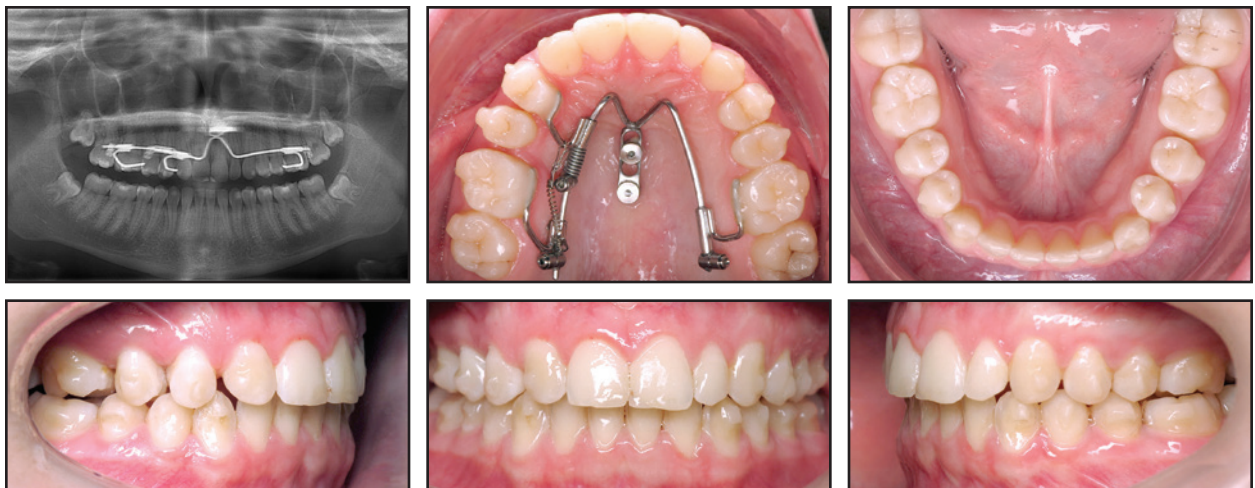


Fig. 12 Case 2. After six months of treatment.



Fig. 13 Case 2. After eight months of treatment.

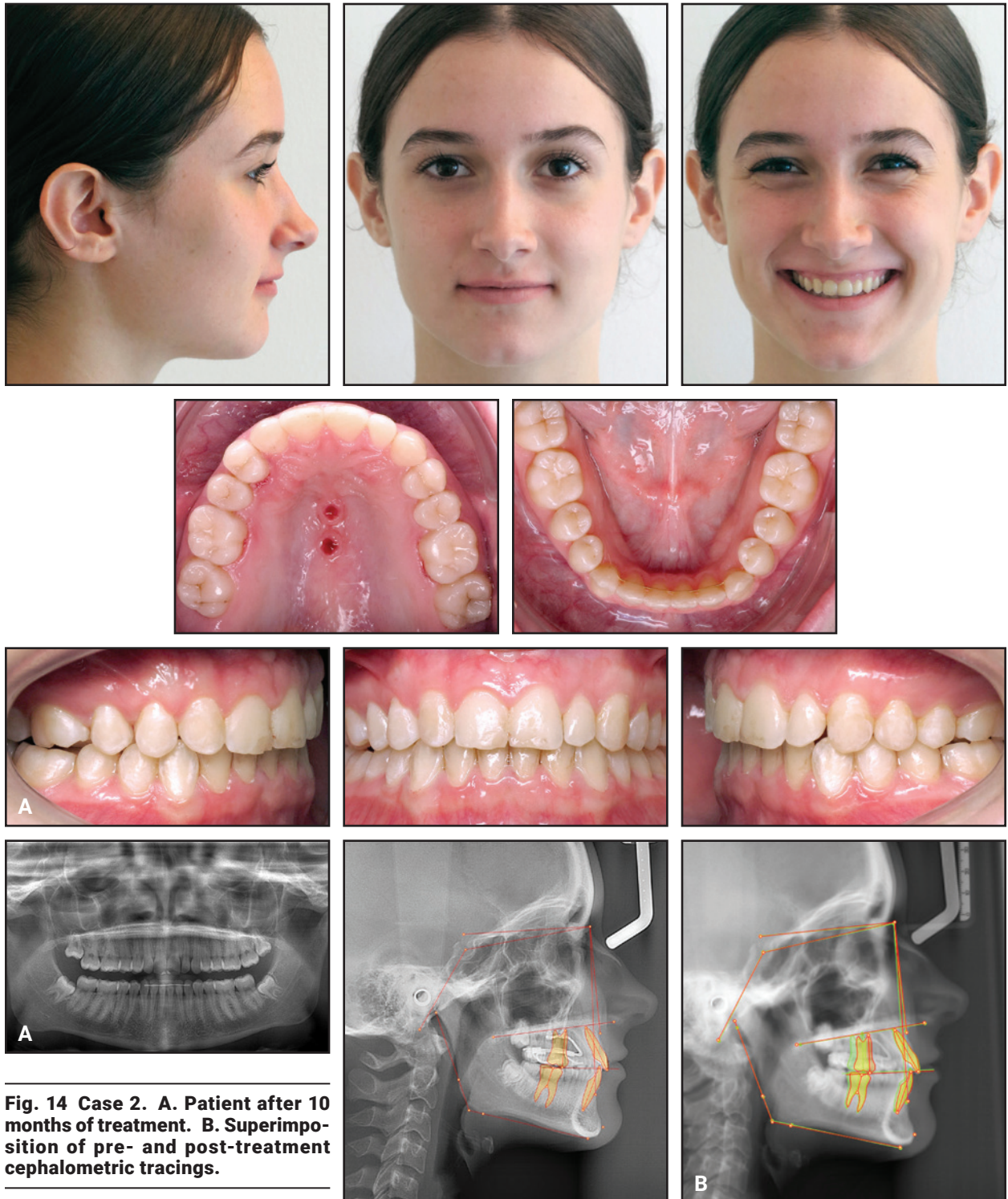


Fig. 14 Case 2. A. Patient after 10 months of treatment. B. Superimposition of pre- and post-treatment cephalometric tracings.

Fig. 15 Case 2. Patient one year after treatment.



vertically contoured after treatment. Small, .3mm mesial and distal interdental spaces were maintained in the virtual setup to facilitate later restorative enhancement of the maxillary left lateral incisor for coordination with the mesialized maxillary right canine.

Final records confirmed the bodily mesialization (Table 2). The results were stable one year after treatment (Fig. 15).

Discussion

The decision to use space closure or opening to address congenital absence of the maxillary lateral incisors should be made individually for each patient.² If space closure is chosen, the B-Mesial-slider offers advantages over other anchorage mechanisms, including less need for compliance than with Class III elastics, for example. Since the incisors are not attached to the device, a midline deviation can be corrected and the incisors can be protruded.²⁸ Brackets are not needed during mesialization, shortening the patient's time in fixed appliances or allowing combined treatment with clear aligners.

If aligners are to be worn simultaneously with a TAD-borne slider, we recommend the use of bonded molar tubes, as in Case 2, rather than

the stainless steel molar bands used in Case 1.³⁸ The advantage of a bonded tube is that it does not affect the adaptability and fit of the aligner, which can cover the bonded connection as it would a large attachment (Fig. 11).

Our initial experience in using the slider appliance in conjunction with aligners was with a two-stage approach, as demonstrated in Case 1.³⁸ In this protocol, an impression or scan is needed for fabrication of the aligners after mesialization is completed. The advantages are that the tooth movement with the slider does not have to be coordinated with staging of the clear aligners, and that fewer aligners are likely to be required. The primary disadvantage is a longer treatment time.

In the one-stage protocol, as in Case 2, the impressions or scans for aligners are taken prior to mesialization, and the anticipated tooth movement is programmed into the software platform. Synchronization of the appliances is challenging but feasible. A two-dimensional superimposition of the ClinCheck** and an image of the Mesial-slider may help coordinate tooth movement in the horizontal plane. The rate of mesial maxillary

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molar movement produced by a Mesialslider is about .6mm per month, or .15mm per week.³⁹ This should be kept in mind when designing the ClinCheck, because if the mesial molar movement outpaces the aligner staging, the fit and accuracy of the aligners may be compromised. Since the teeth connected to the slider will move parallel to the wire, any rotation or tipping of these teeth cannot be integrated into the ClinCheck. Attachments are still important in the design, however, for proper coordination of the slider and aligners. In clinical reality, the slider is probably the pacemaker, while the aligners can potentially reduce the rate of tooth movement. Aside from the mesialization, all other tooth movements are controlled by the aligners.

In our clinical experience, a sequential mesialization is not always required. The entire maxillary arch can be mesialized simultaneously, thanks to the absolute molar anchorage provided by the TAD-borne appliance. The stretch of the interdental fibers supports the simultaneous mesial drift of the maxillary posterior teeth. On the other hand, sequential mesialization may provide better control, since the aligners will have more surface contact with the teeth being moved. Another important point: when a refinement stage is planned and new aligners are ordered, the slider must be maintained in a passive state to ensure proper adaptation and fit of the aligners.

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