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Asymmetric Noncompliance Upper Molar Distalization in Aligner Treatment Using Palatal TADs and the Beneslider

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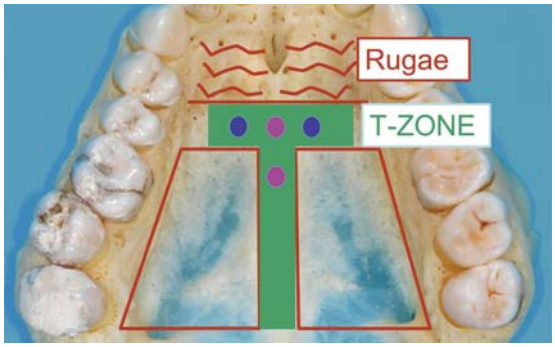
Upper Distalization in Aligner Treatment

Class II malocclusions are frequently encountered in orthodontic practice, with a prevalence of approximately 15%. The distalization of the maxillary first permanent molar teeth may be considered as a viable treatment option for patients presenting with an Angle Class II malocclusion characterized with an increased overjet and anterior crowding. Molar distalization can be performed using intraoral or extraoral appliances. Potential issues arising with patient compliance may be associated with the prolonged use of headgear.[1,2] There has been an increasing trend in the clinical use of purely intraoral appliances that require minimal need for patient cooperation. Unfortunately, most of the conventional devices for noncompliance upper molar distalization produce unwanted side effects, such as anchorage loss.[3] Most tooth-borne appliances for upper molar distalization produce an unwanted side effect of anchorage loss resulting in maxillary incisor proclination, reported to be 24% to 55 % of observed tooth movement.[3–5] In clinical cases requiring unilateral distalization, a midline shift of the anterior teeth is commonly observed. One possibility to reduce unwanted orthodontic effects of reciprocal forces is the usage of a palatal acrylic pad or Nance button. However, the anchorage stability of these soft-tissue-borne elements is not always certain. Moreover, oral hygiene is often impaired because of the partial coverage of the palatal area. To minimize anchorage loss, mini-implants have been incorporated into the design of maxillary distalization appliances.[6–16] Mini-implants can be positioned intraorally with minimal degrees of surgical invasiveness, are readily integrated with concomitant biomechanical initiatives, and are relatively cost effective.[16–22]

An increasing number of patients seek orthodontic treatment with sequential plastic aligner therapy. Pure bodily tooth movement with sequential plastic aligner therapy is challenging to achieve to a high degree of predictability. As a consequence, unilateral or bilateral molar distalization is limited when relying on aligner movement alone. While there are limited reports of successful upper molar distalization of up to 2.5 mm in the literature, a very long treatment time and high level of patient compliance are expected with requirement for intermaxillary Class II elastics to be worn during the long period of the sequential upper molar distalization.[23–25] Moreover, the potential side effects of Class II elastics must be considered in terms of mesial shift of the lower anchorage teeth; this might be a severe problem, especially in unilateral Class II elastics applications with the potential for development of a lower midline shift, maxillary arch rotation and a yaw discrepancy, and transverse occlusal canting.

Optimal Insertion Sites for Mini-Implants

Various iterations of implant-supported distalization appliances have been published recently. The retromolar region is an unsuitable area for mini-implant insertion because of the unfavorable anatomic conditions (poor bone quality and thick soft tissue).[26] In addition, the alveolar process has also been shown to be inappropriate in cases of a desired molar distalization, since the mini-implants are in the direct path of the moving teeth, resulting in a failure rate that is much higher compared to the anterior palate.[26,27] Therefore the palatal area posterior from the rugae (Fig. 7.1, T-Zone[28]) seems to be the preferred insertion site for mini-implants where the treatment objective is for distal movement of the maxillary first permanent molar without associated anchorage loss and maxillary incisor displacement. Furthermore, good bone quality with thin attached mucosa



• **Fig. 7.1** T-Zone palatal posterior from the rugae seems to be the optimum TAD insertion site for distalization of molars in the maxilla. Within the T-Zone, mini-implants can be inserted in a median or paramedian fashion.

implies minimal risk of tooth-root injuries and a very high success rate in the anterior palatal region.[29] In contrast to treatment strategies involving the interradicular positioning of mini-implants, the molar teeth can be distalized and the premolars are free to move distally because of the stretch of the interdental fibers without any interference, since the palatally positioned mini-implants are not in the path of moving teeth. Within the T-Zone, the mini-implants can be inserted in a median or paramedian orientation,[28] with both insertion sites showing a similar stability.[30]

Clinical Procedure and Rationale of the Beneslider

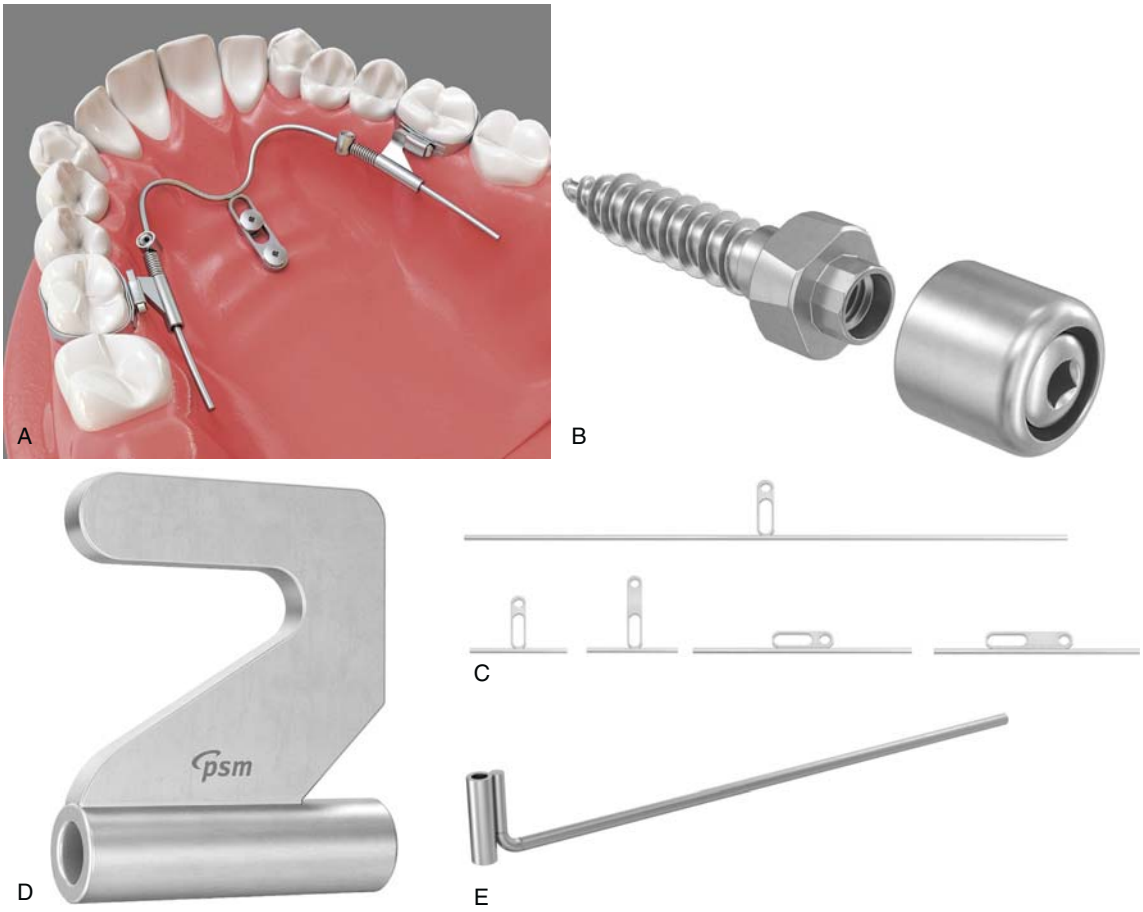
The Beneslider (Fig. 7.2)[20,31–33] is a maxillary molar tooth distalization appliance, principally designed on the use of one or two mini-implants coupled in a median or paramedian orientation in the anterior palate. Mini-implants with exchangeable abutments are indicated (see Fig. 7.2B) with the goal to achieve a stable and safe connection between the mini-implants and the distalization mechanics. Following the application of local or topical anesthesia in the anterior hard palate, the mini-implants are inserted usually without the need for predrilling of bone. It is advisable to choose mini-implants with a diameter of 2 or 2.3 mm, since they provide a superior stability.[34–37] An adult patient will typically present with areas of higher bone density in the anterior hard palate, and require a preparatory step of drilling a pilot hole to an approximate depth of 2 to 3 mm to be performed to keep the insertion torque within a safe range.[34] Predrilling can be performed using a handpiece that is adapted to a regular contra angle, without the need for cooling. The Benefit mini-implant[31–33,38] abutments (see Fig. 7.2B) can be secured with the use of an inner microscrew or fixation cap. If a single mini-implant is used, one abutment is fixed for the distalization mechanics. To increase the stability and prevent a rotational tendency leading to loosening, two Benefit mini-implants can be coupled with the Beneplate[32] (see Fig. 7.2C). To secure the Beneplate, a small fixation screw is used. Both abutments as well as Beneplates are available with 1.1-mm stainless steel wire configuration (see Fig. 7.2B and C). Depending on the axis and the location of the two positioned mini-implants, the Beneplate framework requires adjustment. By modifying the angulation of the 1.1 mm SS wire, it is possible to achieve a simultaneous intrusion or extrusion of the molars.[39–41] The distalization force is delivered by two springs (usually 240-g) activated by two locks (see Fig. 7.2A). At the same appointment, stainless steel bands with lingual sheaths are adapted to the maxillary molar teeth. These springs are pushing the sliding tubes (see Fig. 7.2D) into the lingual sheaths of the molar bands.

It seems advantageous that the Beneslider appliance can be fitted directly without the requirement for adjunctive laboratory work in terms of welding or soldering, or the need to record an intraoral impression. Alternatively, the clinician has the choice to record an intraoral impression and transfer the clinical setup to a plaster cast model using an impression cap and laboratory analogue from the Benefit system.

How to Combine Beneslider and Aligners, Strategies and Clinical Tips

If sequential plastic aligners are to be used to realize the planned tooth movement, we recommend the use of bonded tubes (see Fig. 7.2E) instead of bands, sheaths, or welded tubes (see Fig. 7.2A and D). The primary advantages of a bonded tube are esthetics, and the adaptability, accuracy, and fit of the aligners are not undermined by the presence of stainless steel molar bands. The aligner material could cover this bonded connection (Fig. 7.3A), or the aligner could be cut out in this connection area (Fig. 7.3B).

Following distalization of the maxillary molar teeth, steel ligatures can be used (see Fig. 7.3A) or springs removed (see Fig. 7.3B) to modify the Beneslider from an active distalization device to a passive molar anchorage device. The primary objective is to stabilize the maxillary molar teeth during the retraction of the maxillary anterior teeth. Our experience in using the Beneslider appliance in conjunction with aligners commenced with a two-phase approach[39]: the initial phase involving molar distalization, and the secondary phase for the final detailing of the occlusion with sequential plastic aligners. With a two-phase approach, an impression (or scan) is recorded *after* distalization (Fig. 7.3C). To reduce the total treatment time, we now recommend simultaneous distalization with the Beneslider and alignment with sequential plastic aligners. With a single-phase approach, the impressions for aligners are taken *before* distalization of the maxillary molar teeth and the anticipated tooth movement to be produced by the Beneslider appliance is programmed in the digital software platform. According to our clinical findings, a sequential step-by-step distalization is not required (ClinCheck, Align Technology). The entire maxillary dental arch can



• **Fig. 7.2** The Beneslider appliance (A) is based on one or two mini-implants with exchangeable abutments (B). On top of the mini-implants, abutments and miniplates (C) can be fixed. For median paramedian mini-implants, Beneplates with a wire parallel with the plate is used (long and short); for paramedian mini-implants, Beneplates with a wire perpendicular with the plate is used (long and short). The distalization force is delivered by springs and activated by two activation locks (A). Sliding tubes (D) can be stuck in lingual sheaths of upper molars, or tubes (E) can be bonded to the palatal surface.

be distalized simultaneously because of the absolute molar anchorage provided by the Benefit appliance; the stretch of the interdental fibers supports the simultaneous distal drift of maxillary anterior teeth.

If the sequential plastic aligner material covered the connection area with the molars (see Fig. 7.3A), the impressions for aligners should be recorded following the fitting and insertion of the Beneslider appliance. The Beneslider should not be activated before the delivery of the aligners. If the aligners have a cut out area (see Fig. 7.3B, Invisalign: "Button cut out"), the impressions for aligners are able to be recorded either before or after insertion of the Beneslider appliance. Distalization forces can be applied to the first (see Fig. 7.3A left) or second (see Fig. 7.3B right) maxillary molar teeth. Our clinical experiences have shown that force application to the first molar is a superior approach, as direct force application to the second molar teeth is associated with precocious distalization of the second molars leading to improper tracking and fitting of the sequential plastic aligners; a risk that is reduced if the maxillary first molar teeth are connected to the Beneslider.

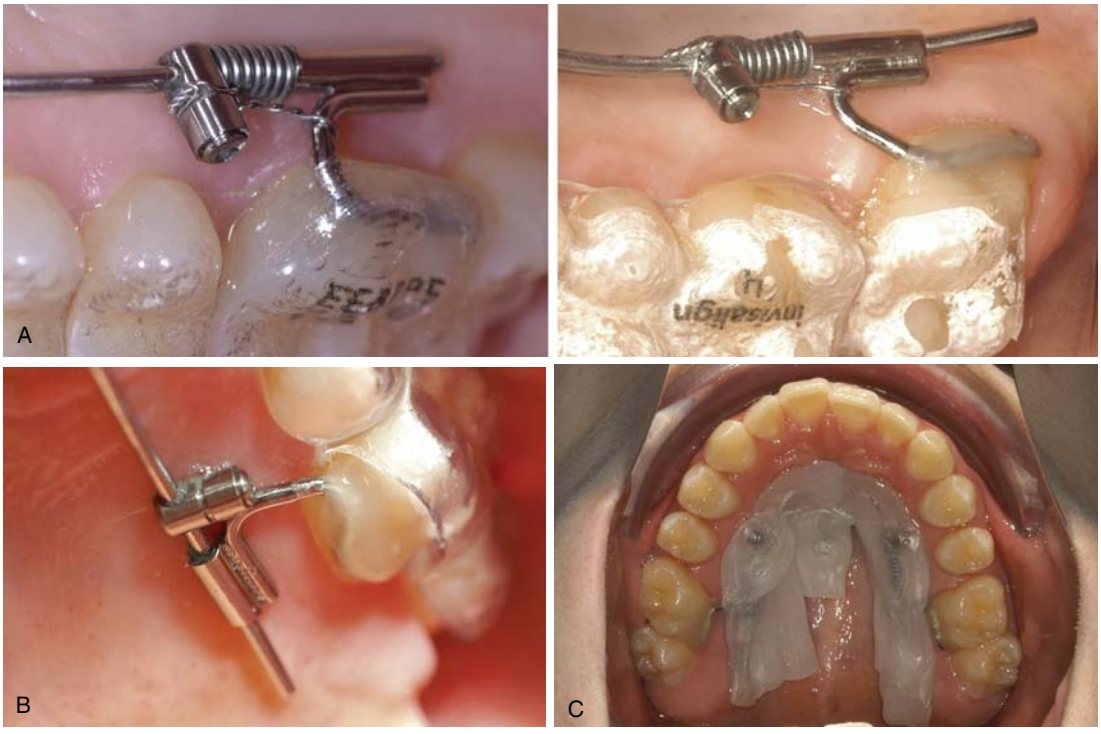
Clinical Case 1: Simultaneous Start of Aligner and Distalization

A 33-year-old male patient presented seeking orthodontic care to resolve an Angle Class II Division I subdivision right-hand-side malocclusion, characterized by anterior crowding, and a maxillary midline deviated to the left (Fig. 7.4, Table 7.1). The maxillary lateral incisor teeth were migrated mesially to the right side resulting in an asymmetric maxillary dental arch and an arch-length insufficiency for alignment of

the maxillary right canine. The patient specifically requested an invisible orthodontic treatment option, to be performed on a nonextraction basis. Following the insertion of two Benefit mini-implants in the anterior palate (Fig. 7.5A), the Beneslider appliance was passively installed (Fig. 7.5B, the spring is not activated) and the impressions were recorded for fabrication of clear sequential plastic aligners (Orthocaps, Hamm, Germany). The aligner manufacturer was instructed to design the aligners in such way that the aligner material covered the connection area (Fig. 7.6A). After delivery and insertion of the aligners, the Beneslider was activated by pushing the 240-g nickel-titanium (NiTi) springs distally using the activation lock (Fig. 7.6B). In the first quadrant, the maxillary molars were to be distalized approximately 6 mm, and in the second quadrant only 1 to 2 mm. The patient reportedly adapted to the appliance without issue. The panoramic radiograph denotes bodily distalization of all maxillary posterior teeth after 5 months (Fig. 7.7). Minor interdental spaces were noted in the maxillary arch (Fig. 7.8); this may have happened because of inadequate wear of the aligners or the use of an excessive distalization force resulting in precocious distalization of the maxillary molar teeth. The patient was encouraged to commit to the appropriate period of wearing the aligner, and the rate of molar distalization was reduced. After 14 months of treatment, the maxillary molar teeth were distalized into an Angle Class I occlusion, and a steel ligature was used between the bonded tube and the activation lock to deactivate the Beneslider (Fig. 7.9). The Beneslider was converted from a distalization device to a molar anchorage device. For the final finishing phase, absolute anchorage to stabilize the maxillary molar was no longer required and the Beneslider appliance was removed (Fig. 7.10). Comprehensive treatment was completed after 18 months (Fig. 7.11), and the palatal mini-implants were removed without the adjunctive use of local anesthesia.

Clinical Case 2: Aligner Start During Distalization

A 41-year-old female patient presented with an Angle Class II division 1 subdivision left-hand-side malocclusion, characterized by anterior arch crowding (Fig. 7.12 and Table 7.2). The maxillary posterior teeth were noted to be mesially positioned on the left side, resulting in an asymmetric maxillary dental arch, with insufficient arch length for the alignment of the maxillary left canine. The patient specifically requested an invisible orthodontic treatment option, to be performed on a nonextraction basis. After insertion of two Benefit mini-implants in the anterior palate, a Beneslider appliance was adapted for the appliance. Given the



• **Fig. 7.3** The aligners can cover the bonded connection (A) or the aligners can be cut out in this connection area (B). After distalization, steel ligatures are used (A) or the springs are removed (B). Wax should be used for a silicone impression (C).

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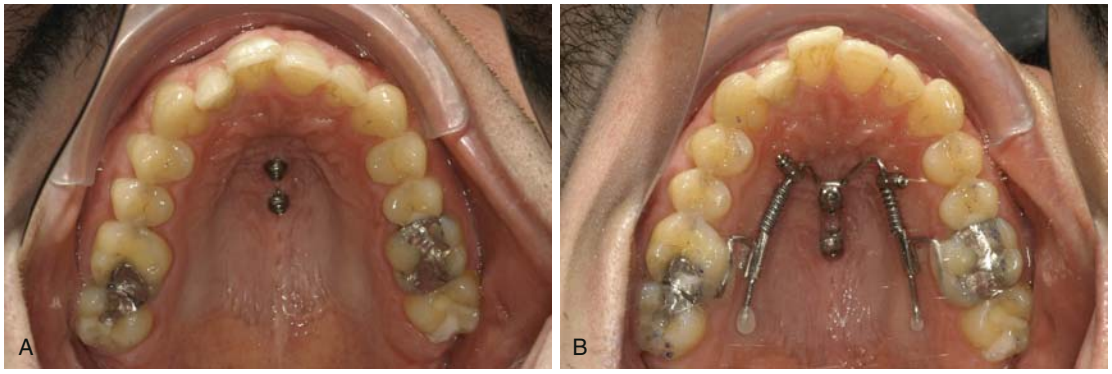
• **Fig. 7.4** A 33-year-old male patient with an Angle Class II Division I subdivision right-hand-side malocclusion, characterized by anterior crowding, and a midline shift to the left side.

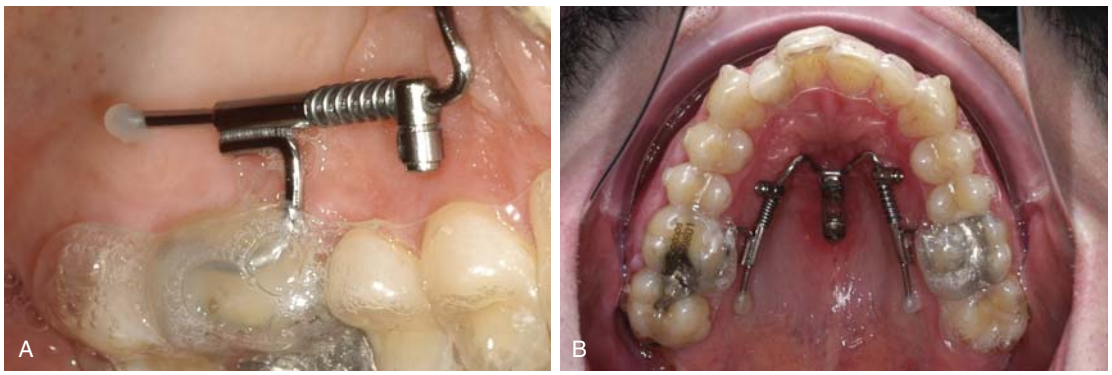
7.1 Case 1, Cephalometric Summary

	Pretreatment	Posttreatment
NSBa	123.9 degrees	124.5 degrees
NL-NSL	7.9 degrees	6.3 degrees
ML-NSL	35.0 degrees	38.3 degrees
ML-NL	27.2 degrees	32.1 degrees
SNA	80.5 degrees	78.5 degrees
SNB	76.2 degrees	74.0 degrees
ANB	4.3 degrees	4.6 degrees
Wits	3.7 mm	2.6 mm
U1-NL	117.6 degrees	106.6 degrees
L1-ML	93.3 degrees	94.5 degrees
U1-L1	121.9 degrees	126.8 degrees
Overjet	6.1 mm	3.9 mm
Overbite	2.0 mm	1.6 mm

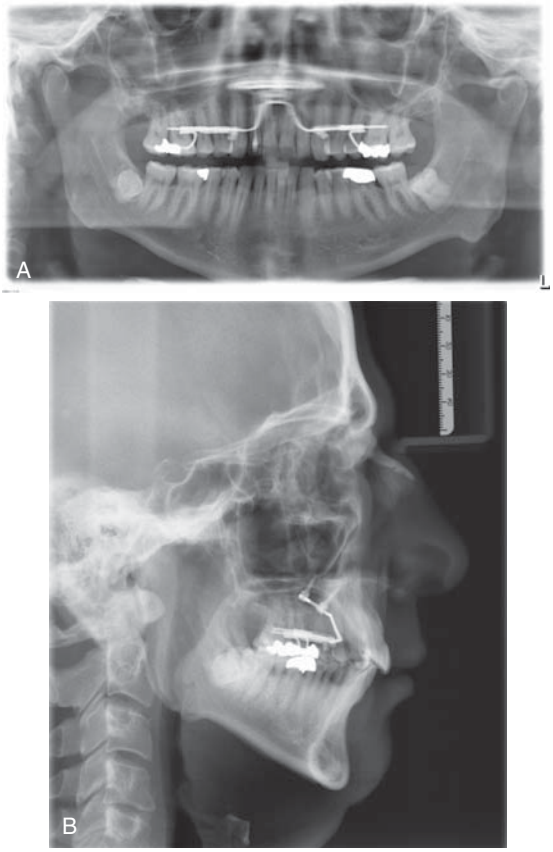
significant amount of distal movement of the maxillary left molar teeth required, an additional tube was used to support the bodily distalization of the maxillary left first premolar tooth (Fig. 7.13). Treatment commenced with the Beneslider being activated by compressing the lock on to the 240-g NiTi spring. In the second quadrant, the molars were to be distalized approximately 7 mm, in the first quadrant only 2 to 3 mm. After seven months of distalization, several small interdental spaces were visible in between the maxillary left lateral teeth, and an elastic chain was added for retraction of the upper left canine (Fig. 7.14). The panoramic radiograph denotes bodily distalization of all upper lateral teeth. Subsequently, impressions were recorded for fabrication of clear sequential plastic aligners (Invisalign, San Jose, United States). The aligner manufacturer was instructed to design and construct the aligners in such way that the aligner material covered the connection area on the palatal side of the molar (Fig. 7.15). After 16 months of treatment with the Beneslider appliance, the second right molar was distalized into a Class I occlusion and a steel ligature was used between the bonded tube and the activation lock to deactivate the Beneslider in the first



• **Fig. 7.5** After insertion of two Benefit mini-implants in the anterior palate (A) and installation of the Beneslider mechanics (B).

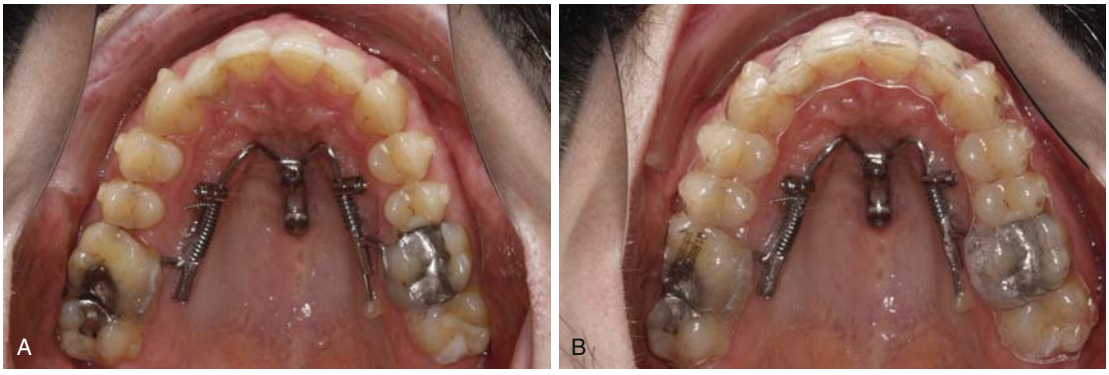


• **Fig. 7.6** (A, B) The aligners are covering the connection areas (Beneslider with the molars).



• **Fig. 7.7** OPG (A) and Cephalogram (B) after 5 months of treatment.

• **Fig. 7.8** Interdental spacing noted after 10 months.



• **Fig. 7.9** After 14 months of treatment, the molars were distalized into a Class I occlusion and a steel ligature was used between the bonded tube and the activation lock to deactivate the Beneslider (upper jaw without aligner [A] and with aligner [B]).

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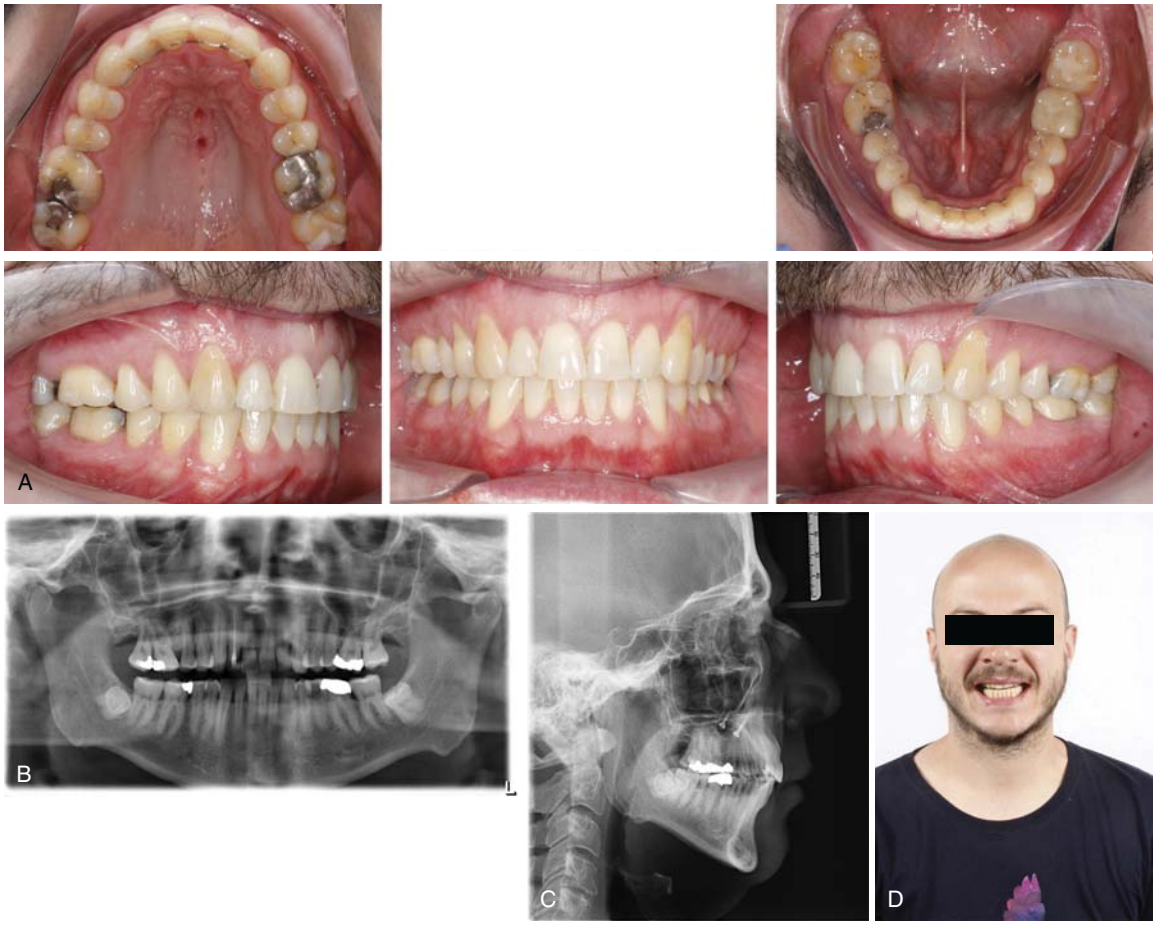
• **Fig. 7.10** After removal of the Beneslider appliance.



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• **Fig. 7.11** Treatment result after 18 months. Intraoral pictures (A), radiographs (B, C), and patient front view (D).

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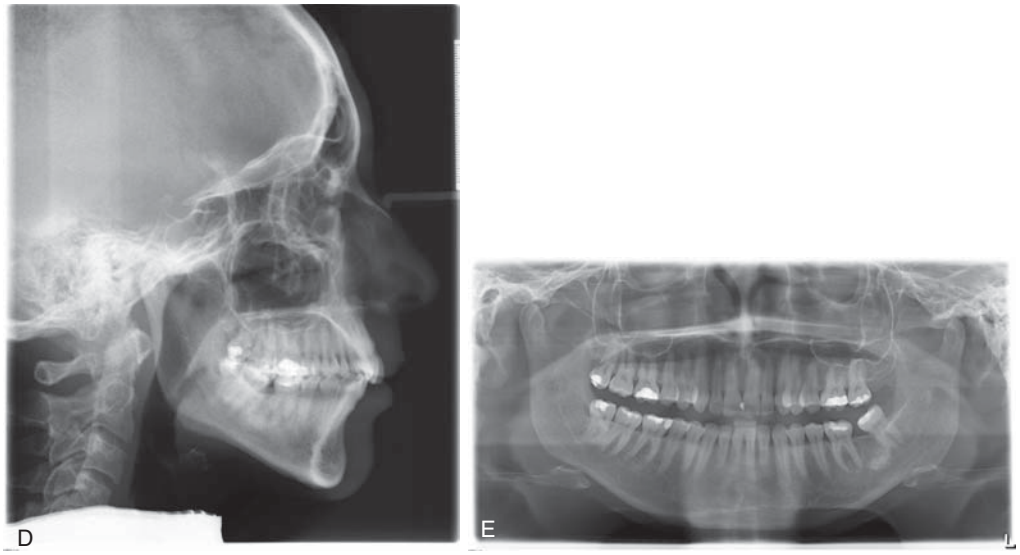
• **Fig. 7.12** A 41-year-old female patient with an Angle Class II Division I subdivision left-hand-side malocclusion, characterized by anterior arch crowding. Patient front view (A), intraoral pictures (B), and study models (C).

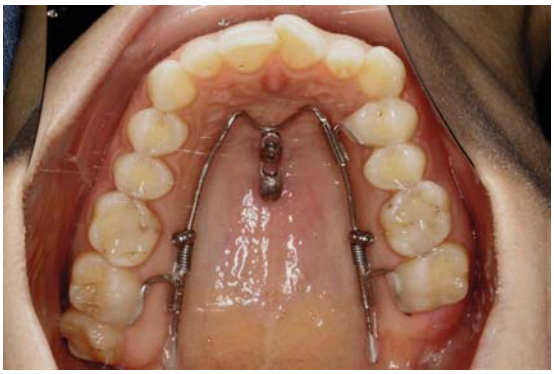


• **Fig. 7.12** cont'd

7.2 Case 2, Cephalometric Summary

	Pretreatment	Posttreatment
NSBa	131.7 degrees	132.5 degrees
NL-NSL	11.1 degrees	11.7 degrees
ML-NSL	40.7 degrees	40.8 degrees
ML-NL	29.6 degrees	29.1 degrees
SNA	78.1 degrees	77.3 degrees
SNB	73.0 degrees	72.6 degrees
ANB	5.1 degrees	4.7 degrees
Wits	6.7 mm	3.9 mm
U1-NL	111.7 degrees	107.6 degrees
L1-ML	96.2 degrees	92.5 degrees
U1-L1	122.6 degrees	130.7 degrees
Overjet	4.7 mm	3.7 mm
Overbite	2.8 mm	2.6 mm

quadrant (Fig. 7.16). After 20 months, all the interdental spaces were closed to the distal, with the digitally planned positions of the maxillary teeth realized in the final anterior-posterior position. The Beneslider appliance was removed, since absolute molar anchorage was not required for the final finishing phase (Fig. 7.17) of treatment. Comprehensive treatment was completed after 22 months (Figs. 7.18 and 7.19), and the palatal mini-implants were removed without anesthesia.



• **Fig. 7.13** Beneslider in place with an additional tube at the upper first left bicuspid.

Clinical Considerations

Our initial approach to combining sequential plastic aligner therapy and the Beneslider appliance involved a two-phase protocol: *phase 1:* distalization, and after distalization of the maxillary molar to proceed with *phase 2*: impression/scan and finishing with aligners.[39]

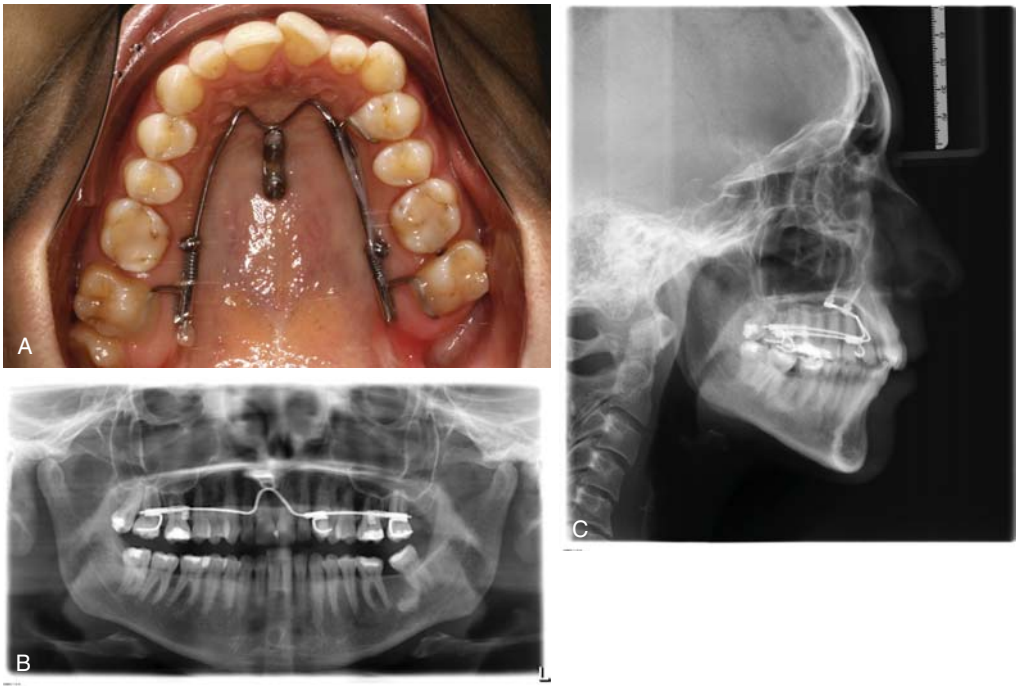
Advantages of this two-phase procedure:

- No need for coordination of tooth movement with Beneslider and aligners.
- An expected requirement for fewer aligners to achieve treatment objectives.

Disadvantages of the two-phase procedure:

- An expected increased treatment time.

To reduce the total treatment time, we modified our approach to a single-phase protocol involving



• **Fig. 7.14** After 7 months of distalization, several small interdental spaces were visible in between the upper left posterior dental segment. An elastic chain was added for retraction of the upper left first bicuspid. Upper jaw (A) and radiographs (B, C).

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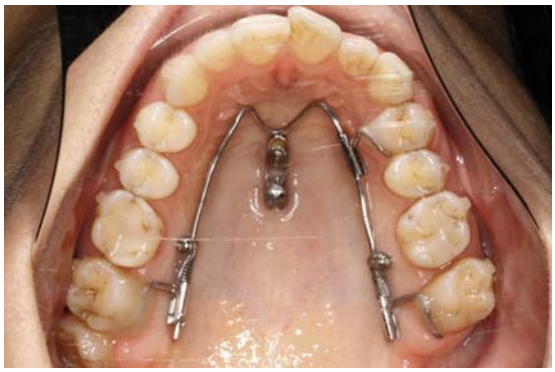
• **Fig. 7.15** Beneslider and aligner in place: the aligner material is covering the connection area on the palatal side of the molar. Upper jaw (A) and palatal view on the second quadrant (B).



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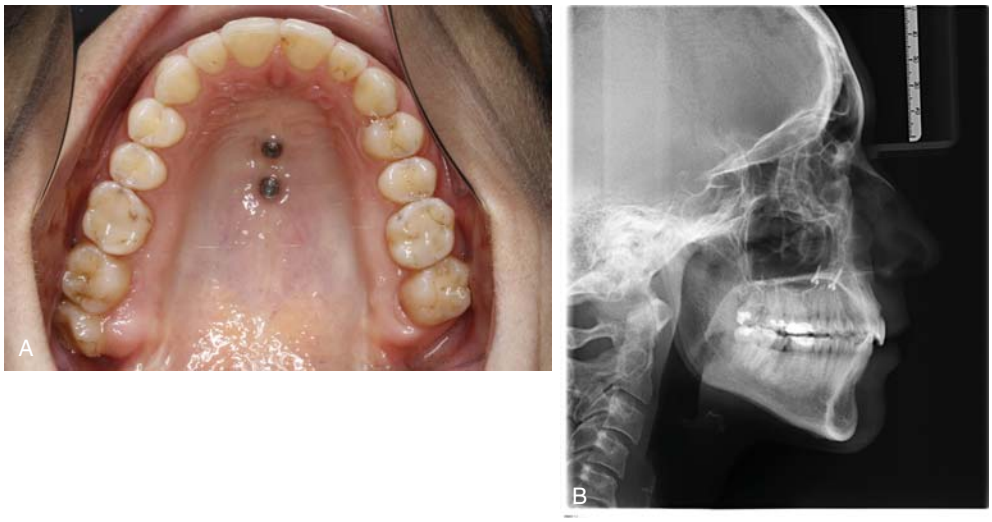
• **Fig. 7.16** After 16 months of treatment. A steel ligature is used between the bonded tube and the activation lock to use the Beneslider as a passive molar anchorage device.

simultaneous distalization and alignment with sequential plastic aligners. We have found that a single-phase protocol is associated with significantly reduced overall treatment time. The potential drawback with this approach is the coordination between the Beneslider appliance and planned aligner tooth movements. If the distalization force and/or the rate of distal molar movement are excessive compared to the aligner staging, the fit and accuracy of the aligner may be undermined with the appearance of maxillary interdental spacing. A second factor to be considered is the possibility of insufficient aligner wear by the patient. If this is recognized during active treatment, the rate of distalization may be reduced or the wear time

• **Fig. 7.17** After 20 months: all spaces are closed to the distal.



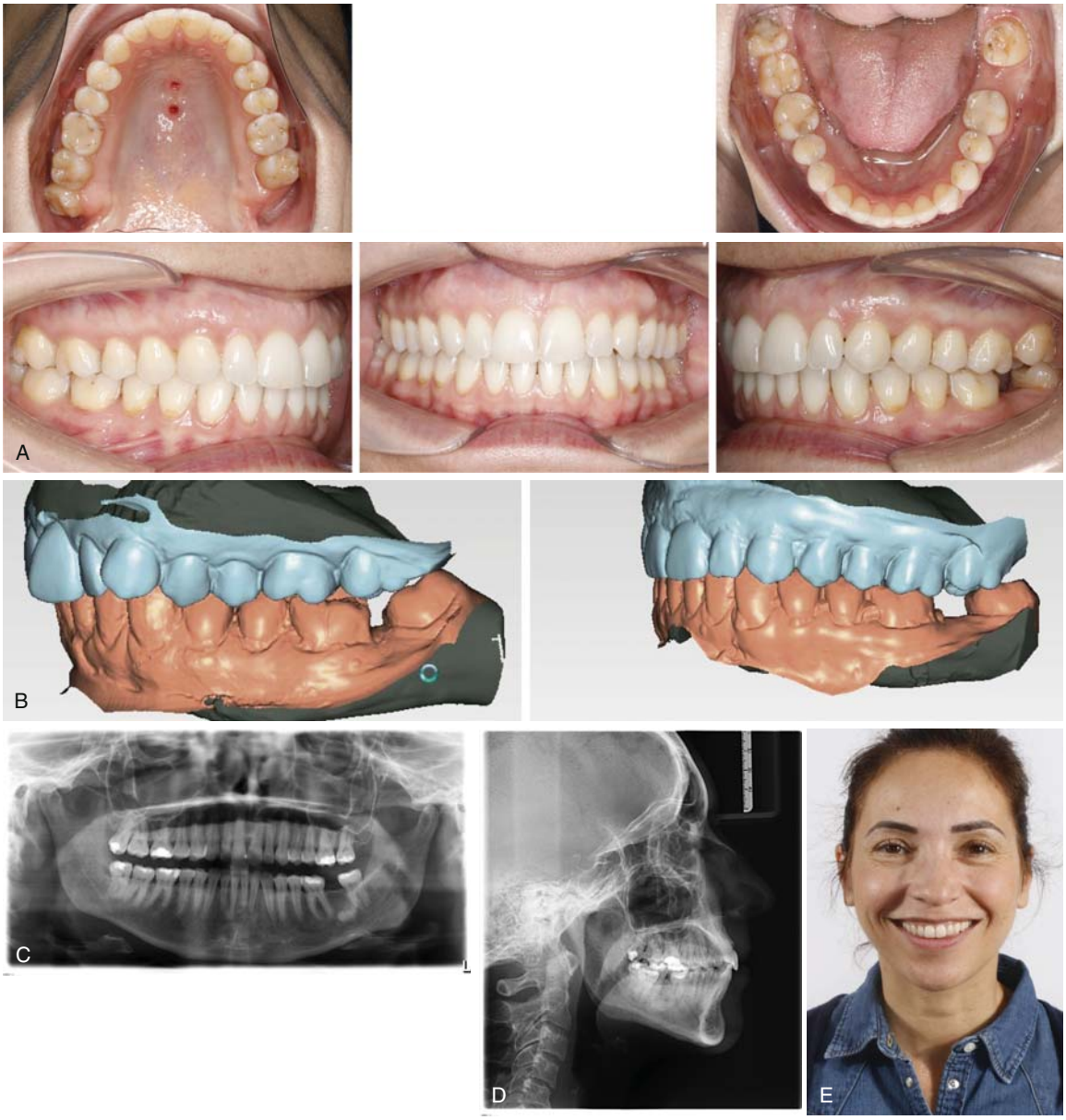
• **Fig. 7.18** After removal of the Beneslider in the final finishing phase. Upper jaw (A) and cephalogram (B).

of an aligner may be prolonged, for example, wearing each aligner for two weeks instead of one. The rate of the maxillary molar distal movement associated with the use of a Beneslider appliance is approximately 0.6 mm per month[42]; this rate of molar distalization speed should be kept in mind when determining the appropriate aligner staging (ClinCheck).

The distalization force can be directly applied to the first or second molar teeth. To have a maximum retention with the teeth that are to be moved distally, we recommend bonding the Beneslider to the first molar teeth instead of the second molars. If the distalization forces are applied to the second molars and the aligner fitting at the second molars is not perfect, small unexpected spaces can develop in between the upper first and second molar teeth (see Fig. 7.16). In this situation, the distalization force must be reduced to regain aligner fitting.

Another point that must be recognized: when a refinement is planned and new aligners are ordered, the Beneslider must be maintained in a passive manner to ensure the accuracy of the fit of the aligner.

The anterior hard palate has proven to be the most convenient region of the maxilla for insertion of mini-implants.[27,28] Since there are no roots, blood vessels, or nerves, the risk of a complication associated with the placement of a mini-implant is minimal. Even the penetration of the nasal cavity does not result in any problems. Recently, a computer-aided design/computer-aided manufacturing (CAD/CAM) manufactured insertion guide was introduced (Easy Driver, Parma, Italy), which facilitates safe and precise insertion of mini-implants in the anterior hard palate, allowing the opportunity for the use of palatal implants to the less experienced clinician. Secondly, these insertions guides allow for the insertion of mini-implants and installation of the appliance in a single office visit.[43]



• **Fig. 7.19** Treatment result after 22 months (A, C, D, E) with a three-dimensional scan of before and after (B, left side).

Conclusions

- By using palatal mini-implants and a Beneslider device, unilateral or bilateral distal tooth movement can be realized without anchorage loss.
- The Beneslider can be easily integrated in aligner therapy by using bonded tubes on the palatal surfaces.
- A combined, single-phase treatment approach with simultaneous distalization and alignment is possible.

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