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# APPLICATION AND EFFECTIVENESS OF THE BENESLIDER: A DEVICE TO MOVE MOLARS DISTALLY

**Aim:** Distal movement of maxillary molars is a reasonable but often challenging treatment alternative for patients with a dental Class II occlusion and an increased overjet or anterior crowding. One problem is that most of the conventional noncompliance devices that distally move maxillary molars lead to some anchorage loss. As such, a new appliance was designed that is connected to two coupled mini-implants with exchangeable abutments. The aim of this study was to evaluate the effectiveness of this system for distal movement and the extent of its adverse effects.

**Methods:** Maxillary molar distal movement was performed in 18 patients (10 females, eight males) in 6 to 10 months. The appliance (Beneslider) combined elements of the distal jet and Keles slider with two abutment mini-implants (spider screws or Benefit mini-implants). Pre- and post-treatment casts were scanned with cone beam computed tomography. To assess the amount of molar distal movement, molar rotation and transverse expansion the 3D scans were digitally superimposed. Lateral cephalograms were used to measure molar tipping. **Results:** The mean distal movement of the first molars amounted to  $4.6 \pm 1.5$  mm, the mean mesial rotation to  $3.4 \pm 2.0$  degrees, the transverse expansion in the first molar region to  $1.9 \pm 1.0$  mm, and the distal tipping to  $1.9 \pm 1.3$  degrees.

**Conclusion:** Two coupled mini-implants with exchangeable abutments and a heavy wire were an effective way to bodily move maxillary molars distally. World J Orthod 2010;11:331–340.

**Key words:** molar distalization, TADs, mini-implants, Class II treatment

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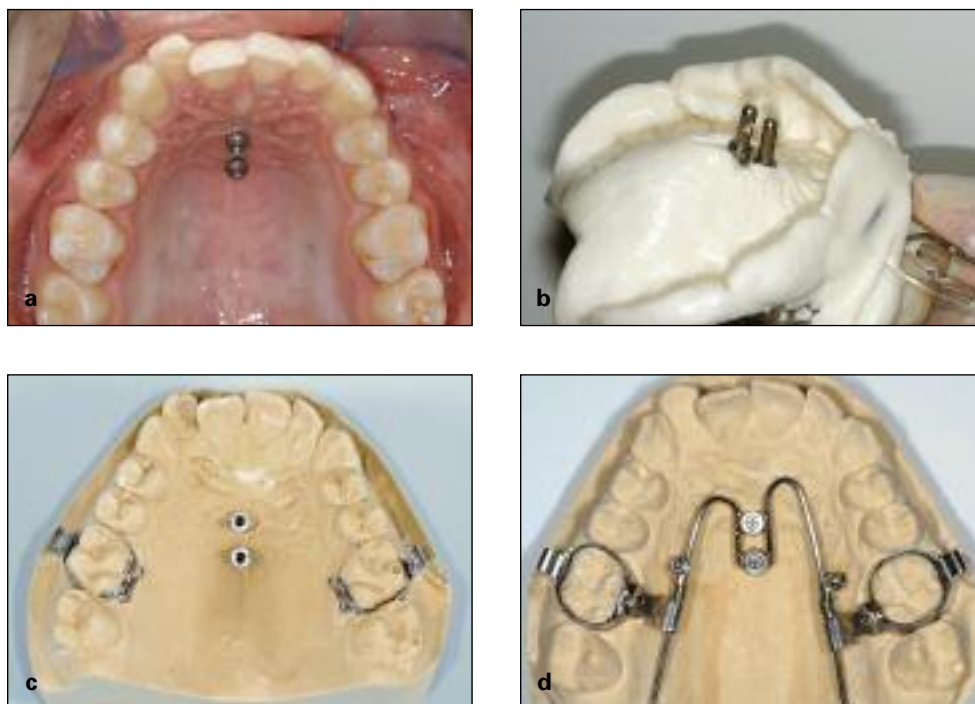
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For patients with a dental Class II occlusion with increased overjet or anterior crowding, moving the maxillary molars distally is recommended when extraction therapy is not indicated. Due to esthetic drawbacks and the length of wear, distal movement with headgear is unpleasant for many patients.<sup>1,2</sup> Therefore, intraoral appliances with minimal need for patient cooperation are preferable. However, most of the conventional devices for noncompliance molar distal movement result in some anchorage loss (mesial migration of premolars or protrusion of the anterior teeth).<sup>3,4</sup> One way to reduce this adverse effect is the use of

palatal acrylic pads (Nance buttons). Yet, the anchorage stability of any soft tissue-borne element is questionable. Moreover, such buttons impede optimal oral hygiene.

To minimize or eliminate anchorage loss, skeletal anchorage devices have been integrated into distal-movement appliances.<sup>5–14</sup> In particular, mini-implants have attracted great attention in recent years because of their versatility, minimal surgical invasiveness, and low cost.<sup>15–20</sup> Still, most of these devices do not solely rely on mini-implants, but still employ teeth or Nance buttons as additional anchorage elements.



**Fig 1** (a) Two mini-implants with a diameter of 2.0 mm are inserted into the anterior region of the palate. (b) Transfer caps and laboratory analogs are positioned in the impression. (c) Plaster cast with molar bands and laboratory analogs. (d) Beneslider appliance comprising activation locks and coil springs from the distal jet and headgear tubes from the Keles slider soldered on the molar bands. The 1.1-mm stainless steel wire is laser-welded to the two mini-implants.

The major drawback of devices employing indirect anchorage is that they require two treatment phases: (1) distal movement of the molars and (2) retention of the molars and distal movement of the premolars or retraction of the anterior dental segment. Entering the second phase involves a major reconstruction of mechanics.

Consequently, a device for maxillary distal movement establishing direct anchorage on mini-implants is advantageous because it is a one-phase treatment so appliance reconstruction is not necessary; Nance buttons are not needed, which improves patient comfort and hygiene; and anchorage loss is avoided since teeth are not included in the anchorage unit.

To profit from these advantages, the Beneslider,<sup>20,21</sup> a distal-movement appliance connected to two coupled mini-implants with exchangeable abutments in the anterior palate, was designed.

The aim of this study was to assess whether mini-implants alone can provide sufficient anchorage for maxillary molar distal movement. The effectiveness of distal movement and extent of possible adverse effects were also evaluated.

## METHOD AND MATERIALS

Maxillary molar distal movement was performed in 18 patients (10 females and eight males). Twelve were children or adolescents (10 to 15 years of age, mean age 12.4 years), while six were adults (aged 25 to 47 years, mean age 35.2 years).

### Clinical application and construction of the Beneslider

After local anesthesia, two mini-implants were inserted with a contra-angle in the anterior median region of the palate next to the second and third palatal rugae (Fig 1a). A dental probe was used to identify a region with thin mucosa, which is important to avoid a large lever arm and thus to achieve sufficient primary stability.<sup>22,23</sup> In four patients, spider screws (HDC) were inserted, while 14 patients received Benefit mini-implants<sup>21</sup> (PSM, Tuttlingen, Mondeal). The implant diameter was 2.0 mm because previous studies have shown that implant diameter and primary stability are positively correlated.<sup>24-27</sup> Depending on the available bone, as observed in the patient's cephalogram, the lengths of

**Fig 2** The spider screw system ( $2.0 \times 11.0$  mm) with its acrylic abutment is secured by a tiny screw and screw-driver.



**Fig 3** The Beneslider attached to a spider screw ( $2.0 \times 11.0$  mm) with its acrylic abutment, around which a small premolar band was bonded. This band was laser-welded to the 1.1-mm wire. The posterior mini-implant is a Dual Top Screw ( $2.0 \times 8.0$  mm) that was coupled to the spider screw after insertion of the distalization appliance. No spaces appeared between the second premolars and the first molars when the latter moved distally. In Fig 3c, distal movement can be observed by the length of the wire extending distally out of the headgear tube.

the mini-implants were 7.0 to 9.0 mm posteriorly and 9.0 to 11.0 mm anteriorly. To minimize implant tipping, two mini-implants were coupled (tandem implant) in the direction of the estimated load.

At the same appointment, bands were fitted to the maxillary molars. After application of transfer caps (for the spider screw, the abutment was used as a transfer cap), an alginate or silicone (Provil, Heraeus) impression was taken. For superior precision, silicone is preferred. The angular relation of the transfer caps was maintained by intraorally connecting them with Transbond LR (3M).

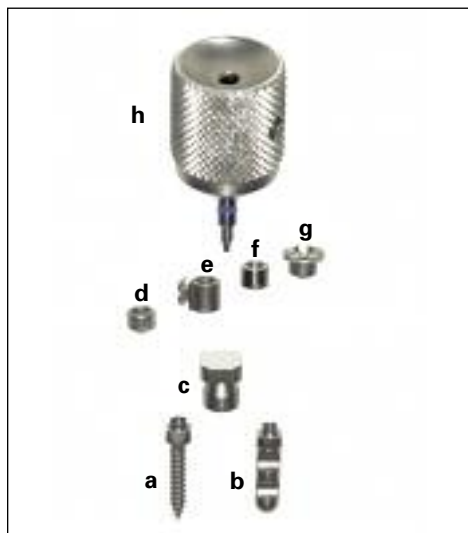
After impression taking, the laboratory analogs (for the spider screws, normal mini-implants) were placed on the transfer caps (Fig 1b). After pouring a plaster cast with all necessary elements in place, the bands were positioned in the impression (Fig 1c).

The Beneslider appliance comprises elements of the distal jet<sup>28,29</sup> (two activation locks and two coil springs, American Orthodontics) and the Keles slider<sup>30</sup>

(headgear tubes, Forestadent), as well as the two aforementioned mini-implants. A 1.1-mm stainless steel wire was bent and laser-welded to the abutments. The headgear tube was positioned near the estimated center of resistance of the respective molar to avoid its tipping. Molar distal movement was achieved by pressing the activation locks against the coil springs (Fig 1d).

### Beneslider on spider screws

Spider screws ( $2.0 \times 11.0$  mm) with acrylic abutments secured by tiny inner screws (Fig 2) were inserted anteriorly. Around the abutments, a small premolar band was bonded and laser-welded to the 1.1-mm wire. In these patients, the posterior mini-implants were Dual Top Screws (Jeil,  $2.0 \times 8.0$  mm). After insertion, this implant was coupled to the distal movement appliance with Transbond LR. One of the four patients in whom spider screws were used is shown in Fig 3.



**Fig 4** Benefit system. (a) Mini-implant; (b) laboratory analog; (c) impression cap; (d) wire abutment; (e) bracket abutment; (f) standard abutment; (g) slot abutment; (h) screwdriver for fixation of the abutment.



**Fig 5** Beneslider on Benefit mini-implants (2.0 × 11.0 mm). Under the premise of stable mini-implants, the distal movement of the molars can be verified by appraising the length of the wire extending distally out of the headgear tube.

### Beneslider on the Benefit system

To improve the mechanical coupling, the Benefit abutment system was used (Fig 4). It also comprises transfer (impression) caps (Fig 4c) and laboratory analogs (Fig 4b). The two Benefit mini-implants (Fig 4a) were again inserted in the anterior area of the palate. For the Beneslider, the so-called standard abutment was chosen and mounted on top of the Benefit mini-implant with an inner abutment-integrated screw. One of the 14 patients in whom the Benefit system was used is illustrated in Fig 5.

### Evaluation of the distal movement and its adverse effects

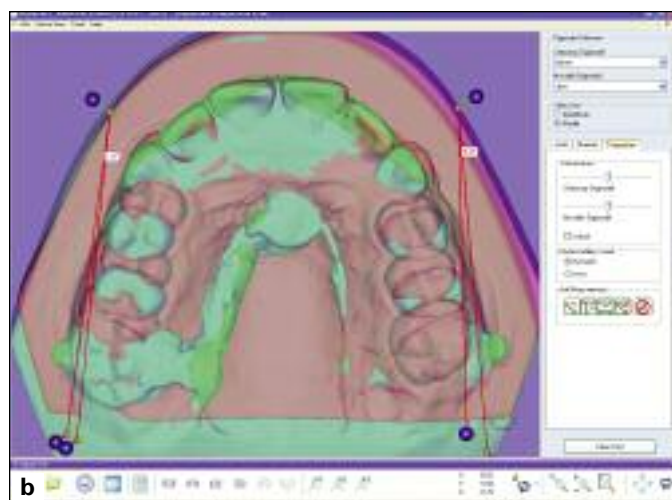
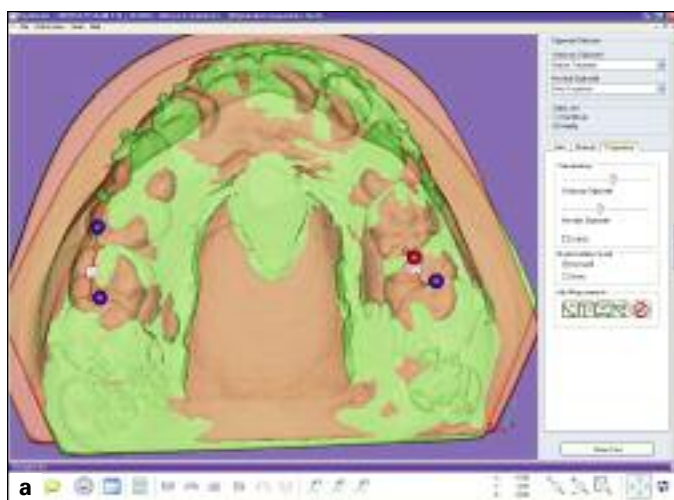
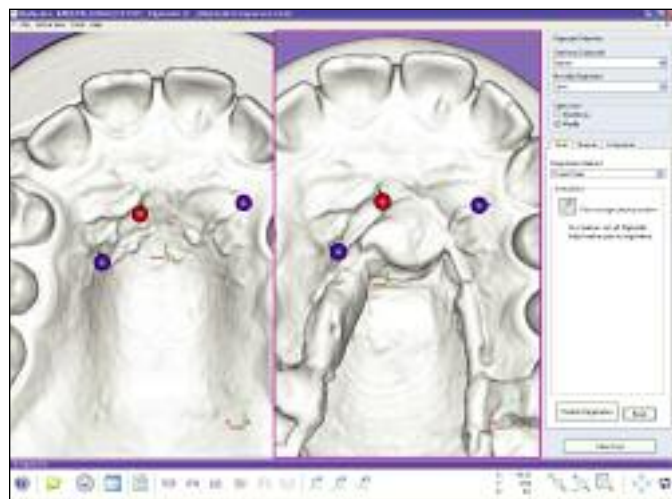
Pre- and posttreatment plaster casts were scanned with cone beam computed

tomography. To assess the extent and type of molar movement, the 3D scans were digitally superimposed using Digi-Model software (OrthoProof) (Fig 6).

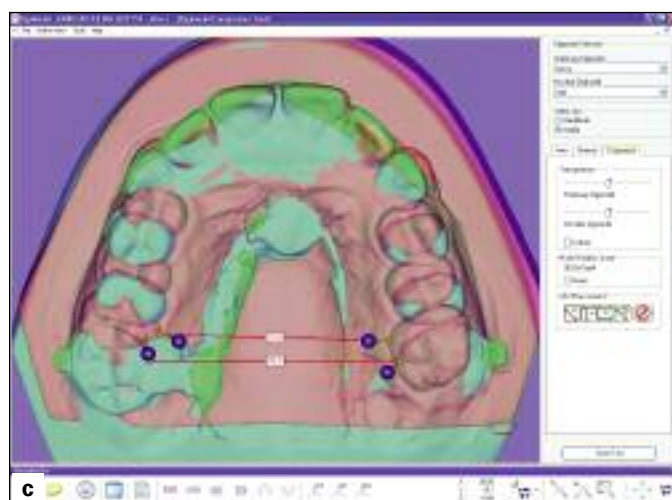
The distal movement was measured on each side to identify corresponding points at the molars before and after distal movement (Fig 7a). The amount of the mesial rotation on each side was evaluated by measuring the angle between the buccal surfaces of the molars before and after distal movement (Fig 7b). The transverse effects were quantified by gauging the distance of two corresponding points at the first molars before and after they were moved distally (Fig 7c).

The amount of molar tipping was assessed on lateral cephalograms by measuring the angle between the line ApUpMol and CpUpMol before and after distal movement (Fig 8).

**Fig 6** Definition of three landmarks with the DigiModel software in the 3D scans of the plaster casts before and after moving the first molars distally for subsequent superimposition.



**Fig 7 (a)** Superimposition of the plaster models from before and after moving the first molars distally and measurement of the movement distance by identification of corresponding points. **(b)** Defining the amount of the mesial rotation on each side by evaluating the angle between the buccal surfaces of the molars before and after distal movement. **(c)** Quantification of the expansion by measuring the distance of corresponding points at the first molar before and after distal movement.

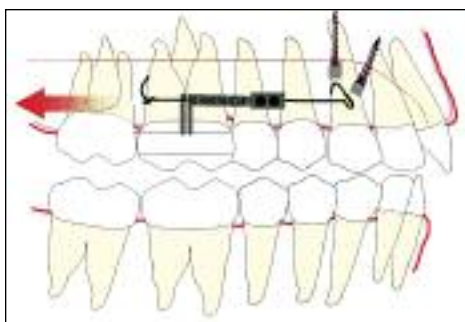




**Fig 8** Superimposition of pre- and post-distal movement cephalograms. Clinical example with spider screw mini-implants (treatment duration 10 months). The amount of molar tipping was evaluated by measuring the angle between the line ApUpMol to CpUpMol before (*black*) and after (*white*) distal movement.



**Fig 9** Superimposition of the (*black*) pre- and (*white*) postdistal movement cephalogram of a patient treated with the Benefit system (treatment duration 8 months).



**Fig 10** Schematic drawing of the employed mechanics: To achieve a bodily movement of the molars, these teeth are guided by a 1.1-mm wire, since the force vector runs through the center of resistance. To prevent tipping of the mini-implants, two large coupled ones should be inserted to receive the counterforce.

**Table 1 Mean molar distal movement, mesial rotation, transverse expansion (mm, derived from 3D cast scans), and molar tipping (degrees, derived from lateral cephalograms)**

	Mean distal movement (mm)	Mean mesial rotation (degrees)	Mean transverse expansion (mm)	Mean molar tipping (degrees)
Right	4.7 ± 1.5	3.1 ± 2.2		
Left	4.5 ± 1.6	3.8 ± 1.8		
Total	4.6 ± 1.5	3.4 ± 2.0	1.9 ± 1.0	1.9 ± 1.3

## RESULTS

Achieving the intended molar distal movement took between 6 and 10 months. In the first clinical example (spider screws), treatment duration was 10 months (Fig 8); in the second (with the Benefit system), it was 8 months (Fig 9).

The mean distal movement on the right side was 4.7 ± 1.5 mm, 4.5 ± 1.6 mm on the left side, and 4.6 ± 1.5 mm in total. The mean mesial rotation of the right first molars was 3.1 ± 2.2 degrees, 3.8 ± 1.8 degrees of the left, and 3.4 ± 2.0 degrees in total. Transverse expansion in the first molar region was 1.9 ± 1.0 mm and tipping 1.9 ± 1.3 degrees (Table 1).

In one of the four patients with the spider screw system, the appliance had to be removed after 4 months due to excessive mesial migration of the Beneslider. The reason for this was a failure of the Transbond coupling of the appliance with the posterior Dual Top Screws. Obviously, the spider screw cannot withstand the reactive load alone.

## DISCUSSION

The Beneslider with two mini-implants with exchangeable abutments is an effective device to bodily move maxillary molars distally with only small adverse effects.

The evaluation of the distal and transverse movement and rotation by 3D scans is a very suitable method. In contrast to lateral cephalograms, it allows separate assessment of both sides, measuring the rotation of the molars and their transverse movement. However, the cephalogram seems to be advantageous when molar tipping needs to be evaluated.

The distal moving effect of the Beneslider (4.6 mm) is adequate and in the upper third when compared to previous studies that evaluated the effectiveness of devices to move maxillary molars distally (1.4 to 6.1 mm).<sup>31</sup> The observed tipping of the first molars was very small (1.9 degrees) in comparison with values from other studies<sup>31</sup> (1.0 to 14.5 degrees). This can be attributed to the fact that the force vector was near to the estimated center of resistance of the molars and the exact molar guidance along the 1.1-mm wire (Fig 10). If the second molars were not bonded, they showed distinctive tipping.

The transverse expansion in the molar region led to a tendency of a Brodie bite in some patients. To reduce this problem, a parallel arrangement of the 1.1-mm wire (U-shape) seems to be advantageous compared with the divergent design (V-shape). However, the anatomy of the palate in some patients limits such a design. If a transverse expansion occurs, the 1.1-mm wire on the side with the Brodie bite tendency should be activated accordingly with a three-prong pliers.

In all patients, including the adolescents, the mini-implants were inserted in the region of the midpalatal suture. This leads to two queries: whether the mini-implant is stable in this location and whether the growth of the maxilla is influenced by the mini-implant insertion.

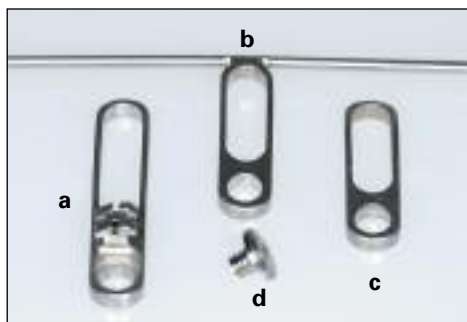
In regard to the former, it should be noted that only one mini-implant of 36 failed. Compared with failure rates in other regions, this rate is very low (2.7%). Also, the registered maximum insertion moment in the anterior and median regions of the suture ranged from 8.0 to 25.0 Ncm, which can be regarded as adequate to achieve a sufficient primary stability.

The question of a possible impairment of transverse maxillary growth due to implant insertion into the midpalatal suture was investigated by Asscherickx et al.<sup>32</sup> They inserted two Orthosystem (Straumann) implants in the suture of beagle dogs and observed an inhibition of transverse maxillary growth.<sup>32</sup> However, this study had only one control animal and one parameter differed.<sup>33</sup> Secondly, it is questionable whether Orthosystem implants, with their greater diameter and rough surface, can be compared to mini-implants. Also, clinical observations never revealed any tendency of reduced transverse growth of the maxilla. Yet, further studies should investigate this issue in more detail. If necessary, mini-implants can be inserted lateral of the suture because sufficient bone volume is available up to 3.0 mm lateral to it.<sup>34</sup>

Tandem coupled mini-implants withstood the forces needed to move maxillary molars distally without Nance buttons or additional anchorage teeth. The Keles slider combined with the Orthosystem<sup>35</sup> palatal implant system achieved this, as well.<sup>30</sup> However, the application of tandem mini-implants has some advantages, including insertion with only minor surgery, possible for orthodontists to insert, no lay-time for osseointegration, easy removal without surgical intervention, and low cost.

The only disadvantage of mini-implants seems to be a somewhat higher failure rate.<sup>35-40</sup> However, it should be kept in mind that reported failure rates are registered from various intraoral sites. It is





**Fig 11** (left) Beneplate system. **(a)** A long Beneplate with bracket in place; **(b)** short Beneplate with wire (1.1 or 0.8 mm) in place; **(c)** short Beneplate; **(d)** fixing screw.

**Fig 12** (right) Beneslider anchored with a Beneplate at the end of the molar distal movement; anterior bite blocks allow for unimpeded movement.

these authors' clinical experience that the failure rate in the anterior area of the palate is lower compared to other insertion sites. Consequently, it can be assumed that, in the anterior palatal region, failure rates of mini-implants and Orthosystem implants are comparable. To increase stability and avoid implant tipping in the direction of loading, it is advisable to couple two mini-implants (tandem implant) with a diameter of at least 2.0 mm in the line of force. The observed mesial tipping of the mini-implants used by Kinzinger et al<sup>12</sup> for a distal jet appliance can be explained by their small diameter (1.6 mm) and the fact that they were not coupled as tandem.

As demonstrated, the most advantageous location for the posterior tube to allow for a bodily movement of the molar is near its estimated center of resistance.

Another aspect that needs to be discussed critically is the relatively long time it takes to move molars distally. Usually, it takes 3 months until any movement of the molars becomes apparent. This can be explained by the fact that the transseptal fibers are stretched and thus induce a simultaneous distal migration of the premolars with the molars. Premolars migrate mesially and spaces between the second premolars and the first molars open, which may falsely be interpreted as distal movement of the first molars. Besides this, any bodily tooth movement takes more time than tipping. Last but not least, friction can also be a reason for the slightly longer time to move the molars distally.

Although patients treated with the spider screws generally revealed successful distal movement of the molars, fixation of the acrylic abutments with a premolar

band is inconvenient. Also, premolar bands are very thin; hence, it is difficult to weld them to the main wire. A stainless steel abutment, as fixed on a Benefit mini-implant, prevents this problem. Lastly, the abutment fixing screw, which is integrated into the Benefit abutment, makes insertion of the appliance much easier.

Any error during impression taking, cast pouring, or laboratory fabrication will affect the appliance fit on the inserted implants. In this case, one abutment can be removed and refixed intraorally with Transbond. An alternative to two coupled abutments is the prefabricated Beneplate, which has minor precision requirements<sup>41</sup> (Figs 11 and 12). Also, by using the Beneplate, the appliance can be made without any laboratory procedures (impressions).

In any case, the indication for maxillary molar distal movement has to be evaluated properly. In skeletal Class II patients with an unfavorable profile, other mechanics (Mara or Herbst appliances) are preferable.

## CONCLUSION

Two coupled mini-implants with exchangeable abutments and heavy wire guidance are effective to bodily move maxillary molars distally with negligible adverse effects. The Benefit system is more secure and more comfortable for the clinician than the spider screw system.

## ACKNOWLEDGMENT

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