
Closure of an open bite using the 'Mousetrap' appliance: a 3-year follow-up

Benedict Wilmes,^{*} Sivabalan Vasudavan,[†] Bruce Stocker,^{*} Jan H. Willmann^{*} and Dieter Drescher^{*}

Department of Orthodontics, University of Duesseldorf, Duesseldorf, Germany^{*} and Department of Developmental Biology, Harvard School of Dental Medicine, Boston, Massachusetts, USA[†]

Recently, skeletal anchorage devices have been used as anchorage units for upper molar intrusion as a way of correcting an anterior open bite malocclusion. To avoid the surgical procedures associated with the placement of miniplates in the zygomatic area, mini-implants may be inserted palatally or buccally in the alveolar process. However, consideration must be given to the potential risks of root damage and a higher failure rate associated with the placement of temporary anchorage devices (TADs) in the interradicular area. The anterior hard palate provides a safer and more stable alternative for TAD placement. The current paper describes the biomechanical principles and the clinical procedures of 'Mousetrap' mechanics using mini-implants in the anterior palate for upper molar intrusion. The stomatognathic response of maxillary molar intrusion is an autorotation of the mandible and so the sagittal implications for each patient must be considered. The presented patient demonstrates successful correction and stability of the treatment result at a three-year review.

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Benedict Wilmes: wilmes@med.uni-duesseldorf.de; Sivabalan Vasudavan: Sivabalan_Vasudavan@hsdm.harvard.edu;

Bruce Stocker: Bruce.Stocker@med.uni-duesseldorf.de; Jan H. Willmann: Jan.Willmann@med.uni-duesseldorf.de;

Dieter Drescher: drescher@med.uni-duesseldorf.de

Introduction

An anterior open bite is a challenging malocclusion to successfully address.¹ Patients presenting with a skeletal open bite may have a hyperdivergent facial pattern, an accompanying increase in lower anterior facial height and divergent maxillary and mandibular occlusal planes. A posterior maxillary vertical excess may be present and accompanied by a secondary downward and backward rotational displacement of the mandible.

The treatment approach to address an anterior open bite is often related to the underlying aetiology and the age of the patient. The correction may require surgical intervention involving the repositioning of the maxilla.¹ Alternative treatment approaches include the use of posterior bite block appliances with and without repelling magnets, and extra-oral traction with vertically-directed forces applied through the maxillary posterior teeth.^{2,3}

Absolute molar intrusion has long been considered difficult in orthodontic biomechanics. In order to achieve molar intrusion, it is necessary to direct the line of force action close or through the centre of resistance (CR) of a tooth in all three planes of space. An approximation of the CR of an upper molar is localised in the horizontal plane of space corresponding to the palatal root. If an intrusive force is applied only on one side, a moment relative to the CR will be created and buccal or palatal tipping may be clinically observed. To prevent this occurrence, forces need to be applied buccally and lingually relative to the CR and a transpalatal arch (TPA) can be utilised in this regard.

Temporary anchorage devices (TADs) have been integrated into the biomechanics of open bite treatment to attempt intrusion of the maxillary molars in an effort to avoid a surgical procedure.⁴⁻¹² Miniplates inserted in the area of the zygomatic buttress can

be employed to deliver a buccal intrusive force to a molar.^{7,8,13-15} However, the surgical placement of the titanium plate requires the elevation of a tissue flap and exposure of the underlying alveolar bone. The insertion of mini-implants of greater dimension in the zygomatic buttress is a second but less recommended alternative, since the area is covered by unattached mucosa. The disadvantages of mini-implant insertion into sites of unattached mucosa are a higher screw failure rate and soft tissue irritation causing patient discomfort and pain.^{16,17}

An alternative site of placement of mini-implants is in the alveolar process.^{5,6,9,18} However, there are a number of disadvantages related to the insertion into the interradicular area of the upper molars:

- There is often insufficient space on the buccal aspect to insert a mini-implant safely between tooth roots.¹⁹⁻²¹
- The increased thickness of the soft tissue overlying the palatal aspect of the alveolar process requires a long lever arm to the TAD, which increases the risk of mini-implant tipping and failure.²²
- The periodontal structures may be damaged if the mini-implant contacts the surface of a tooth root and the risk of failure of the mini-implant will be higher.^{23,24}
- The reduced interradicular area on the buccal alveolar process of the upper molars limits the placement of mini-implants to those with a small diameter.²⁵ However, small implant diameters are associated with a higher risk of fracture²⁶ and failure.^{17,22,27}
- Intrusive movement may be stopped and the root surface may be damaged when a molar is moved directly against a mini-implant during intrusion.^{28,29}
- There is a risk of penetration of the maxillary sinus when a mini-implant is inserted into the posterior area of the upper alveolar process.³⁰

To minimise insertion risks, a prudent strategy is the placement of mini-implants safely away from the roots and the teeth to be moved. The anterior palate provides for a suitable alternative insertion site where mini-implants with larger dimensions and higher stability^{31,32} may be placed in a region with a high bone quality, thin overlying soft tissue and negligible risk of causing interference with nearby teeth.³³ The 'Mousetrap' intrusion device, using TADs in the

anterior palate, was introduced for intrusion of supra-erupted upper molars.³⁴ In addition, the 'Mousetrap' can also be used to correct an anterior open bite malocclusion.

Clinical procedure and biomechanics of the 'Mousetrap' appliance

Figure 1 shows the construction principle of the Mousetrap appliance. For molar intrusion, lever arms are connected to two mini-implants inserted in the anterior palate. A transpalatal arch (TPA) is placed to avoid tipping of the molars during intrusion. In fabrication, stainless steel bands with a welded palatal sheath are cemented on the molar teeth designated for intrusion. A modified Goshgarian TPA with a distal loop is fitted with sufficient clearance between the palatal mucosa to avoid impingement and irritation during and after successful molar intrusion.

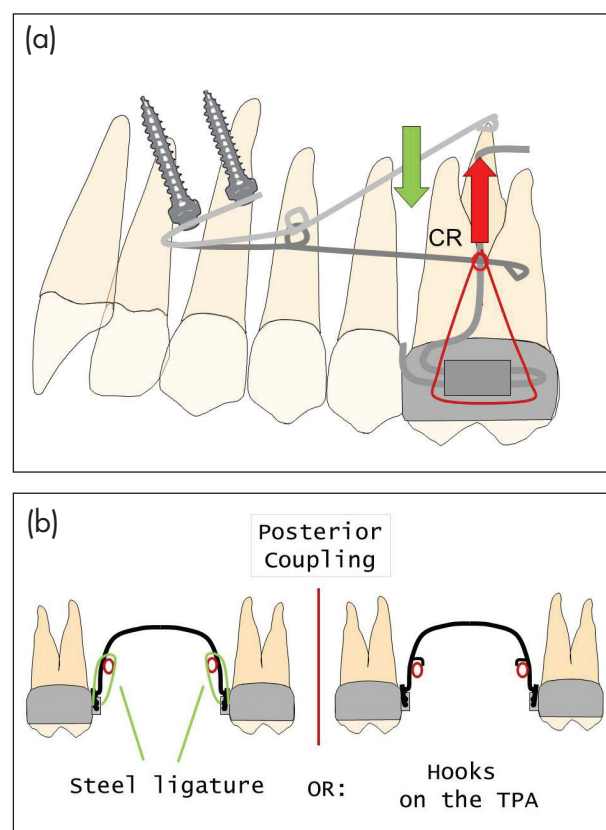


Figure 1. (a) Construction principle of the mousetrap appliance. Lever arms are connected to two mini-implants inserted in the anterior palate. In deactivated state the distal ends of the lever arms are located cranially to the centres of resistance (CR) of the molars. Pulling the lever arms downward (green arrow) and connecting them to the molars, a constant intrusive force is produced (red arrow). (b) Options for the posterior connection of the intrusion lever arms to the molars: Using steel ligatures (left) or soldering hooks on the TPA used as a stop for the lever arm (right).

Following the application of topical and/or local anaesthesia, two mini-implants (Benefit system,³⁵ PSM medical solutions, Tuttlingen, Germany) are inserted just posteriorly to the third palatal rugae using a manual contra-angle driver or with a motorised unit (2 × 9 mm anterior, 2 × 7 mm posterior). Pre-drilling (2–3 mm depth) is indicated in adult patients, due to a higher level of bone mineralisation. The implants are oriented perpendicularly to the palatal curvature. The Benefit mini-implants have a special head characterised by an inner screw thread (Figure



Figure 2. Head of a Benefit mini-implant with an inner screw thread.

2), which enables fixation of a selection of abutments and miniplates (Figure 3). The Beneplate³⁶ is fixed by two small screws (Figure 3D). In its deactivated state, the distal ends of the lever arms are located superiorly (Figure 1a). Activation of the 'Mousetrap' appliance occurs by pulling the lever arms downward (green arrow) and connecting them

to the molars, which produces a constant intrusive force. A force gauge (Correx Force Gauge, Correx, Köniz, Switzerland) can be used to measure the level of the applied intrusive force. Clinical protocol dictates the application of an approximate intrusive force of 100 grams per side. If bodily intrusion is indicated, the line of force action should coincide with the centre of resistance (CR) of the molar teeth. Simultaneous intrusion and uprighting of the molars can be achieved by adjusting the line of force action mesially or distally away from the CR.

The options for the anterior connection of the mini-implants to the intrusion lever arms include:

- a Beneplate with an attached bracket (Fig 3C) to which 0.017" × 0.025" lever arms are bent and ligated; or
- a Beneplate with an attached 0.8 mm wire (Figure 3B) adapted to the curvature of the palate.

The options for the posterior connection of the intrusion lever arms to the molars include:

- using a steel ligature (Figure 1a, 1b); or
- soldering hooks onto the TPA, which are used as a stop for the lever arm (Figure 1b right).

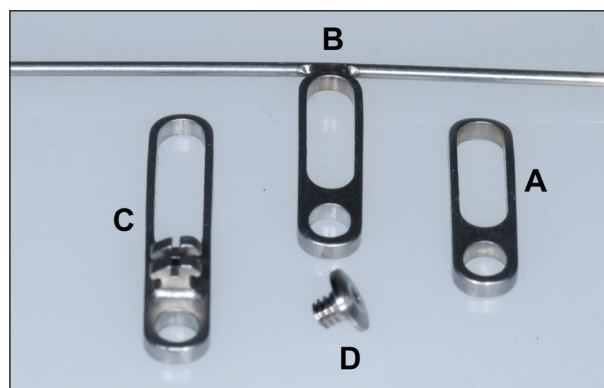


Figure 3. Beneplate system: (A) Standard Beneplate. (B) Beneplate with a wire in place (0.8 or 1.1 mm). (C) Beneplate with bracket in place. (D) Fixing screw

Clinical case example

Diagnosis

A 15-year-old male patient with an anterior open bite malocclusion was referred to the orthodontic department of the University of Duesseldorf (Figure 4). The patient had an Angle Class II molar and cuspid relationship and a mildly convex facial profile. An increased lower anterior facial height was also noted. A pretreatment cephalometric analysis demonstrated a mild skeletal Class III (Table I, Wits: -1.2 mm) and a skeletal open bite PP-MP: 27.9°. The maxilla was rotated anteriorly and the mandible rotated downwards and backwards. The panoramic radiograph demonstrated that three third molar teeth 18, 28, and 38 were present but unerupted. The intra-oral photographs showed a circular open bite of -4.8 mm, with primary occlusal contacts noted on the first and second molar teeth, exclusively.

Treatment objectives

The aims of treatment were:

1. to intrude the upper molar teeth;
2. expected autorotation of the mandible would facilitate correction of the anterior open bite, reduce the convexity of the facial profile and improve the dental Class II relationship;
3. to establish a functional occlusion.

Treatment alternatives

A coordinated orthodontic and orthognathic approach with posterior impaction of the maxilla was considered as an alternative way of surgically treating

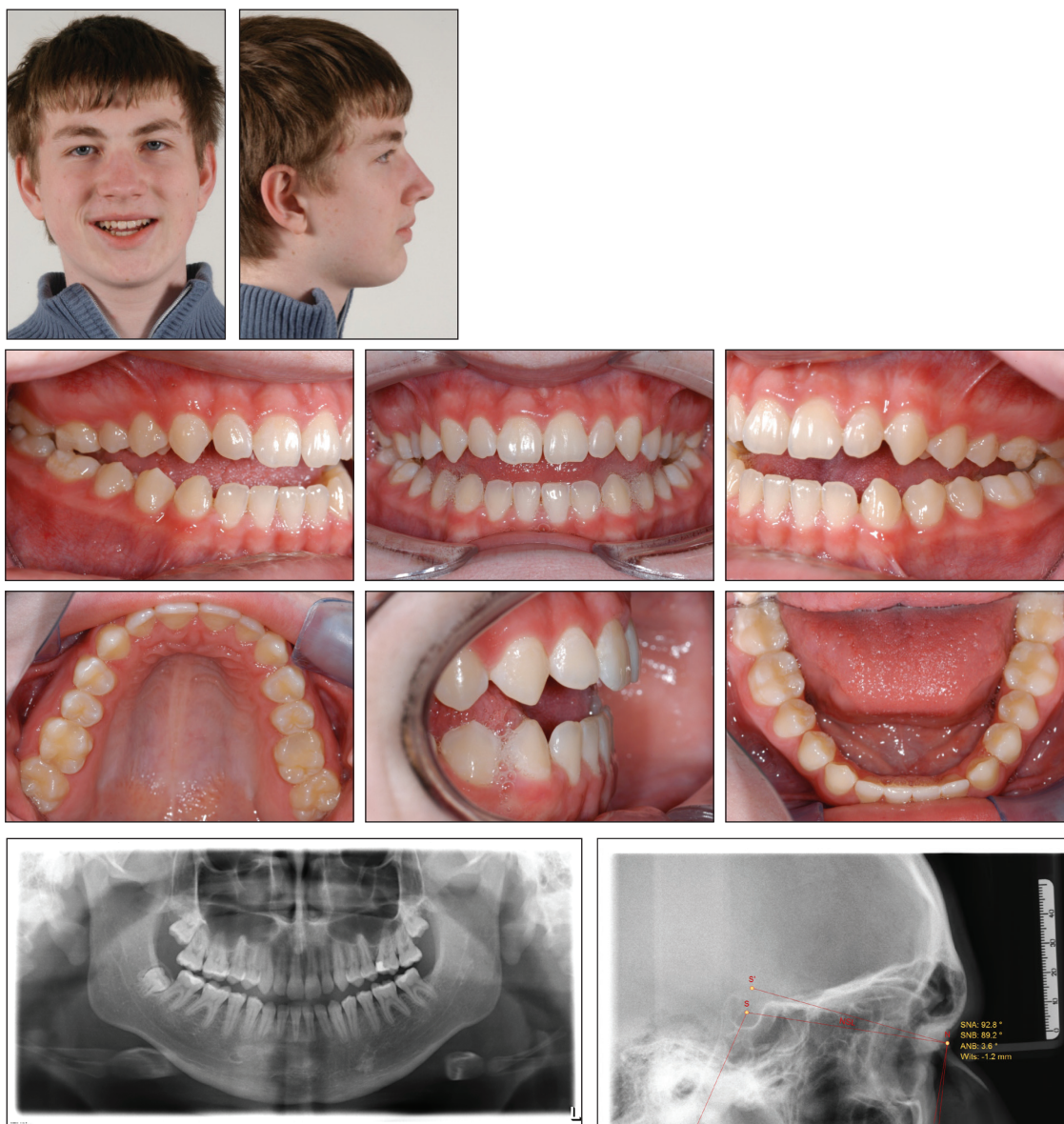


Figure 4. 15-year-old male patient with a skeletal open bite.



Figure 5. Mousetrap mechanics in situ.



Figure 6. Lateral intra-oral view before and at follow up appointments after six, eight and ten months.

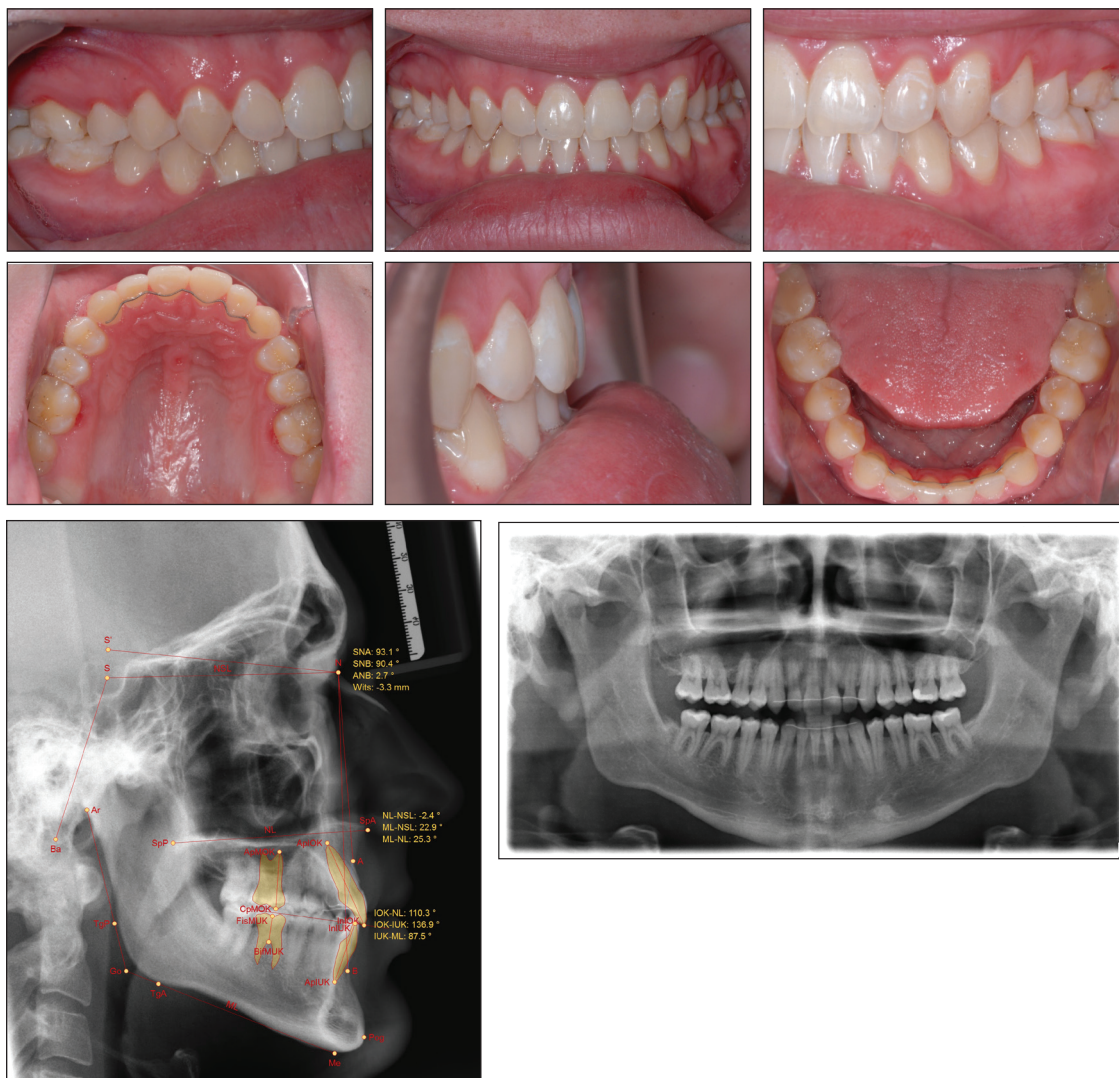


Figure 7. Patient at the end of the treatment.

Table 1. Changes in cephalometric variables before and after treatment.

Cephalometric variables	Before treatment (T1)	After treatment (T2)	Change (T2-T1)
SNA (°)	92.8	93.1	0.3
SNB (°)	89.2	90.4	1.2
ANB (°)	3.6	2.7	-0.9
WITS (mm)	-1.2	-3.0	-1.8
SN-PP (°)	-3.3	-2.4	0.9
SN-MP (°)	24.9	22.9	-2.0
PP-MP (°)	27.9	25.3	-2.6
ArGoMe (°)	126.1	125.2	-0.9
UI-PP (°)	110.4	110.3	-0.1
LI-MP (°)	88.5	87.5	-1.0
UHI (°)	133.2	136.9	3.7
OJ (mm)	3.1	3.2	0.1
OB (mm)	-4.8	0.2	4.6

SNA, Angle Sella-Nasion-A point; SNB, Angle Sella-Nasion-B point; ANB, Difference of SNB and SNA; WITS, Linear difference between B point and A point on functional occlusal plane; SN-PP, Angle Sella-Nasion line to Palatal plane; SN-MP, Angle Sella-Nasion line to Mandibular plane; PP-MP, Angle between Palatal and Mandibular planes; ArGoMe, Angle between Articulare-Gonion-Menton; UI-PP, Angle between Upper incisor long axis and Palatal plane; LI-MP, Angle between lower incisor long axis and Mandibular plane; UHI, Angle between long axes of Upper and Lower incisor; OJ, Overjet; OB, Overbite.

the malocclusion. The relative merits, shortcomings, and risks of each treatment modality were explained to the patient and his parents. Secondary to the underlying concerns about the associated risks of orthognathic surgery and the need to defer correction until growth completion, an informed decision to proceed with treatment was made and directed at molar intrusion.

Treatment progress

Pre-adjusted edgewise appliances were bonded to the maxillary and mandibular dentition and a TPA with two small hooks was placed. Two mini-implants were inserted in the anterior palate and a Beneplate with a 0.8 mm wire was fixed to the mini-implants. This rigid wire was connected to the TPA hooks and served as a bilateral molar intrusion lever arm (Figure 5). The reduction and continued correction of the anterior open bite was observed at review appointments after six, eight and ten months of treatment (Figure 6). The third molars were electively removed during the period of active orthodontic therapy.

Treatment results

The removal of the fixed orthodontic appliances was performed after 13 months of active treatment

(Figure 7). The extra-oral profile images and the superimposition of the pre- and post-treatment lateral cephalograms demonstrated an autorotation of the mandible (PP-MP after: 25.3°) resulting in a skeletal Class III tendency (Wits: -3.0 mm, Figure 8). The result was stable at a three-year review (Figure 9).

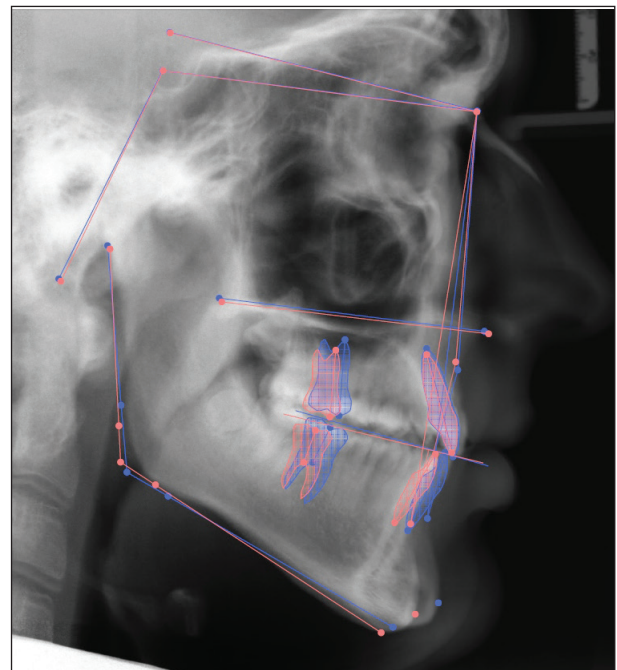
**Figure 8.** Superimposition of before and after cephalograms.



Figure 9. Patient after three years of retention.

Discussion

The presented case report describes the successful correction of an open bite malocclusion that could have alternatively been addressed by surgical repositioning of the maxilla. The intrusion of the maxillary molars and subsequent autorotation of the mandible led to the closure of the anterior open bite malocclusion.

Initially, the sophisticated design of the 'Mousetrap' appliance appeared to be more complicated and more bulky compared with other TAD-based appliances. However, it provided the following advantages:

- A biomechanical approach, which offered a point of force application, as well as a constant force that was measurable and easily modified.
- Low surgical invasiveness.
- No risk of penetration of the maxillary sinus.
- No risk of root damage at the time of insertion of the mini-implant or during molar intrusion.
- The anterior hard palate may be considered an optimum insertion site for a TAD because of lower failure rates and negligible risk of mini-implant fracture.

The clinician needs to consider the possible changes in the sagittal dimension of the maxillo-mandibular complex following successful molar intrusion. The autorotation of the mandible may support the correction of a skeletal Class II relationship secondary to mandibular retrognathia. However, this approach needs to be managed with caution in a skeletal Class I or Class III case, in which the autorotation of the mandible secondary to the intrusion of the maxillary molar teeth may result in the development or worsening of a sagittal dysplasia. As seen in the present case, a mild suggestion of a Class III underlying skeletal pattern may be enhanced by mandibular rotation as a result of upper molar intrusion. The overall relationship was, however, considered acceptable.

Corresponding author

Professor Benedict Wilmes
Department of Orthodontics
University of Duesseldorf
Moorenstr. 5
40225 Duesseldorf
Germany
Email: wilmes@med.uni-duesseldorf.de

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