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APPLICATION AND EFFECTIVENESS OF A MINI-IMPLANT– AND TOOTH-BORNE RAPID PALATAL EXPANSION DEVICE: THE HYBRID HYRAX

Aim: *Rapid palatal expansion (RPE) is used for treatment of skeletal crossbites. It may be combined with a face mask if the maxilla is to be protracted. Conventional tooth-borne appliances rely on an almost complete dentition to transmit the relatively high forces to the bony structures of the maxilla and midface. In most situations, tooth-borne appliances produce adverse effects such as buccal tipping of the lateral teeth, imposing the risk of recessions and vestibular bone fenestrations. To overcome these drawbacks, an RPE appliance was developed that utilizes mini-implants anteriorly in the palate for skeletal anchorage. Because this device is also attached to the first molars, it can be denominated as a bone- and tooth-borne appliance (hybrid hyrax). The objective of this clinical pilot study was to investigate its dental and skeletal effects.* ***Methods:*** *RPE was performed in 13 patients (seven females, six males; mean age 11.2 years). In 10 patients with a skeletal Class III occlusion, a face mask was used simultaneously for maxillary protraction. Three-dimensional scans of the individual study models were digitally superimposed for the assessment of the dental effects. Skeletal effects were evaluated by lateral cephalograms taken before and after RPE and protraction.* ***Results:*** *The time needed to achieve the intended expansion ranged from 4 to 14 days (mean 8.7 ± 3.6 days). The mean expansion in the first premolar/first primary molar region was 6.3 ± 2.9 mm and 5.0 ± 1.5 mm in the first molar region. The Wits appraisal changed from –5.2 ± 1.3 mm to –2.5 ± 1.5 mm (mean improvement 2.7 ± 1.3 mm). The right first molar migrated 0.4 ± 0.6 mm mesially and the left one 0.3 ± 0.2 mm.* ***Conclusions:*** *The hybrid hyrax is effective for RPE and can be employed especially in patients with reduced anterior dental anchorage. Since most teeth are not in the appliance, regular orthodontic treatment can start early. The combination of the hybrid hyrax with a face mask for maxillary protraction appears to be effective in minimizing mesial migration of the dentition.* World J Orthod 2010;11:323–330.

Key words: *rapid palatal expansion, Class II treatment, mini-implant, maxillary protraction*

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Rapid palatal expansion (RPE) is considered the optimum orthodontic procedure to widen the maxilla skeletally. Angell[1] first described this method in 1860; it received comprehensive disapproval at that time due to the lack of radiologic confirmation. This verification was produced in 1908 by Landsberg. Nevertheless, it was not until the middle of the 20th century that RPE was broadly established and reintroduced in the United States.[2] Today, RPE is considered a midpalatal suture distraction osteogenesis. For the treatment of patients

Fig 1 The various components of the 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 abutments.

with a Class III occlusion caused by a retrognathic maxilla, RPE is combined with a face mask for protraction.

Since the orthopedic forces are transmitted to the skeletal structures via anchor teeth, distribution of the forces to as many teeth as possible, as well as completion of their root development, is considered essential. In spite of these considerations, adverse effects such as buccal tipping, gingival recessions, fenestrations of the buccal cortex, and root resorptions of the posterior teeth were repeatedly reported.[3,4] To avoid such complications, orthodontists have advocated pure bone-borne RPE devices.[5,6] However, the insertion and removal of such distractors are invasive since they need flap preparation. Further, they increase the risk of root lesions and infections.[5,7] As a consequence, distractors of this type could not establish themselves as standard devices for RPE.

To minimize the surgical procedure, Harzer et al introduced the Dresden Distractor, which is attached solely to an implant and a mini-implant.[8–10] Mini-implants attracted great attention in recent years because they are versatile, minimally invasive, and low cost.[11] Due to the risk of root lesions during the insertion of mini-implants in the lateral posterior alveolar process and lack of available bone in the middle of the palate posteriorly, in the present approach, the first molars were chosen as the posterior anchorage unit. Anteriorly, there is sufficient bone available for mini-implants in the middle of the palate.[12] Since this appliance is both tooth- and bone-borne, it can be designated a hybrid hyrax.[11,13]

The aim of this study was to assess the clinical applicability and 3D effects of RPE using the hybrid hyrax. The skeletal effects of the combination hybrid hyrax and face mask for maxillary protraction were also evaluated.

METHOD AND MATERIALS

RPE with the hybrid hyrax was performed in 13 patients (seven females, six males; mean age 11.2 years). Ten of these 13 patients were simultaneously treated with a face mask for protraction of the maxilla.

Clinical application and construction of the hybrid hyrax appliance

After local anesthesia, soft tissue thickness was measured using a dental probe so a region with thin mucosa coverage could be identified. This is important to achieve sufficient primary stability and avoid long lever arms.[14–19] In young patients, predrilling is not needed due to the low bone mineralization. After insertion of two Benefit mini-implants (2 × 9 mm; Figs 1a and 2), bands were fitted to the maxillary first molars at this first appointment. After application of transfer caps (Fig 1c), a silicone impression (Provil) was taken. In situations in which the distance between the mini-implants was too small, the transfer caps were trimmed to fit side by side. The angle between the two transfer caps was secured by connecting them intraorally with Transbond LR (3M). The impressions were completed by inserting laboratory analogues (Fig 1b) into the transfer caps, as well as by inserting the molar bands. The resulting laboratory model reflected the intraoral situation (Fig 3).

Fig 2 Two mini-implants (2 × 9 mm, Benefit system, PSM Mondeal) after insertion in the anterior palate next to the midpalatal suture and near the second and third palatal rugae.

Fig 3 Cast with the two laboratory analogs (see Fig 1b) and the two molar bands.

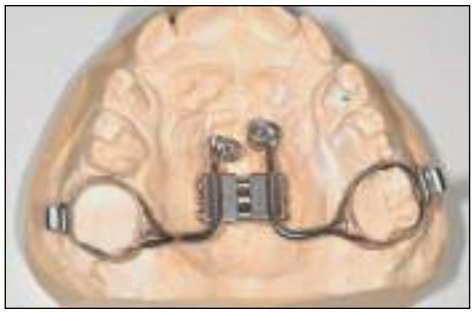

Fig 4 Hybrid hyrax appliance on the cast.

Fig 5 The hybrid hyrax in situ.

Subsequently, two standard abutments (Fig 1f) of the Benefit system were screwed onto the laboratory analogues and a regular split palate screw (Hyrax, Dentaurum) was connected by laser welding to the two abutments and the molar bands (Fig 4). Parallelism of the two mini-implants is advisable, but not a prerequisite: Even if they are not absolutely parallel, the appliance can be fitted onto the mini-implant. The complete appliance was inserted 7 to 10 days after placing the mini-implant. During the insertion, screwing of the two abutments on the mini-implant alternated with the final adjustment of the molar bands (Fig 5). During this time, the hybrid hyrax should be gently pressed against the mini-implant to facilitate fixation. To allow adequate time to install the hybrid hyrax, light-curing acrylic resin (Band-Lok, Reliance Orthodontic Products) should be used for molar band cementation.

If a simultaneous protraction of the maxilla was intended, segmental archwires were inserted into the molar tubes (Figs 5 and 6). The sagittal split screw was activated twice a day by a 90–degree turn immediately after insertion of the hybrid hyrax (Fig 7). This resulted in a daily activation of 0.8 mm. RPE was continued until a 30% overcorrection was achieved (Fig 8). After this, the hybrid hyrax remained in situ for a 3-month retention phase, during which the maxillary incisors migrated mesially spontaneously (Figs 9 and 10).

In 10 of 13 patients, a face mask was prescribed for approximately 6 months to simultaneously protract the maxilla. The applied elastics (5 oz, ¼ inch; RMO Orthodontics) were anterocaudally angulated (Fig 6).

In one of 13 patients, the maximum expansion of the sagittal split screw was attained before sufficient expansion of the maxilla was achieved. Thus, the hybrid hyrax was removed, a second impression taken, and a new appliance fabricated. To prevent relapse, the first hybrid hyrax was reinserted until the second one could be used.

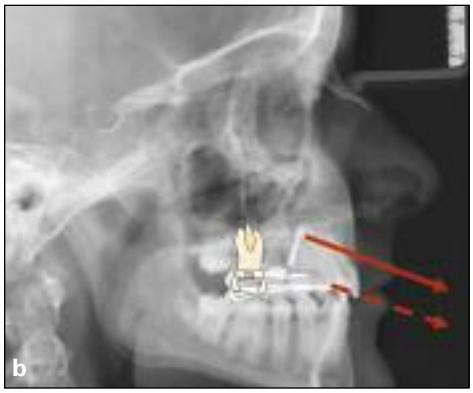

Fig 6a Patient with a face mask for (simultaneous) protraction of the maxilla.

Fig 6b Semischematic illustration of a hybrid hyrax with simultaneous protraction of the maxilla by a face mask. The applied force is transferred to the maxilla via the molars an anterior mini-implants.

Fig 7 *(left)* Activation of the sagittal split screw.

Fig 8 *(right)* Situation at the completion of RPE.

Fig 9 Same patient as in Fig 8 after 3 months of retention with the hybrid hyrax still in situ. The maxillary incisors have spontaneously migrated mesially.

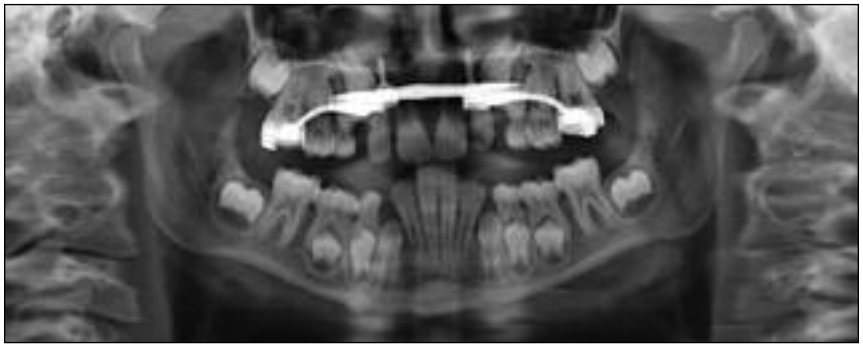

Fig 10 Same patient as in Figs 8 and 9. Panoramic radiograph at the end of the retention phase with the hybrid hyrax in situ.

Evaluation of the dental RPE effects

Pre- and post-RPE models (6 to 9 months after RPE) were scanned with cone beam computed tomography. Transversal expansion and tooth tipping (first premolar/first primary molar and first molar) were measured using DigiModel software (Orthoproof). The overall transversal effect was quantified by gauging the distance of four corresponding points before and after expansion (Fig 11). Tooth tipping was evaluated by calculating the difference of the buccal surface angle of the first premolar/first primary molar and first molar before and after RPE (Fig 12). To assess the symmetry of the expansion, as well as the molar mesial migration, the 3D scans were digitally superimposed using the three-point method of the DigiModel software (Figs 13 and 14).

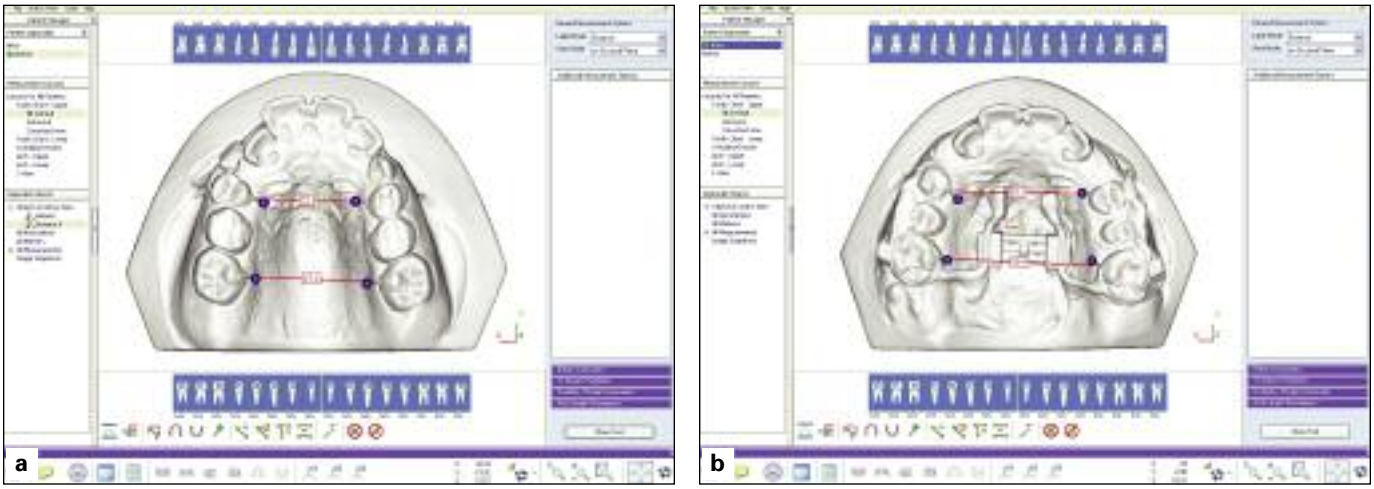

Fig 11 Three-dimensional scans employing cone beam computed tomography **(a)** before and **(b)** after expansion.

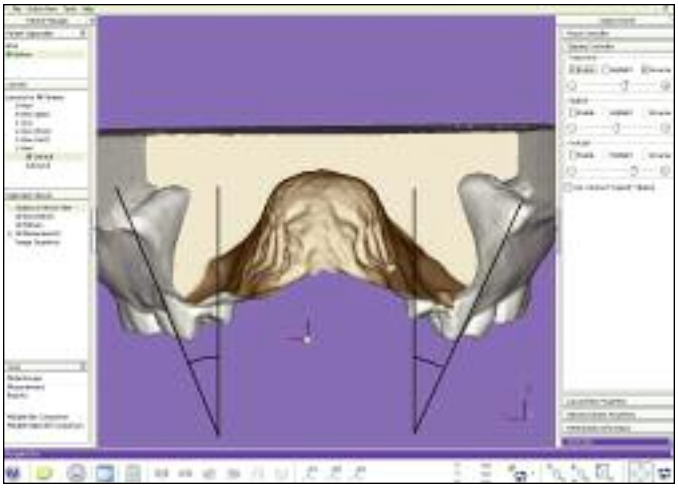

Fig 12 Cut of the 3D scan before expansion. The angle of the buccal surface of the first premolar is measured to a vertical to the occlusal plane.

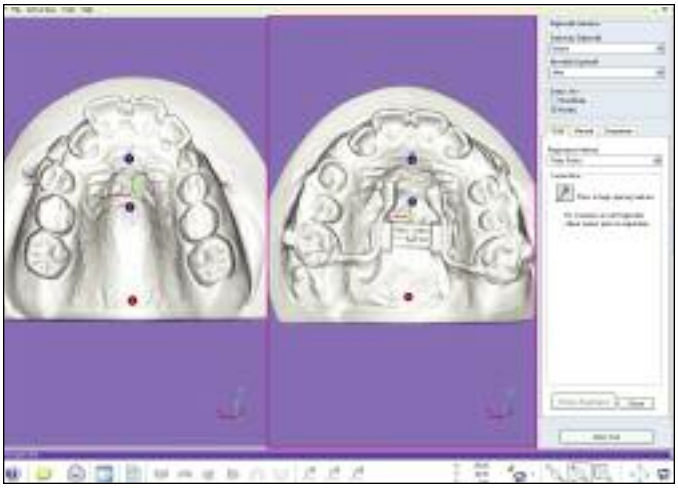

Fig 13 Digital superimposition of two 3D scans using the three-point method of the DigiModel software.

Fig 14 *(right)* Assessment of the expansion symmetry and sagittal molar migrations using the superimposed 3D scans.

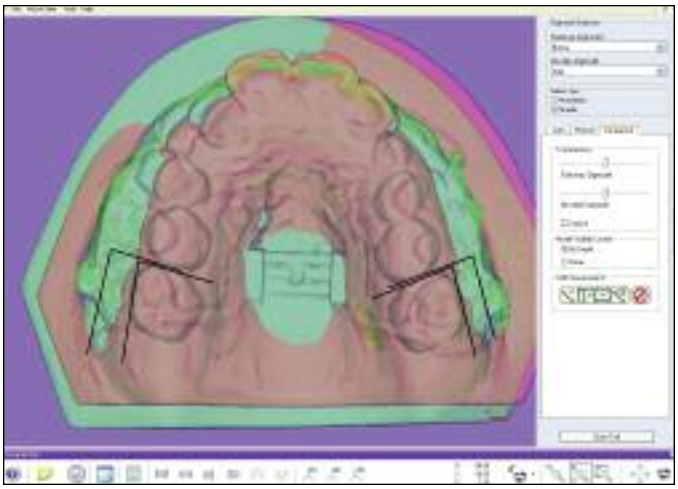

Fig 15 **(a)** Pre- and **(b)** posttreatment overjet and **(c)** pre- and **(d)** posttreatment profile of one of the 10 patients who wore a face mask.

Evaluation of the skeletal protraction effects

Pre- and posttreatment lateral cephalograms of the 10 patients wearing face masks were scanned, and the Wits values were calculated and compared.

RESULTS

All 26 mini-implants were primarily stable with an adequate maximum insertion torque (5 to 15 Ncm), and they were still stable at the time of the hybrid hyrax insertion and at its removal. The time needed to achieve the planned expansion ranged from 4 to 14 days (mean 8.7 ± 3.6 days).

The mean expansion in the first premolar/first primary molar region was 6.3 ± 2.9 mm and 5.0 ± 1.5 mm in the first molar region. The mean difference between right and left expansion in the region of the first molar was 0.8 ± 0.5 mm. The mean buccal tipping of the first premolar/first primary molar amounted to 3.2 ± 0.8 degrees on the right and 4.0 ± 0.7 degrees on the left side. The mean tipping of the first molar was 5.3 ± 0.9 degrees on the right and 6.5 ± 1.7 degrees on the left side.

During protraction, the right first molar migrated 0.4 ± 0.6 mm mesially and the left one 0.3 ± 0.2 mm. The Wits value changed from −5.2 ± 1.3 mm to −2.5 ± 1.5 mm (mean improvement 2.7 ± 1.3 mm). See Fig 15 for pre- and posttreatment photographs of one of the patients who wore a face mask.

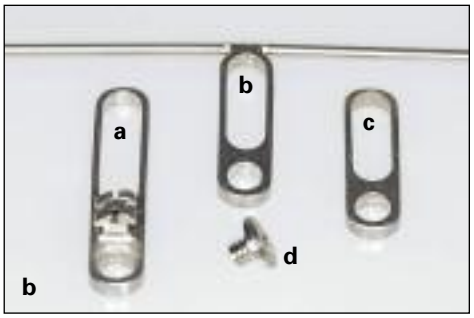

Fig 16a Same patient as in Figs 8 to 10. Intraoral situation after removal of the hybrid hyrax; mini-implants are still stable.

Fig 16b Components of the Beneplate system for the connection of mini-implants. **(a)** Beneplate with bracket; **(b)** Beneplate with wire; **(c)** Beneplate standard; and **(d)** fixation screw.

Fig 16c Skeletal retention by the insertion of a miniplate.

DISCUSSION

The hybrid hyrax with two mini-implants with exchangeable abutments is effective for RPE. An anterior mini-implant insertion approximately 2 mm from the palatal suture seems to be preferable. Sufficient bone is available only in this area.[12]

The 3D scan evaluation of the dental casts to measure the amount of expansion and mesial migration of the molars was very suitable. In some instances, however, the tipping was difficult to assess due to the curvature of buccal surfaces. In this situation, frontal cephalograms might offer an advantage, but the radiation exposure does not justify their application.

The achieved mean expansion in this study was less than in other studies.[20] This can be explained by the fact that in this study, RPE was utilized not only for maxillary expansion, but also for protraction by a face mask. In patients in whom this was the primary goal, the expansion was deliberately limited to activate the midfacial sutures.

The application of the hybrid hyrax is surgically minimally invasive compared with pure bone-borne RPE devices, such as distractors.[5,6] To employ the first molars as posterior and mini-implants as anterior anchorage units provides several advantages. Application is possible in patients with:

- Inferior anterior dental anchorage due to missing primary molars or primary molars with resorbed roots
- Immature premolar roots
- A need for early Class III treatment with a face mask and in whom RPE supports the maxillary advancement by weakening the midface sutures, thus enhancing the skeletal effects of the extraoral traction
- Reduced dental adverse effects, ie, buccal tipping and mesial migration

It seems advisable to retain the skeletal expansion for some time by fixing a miniplate (Beneplate, PSM Mondeal)[21] on the mini-implants with two tiny screws (Fig 16). An additional approach may be the use of the mini-implant–supported hybrix hyrax with a miniplate (Mentoplate) placed in the anterior portion of the mandible, thus avoiding an unesthetic face mask.[22]

ACKNOWLEDGMENT

Dr Benedict Wilmes is a codeveloper of the Benefit mini-implant system.

CONCLUSION

The hybrid hyrax is effective for rapid palatal expansion. It can be employed even in patients with reduced dental anchorage. The anterior teeth are not included in the appliance, and regular orthodontic treatment can therefore be started early. The combination of the hybrid hyrax with a face mask for maxillary protraction is helpful to minimize adverse effects, such as mesial migration of the anterior teeth.

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