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## Transpalatal distraction – State of the art for the individual management of transverse maxillary deficiency – A review of 50 consecutive cases

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### ABSTRACT

Transpalatal distraction has been established as a technique for surgical assisted rapid palatal/maxillary expansion (SARPE/SARME) in order to correct transverse maxillary deficiency.

From 2007 until 2013 bone borne transpalatal distraction devices have been inserted in 50 patients affected by transverse maxillary deficiency and transpalatal distraction has been performed by the same surgical team. Patient records were retrospectively evaluated after ending of the active distraction phase with respect to indication, achieved expansion, additional procedures and side effects.

In all cases the existing transverse maxillary deficiency was corrected by means of transpalatal distraction according to the individual needs. No complications were observed that interfered with that therapeutic aim. Evaluation of the records showed a wide variance of parameters which impedes evidence based statements.

According to that series transpalatal distraction is a safe, powerful and reliable procedure and can be recommended as a state of the art procedure for the individually adapted correction of transverse maxillary deficiency if well known parameters of distraction are respected.

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### 1. Introduction

Since its introduction by Mommaerts and co-workers in 1999 (Mommaerts, 1999) transpalatal distraction (TPD/TPDO) has been established as a bone borne variant for surgically assisted rapid maxillary or palatal expansion (SARPE/SARME). It is indicated in cases of transverse maxillary deficiency that cannot be corrected by orthodontic means alone.

Basically SARPE can be performed either by individually designed tooth borne expansion devices (Hyrax/Haas screws) where expansion forces are indirectly transmitted to the palatal bone or by commercially available bone borne distraction devices which are directly acting on the palatal bone. Both methods are known to provide reliable results (Koudstaal et al., 2009; Verstraaten et al., 2010; Nada et al., 2012). Main advantage of bone borne devices is a more skeletal expansion without dentoalveolar movement which cannot be excluded when tooth borne devices are applied (Landes et al., 2009; Zemann et al., 2009).

Another advantage of bone borne devices is the fact that orthodontic treatment and closure of the interincisival diastema can basically be started at an earlier stage when compared with tooth borne devices as dental movements are not impaired by bone borne distraction devices. This can help to reduce overall treatment time and acceptance especially in adult patients (Mommaerts, 1999; Pinto et al., 2001).

An individually adapted correction of the present transverse maxillary deficiency can be performed by selection of an appropriate device, the intraoperative positioning of the device and modification of the osteotomies which are required for surgically assisted maxillary expansion. The options for the individual management of transverse maxillary deficiency by transpalatal distraction should be demonstrated according to the clinical experiences after a series of 50 patients that have been treated from 2007 to 2013.

### 2. Materials and methods

Since 2007 50 patients affected by transverse maxillary deficiency have been treated by transpalatal distraction (TPD) with or without subsequent combined orthognathic treatment.

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Surgically assisted maxillary expansion was indicated when transverse maxillary deficiency was obvious which could likely not be corrected by orthodontic appliances alone. Selection of appropriate bone borne devices was according to the best fit on individual plaster casts, predominantly the Surgitec TPD “All-in-one” (Surgitec, 9051-Sint-Denijs-Westrem, Belgium) in different sizes was used. In all patients the devices were inserted according to the manufacturer's data (Surgi-Tec, 2007) under general anaesthesia and periop. iv. antibiotic treatment. Surgery consisted in a modified subtotal LeFortI osteotomy according to Betts including median maxillary split without pterygomaxillary disjunction (Betts and Scully, 2009). The devices were activated intraoperatively in order to control the maxillary movements respectively to correct the position of the devices (Figs. 3 and 4b). In order to allow for maxillary expansion without interference stepwise bony resection at paranasal and zygomaticoalveolar buttresses was performed during activation in accordance with the required maxillary expansion. Devices were subsequently reset and locked during latency phase. Gradual activation of the devices was started by the same surgical team after a latency phase of 5–7 days. Depending on the individual tissue feedback gradual distraction was performed with a rate of up to 1 mm/day. After ending of distraction which was determined in agreement with the cooperating orthodontist devices were locked during the consolidation phase. Length of the resulting interincisival diastema as a parameter for distraction length was measured by a calliper intraoperatively and after ending of activation. Orthodontic alignment and closure of the diastema was performed 6 weeks after ending of active distraction in adult patients. Based on experimental data the consolidation period was intended to be at least three months (Adolphs et al., 2005). Removal of the devices was scheduled after consolidation time and clinical examination for transverse stability. In most cases the devices were in place during the orthodontic alignment which typically needed more than 6 months of time and subsequently removed in combination with the orthognathic procedure. In the majority of

patients TPD was the initial step within combined orthodontic-orthognathic treatment. In all patients photo documentation of the preoperative, intraoperative and postoperative follow-up situations was performed. All distraction related data were recorded in patient specific distraction protocols. For the retrospective evaluation photo documentation, distraction protocols, dental casts as well as cone beam based DICOM datasets were used when available. A simple qualitative assessment of the method was performed after device removal: “Would you have TPD again”/“Would we recommend TPD again” (+/-).

### 3. Results

An overview of all 50 patients that have been treated by TPD in our institution since 2007 by the surgical technique described above is presented in Fig. 1. Retrospective evaluation of patient records showed a heterogeneous distribution and wide variance of parameters which impedes evidence based statements.

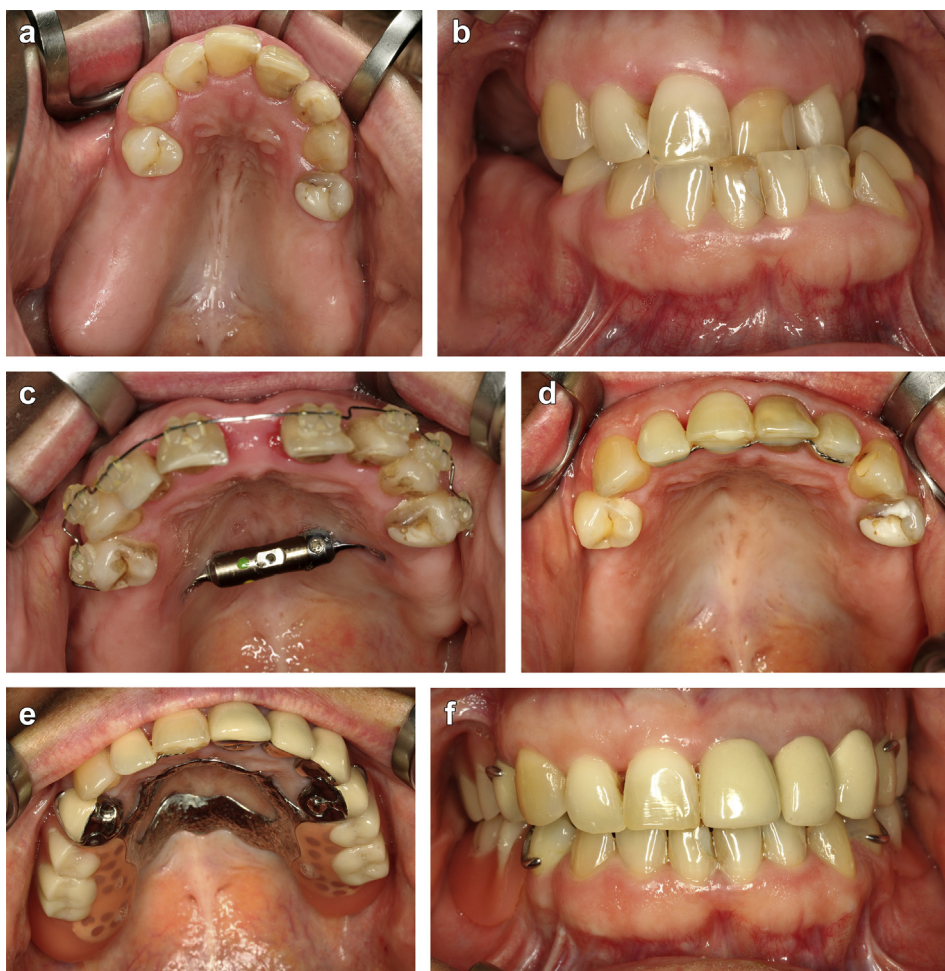
Transversal skeletal maxillary as well as mucosal soft tissues expansion was achieved in all patients according to the required space. No relevant surgery associated complications were observed, there was no massive intra- or postoperative bleeding. In one 39 year old male patient with very compact bone infraction of the vestibular alveolar process occurred during median splitting of the maxilla requiring fixation of the medial incisor by a titanium splint for 6 weeks. No other damage to dental structures was observed.

Pain management during activation was not an issue - according to the WHO pain scale (level 1–10) discomfort, if observed never exceeded grade 4 (moderate pain). Patients affected by discomfort during the final activation phase reported that the sensations stopped about 30 min after activation. If discomfort was noted it could either be managed by fractionated multistep activation or administration of analgetics (Ibuprofen 400 mg p.o) 30 min before activation in combination with physical therapy.

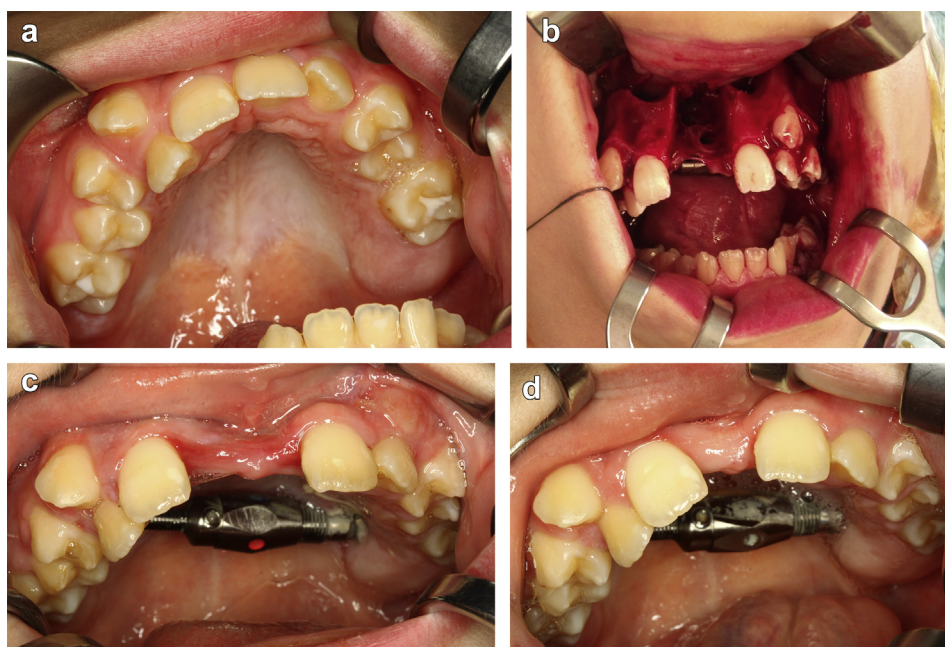
Year	Gender/ age (years)	Angle class	Distractor type & size	Diastema post DO	Consolidation time (weeks)	Follow up (months)	Additional surgeries	Comments / Specials	Overall assessment
2007 n=1	XX, 9	class III BLCP	Surgitec TPD-All in one 1x Module 2	1x 9 mm	8 weeks	>72	-	1x ped. DO (9 years)	+
2008 n=1	XX, 42	class I	Titamed Smile DS 0.12	1x 14 mm	20 weeks	>60	1x TJS	prosthodontic indication	+
2009 n=1	XX, 51	class II	Surgitec TPD-All in one 1x Module 4	1x 9 mm	24 weeks	>48	1x BSSO +	parodontologic indication	+
2010 n=6	2x XY (22,18 years) 4x XX (14,2x18,37 years)	3x open bite, 1x class I 1x class II 1x class III	Surgitec TPD-All in one 1x Module 2 2x Module 2,5 3x Module 3	2 x12 mm, 3 x13 mm 1 x15 mm	2x20 weeks 28, 32, 60 1x 104 weeks	>36	4x TJS 1x Ex 15 1x no surg.	1x ped. TPD (14 years)	+
2011 n=13	7x XX (23,47,27,17,18,31,16 years) 6x XY (6,17,18,19,21,40 years)	1x unclass. 1x open bite 4x class II 7x class III	Surgitec TPD-All in one 2x Module 2 8x Module 2,5 3x Module 3	1x7mm, 1x9 mm 2x10mm,2x11mm, 5x12mm,1x14mm, 1x unmeas.	16, 36, 2x48 2x60, 72, 88, 5x > 96weeks	>24	1 x BSSO + 3+2 x LeFort I 4+1 x TJS 2 x other	1x two jaw DO 3x unilateral expansion 1x rep. ped DO (6 years)	+
2012 n=13	5x XX (18, 20, 21, 27, 29 years) 8x XY (14, 2x23,25,27,28, 38, 45 years)	1x unclass 4x class I 1x class II 7x class III	Surgitec TPD-All in one 8x Module 2,5 3x Module 3 2x Module 4	1x unmeas 1x 6mm 1x10mm, 3x11mm 6x12mm, 1x18mm	1x16, 1x28 1x44, 1x >48 2x 60, 1x 72, 5x > 96weeks	>12	3xno surgery 2x other 1x (BSSO+) 4x LeFort I 3x (TJS)	1x ped. DO (14 years) 1x V-shape 3x unilateral expansion 2x modif. osteotomy	+
2013 n=15	9x XX (9,16,17,20,22, 2x30,32,34 years) 6x XY (17,20,22,25,28,39 years)	3x class I (1xCLP) 5x class II 7c class III	Surgitec TPD-All in one 2x Module 2 10x Module 2,5 2x Module 3 1x KLS Martin RPE 3	1x6mm 2x7mm 2x8mm 8x10mm 2x15mm	4x >4, 1x >12 1x >20, 5x >24 1x28, 3x >48	8x >6 6x recent	5x no surgery 3x (BSSO+) 5x (LeFort I) 2x (TJS)	2 pediatric TPD's 2x two jaw DO	+

Fig. 1. Overview over 50 patients treated by transpalatal distraction from 2007 to 2013.



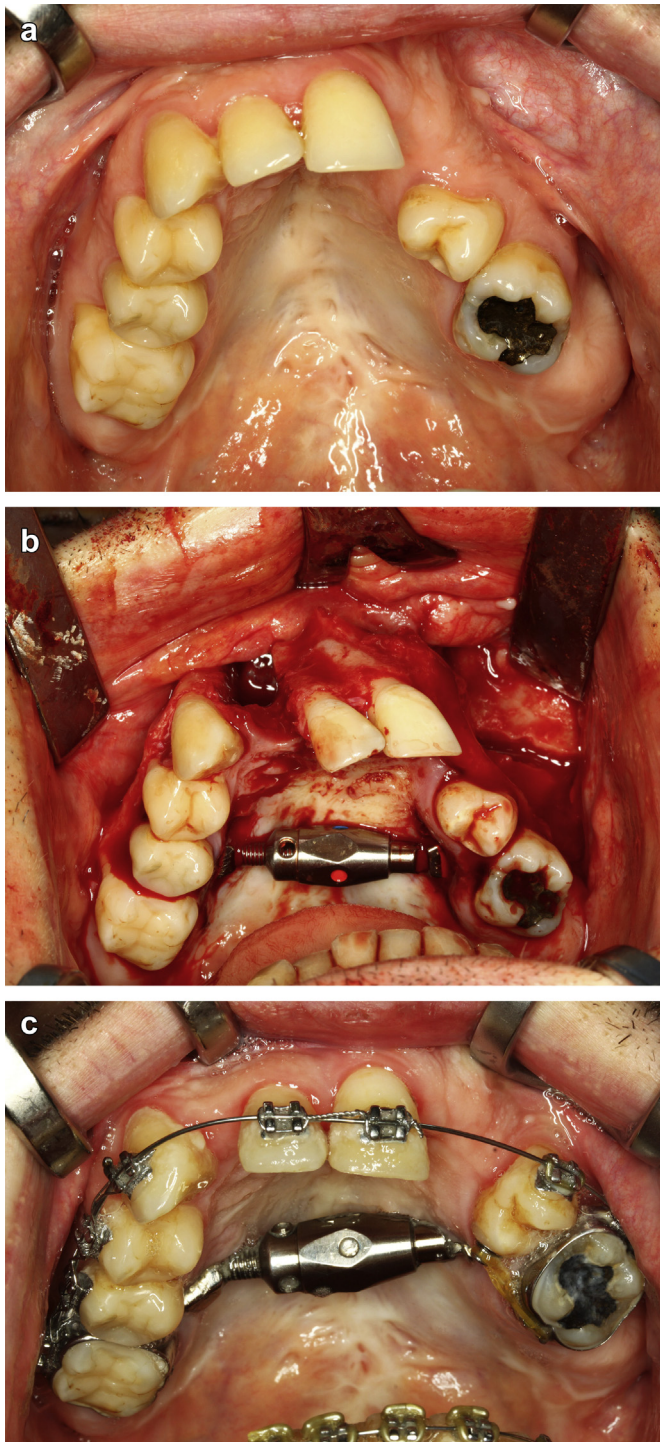


**Fig. 2.** a–f: Unusual prosthodontic indication for transpalatal distraction – severe transverse maxillary deficiency without possibility to use dentures (a, b) – transverse widening by TPD using a device which allows to change the activation thread in order to gain more distance (c) – situation after device removal (d) and additional two-jaw surgery and completed prosthodontic support (e, f).



**Fig. 3.** a–d: TPD as initial treatment in a paediatric patient (10 years) affected by an oblique facial cleft of the left side prior to later orthodontic and orthognathic treatment. Initial maxillary situation showing severe crowding (a); intraoperative testing of the device up to a diastema of more than 15 mm (b); intraoral situation after ending of active distraction showing a diastema corresponding to the intraoperative situation (c); clinical situation 4 weeks after ending of activation – already ongoing spontaneous closure of the gap (d).





**Fig. 4.** a–c: 38-year-old male patient: initial situation more than 30 years after CLP-closure with challenging soft tissues (a) – intraoperative situation during activation of Surgitec All-in-one device (module 2,5) after modified osteotomies for unilateral palatal expansion (b) – situation after termination of distraction with improved palatal situation – soft tissues could be accordingly expanded – fixed bridgework is planned after orthodontic distribution of supporting teeth (c).

Mean length of the interincisival diastema at the end of activation was 9.97 mm ranging from 6 to 18 mm. Follow-up after device removal is more than 6 months in 44 patients, in 6 patients that received TPD in 2013 consolidation phase has been uneventful so far.

With respect to gender almost equal distribution of 28 female and 22 male patients was documented. From 2007 to 2009 only 3 TPD's were inserted, from 2010 on there was an obvious increase of insertions with more than 10 patients per year. The average age at TPD insertion was 24 years ranging from 6 to 51 years. 8 patients were older than 35 years, 11 patients were younger than 18 years and 5 of them were even younger than 16 years (Fig. 3). 21 patients were between 18 and 35 years of age. Devices were well tolerated during and after consolidation phase in the majority of patients until removal. In only one female patient the device had to be removed before secondary orthognathic correction as it caused disturbing frostiness sensation during winter times. There were no complications like loosening, loss of devices or infection which would have adversely affected the therapeutic effect of the maxillary expansion. The overall assessment of the method consequently was positive from both points of view – patient's as well as surgeon's perspective.

The most commonly inserted device ( $n = 28$ ) was the Surgitec TPD "All-in-one", module 2,5 allowing for a maximum of 20 mm activation (Cat-No. 03-925a) as it proved to be the most versatile distractor (Figs. 3 and 4). Identically constructed devices with module 3 were inserted in 11 patients, module 2 in 6 patients and module 4 in 3 patients.

In one patient the Titamed Smile distractor (Titamed, 2550-Kontich, Belgium) was selected according to the optimal individual fitting and the exchangeable activation unit (Fig. 2a–f). In one other female patient the KLS Martin RPE, Size 3 (KLS Martin, Tuttlingen, Germany) was used.

Apart from two patients affected by very unique growth disorders all other patients of this series received combined orthodontic–orthognathic treatment and TPD was inserted in the initial phase. In 29 of these 48 patients combined therapy is already completed in 19 patients combined orthodontic–orthognathic treatment after transpalatal distraction is still ongoing. TPD insertion was predominantly associated with class III malocclusion ( $n = 26$ ,  $3\times$  open bite), followed by class II malocclusion in 12 patients. 10 patients were grouped to class I, in two patients affected by complex growth disorders the Angle classification was not applicable.

In 10 patients no additional surgery after TPD was required so far, in 15 patients two-jaw surgery was performed, in 14 patients LeFortI maxillary advancement was required, in 6 patients BSSO was indicated and in 5 patients other surgical interventions (tooth removal, bone anchor insertion, rhinoplasty, multi-step procedures) were performed.

When complete LeFortI osteotomy was performed secondary to TPD in all non-cleft patients complete bony bridging of the distraction zone was observed. Consequently no palatal relapse consisting in a reduction of the initially achieved widening was observed. In two patients affected by complete palatal clefts additional bone grafting during orthognathic correction was required in order to improve stability. In all patients mucosal soft tissues were expanded without complications, even when scarring or restriction was present (Figs. 2 and 4). In one male patient affected by massive open bite ( $>2$  cm) and class III malocclusion relapse occurred 30 months after two-jaw surgery which required secondary correction. During this procedure additional maxillary widening was performed in order to improve postoperative intercuspitation. If overcorrection during TPD would have prevented that relapse can be discussed. In 6 patients unilateral maxillary expansions were performed. Modified osteotomies were applied in order to use the present bone stock to its extent (Fig. 4a–c). In four paediatric patients with massive maxillary growth restriction TPD was performed before termination of the permanent dentition in order to relief dental crowding and avoid extraction therapy (Fig. 3a–c). In

some patients spontaneous closure of the diastema without additional orthodontic forces was observed which was likely mediated by spontaneous dental shift, transseptal fibres and orolabial muscles (Fig. 3d). Simultaneous transverse expansion of maxilla and mandible was performed in three patients (two-jaw distraction). 3d-models of CBCT-data were analysed when available. Basically skeletal effects after TPD were reproducible however reliable measurements of pre- and postdistraction situations could not be performed which is likely due to orthodontic movements. For that purpose photo documentation of the clinical situations was more effective. Maxillary expansion improved nasal breathing in all patients, however as pre- and postoperative rhinomanometry was performed routinely not before 2012 no reliable data for all patients were available.

#### 4. Discussion

Bone borne maxillary expansion started in 2007 in our department. Until 2009 only three TPD's were inserted. The increase in patient cases from 2010 on is likely related to the fact that the new surgical method needed to be spread across the cooperating orthodontic community. Actually about 1 TPD per month is inserted within a constant number of 40–50 orthognathic corrections that are performed every year in the department.

According to Koudstaal and Nada comparable skeletal results are found after termination of orthodontic therapy when either tooth borne or bone borne devices have been used for transverse maxillary expansion (Koudstaal et al., 2009; Nada et al., 2012). According to Zemann bone borne devices should be preferred in patients affected by dental loss or periodontal damage as tooth borne appliances are working well and are easy to use (Zemann et al., 2009). Landes recommended an individual, patient specific decision if tooth borne or bone borne devices are preferred for maxillary expansion with respect to device specific advantages (Landes et al., 2009). According to our experiences the pros for bone borne devices compared to tooth borne devices are: individual device selection and placement according to patient's needs, longer possible range of distraction, speedy orthodontic treatment 6 weeks after termination of expansion as interference with dental movements is unlikely. Another advantageous aspect is the rigidity of the TPD when compared to tooth borne devices. Forces are directly transmitted to the bone whereas in tooth borne appliances torsion and twisting of connections between teeth and expansion screws can occur and might therefore reduce the effective amount of expansion. Especially when challenging mucosal conditions were present the TPD's that were inserted in our series worked without complications (Figs. 2 and 4). The diversity of commercially available distractors allows for the selection of a suitable device which supports individualised treatment planning. According to our experiences maxillary expansion can be adapted to the underlying individual deficiency by the surgical approach described above. Selection and positioning of an appropriate device, intraoperative testing of maxillary movements respectively the controlled surgical removal of interfering bone during activation contributed to the positive overall results in this series. It can be discussed if this surgical approach in combination with the intraoperative testing as well contributed to the fact that discomfort and pain during activation of the devices was not a major issue in that series even in paediatric patients.

Pinto already pointed out in 2001 that anterior maxillary widening is more likely if TPD's are inserted at the premolar region and pterygomaxillary junction is left intact (Pinto et al., 2001). The pterygomaxillary junction was left intact in our series. The centre of resistance was along the descending palatine vessels when median palatal split has been completed and devices were activated. The

more anterior the devices were inserted the more anterior the maxillary expansion could be achieved increasing the alveolar crest available for orthodontic treatment. If posterior maxillary expansion was needed a more posterior positioning of the device was required. A V-shaped expansion (posterior more than anterior) can be achieved if a temporary suture or cerclage at the incisal region is applied (Pinto et al., 2002). Unilateral expansion can be realised either by unilateral LeFortI osteotomy or by different amounts of bone removal at the buttress structures as it has been already advocated by Swennen and Roelofs (Swennen et al., 2003; Roelofs et al., 2010).

Positioning of the device is mainly determined by device geometry and individual patient anatomy (thickness of the mucosa, palatal height). The closer the device can be placed to the palatal plate, the more parallel the maxillary expansion will occur. The closer the device is placed to the limbus alveolaris the more trapezoid the expansion will be in favour of the alveolar crest (Landes et al., 2009). It may occur that maxillary expansion then has features of an upward bending which can reduce vertical maxillary dimension. However secondary orthognathic surgery might correct such effects.

In cases of trapezoid maxillary movements assessment of the effective palatal amount of distraction might be difficult. For orthodontic correction of frontal crowding after TPD it is sufficient to achieve enough additional alveolar crest in order to align the teeth properly with respect to their correct inclination. Active distraction was individually terminated after conferring with the cooperating orthodontist. From the surgical point of view it would be helpful to have already finished orthodontic treatment in the mandibular dental arch before TPD insertion is performed in order to determine the required space reliably. As this was not the case in all patients length of distraction was certainly more assessed than measured which is likely to be continued within daily clinical routine. In 2012 Pereira recommended an adaptation of the surgical technique to the present transverse maxillary deficiency (Pereira et al., 2012) which could be realised in our series by the surgical approach with intraoperative activation and control of maxillary movements.

Modern CB-CT datasets certainly can contribute to objectify skeletal changes before and after TPD. However an additional scan 4–6 weeks after ending of active distraction would be required in order to exclude the influence of orthodontic effects which is problematic due to additional radiation exposure. The evaluation of datasets after ending of orthodontic treatment before orthognathic surgery was not helpful for that purpose in our series. Photo documentation of the distraction related effects was the most effective method in order to visualise the changes after TPD.

In 2009 Verstraaten advocated a prospective randomised study of the effects of bone borne devices for maxillary expansion compared to tooth borne devices based on standardised surgical technique and standardised distraction protocols (Verstraaten et al., 2010). Although there was no control group in our series all patients were treated by the same surgical team according to the individual needs. Certainly in some of the patients as well tooth borne devices could have been used with comparable results however according to our experiences bone borne transpalatal devices offer more options for individually adapted maxillary expansion. If standardised distraction protocols are really helpful may certainly be discussed as gradual expansion as well was individualised according to the patient specific conditions. From the surgical point of view there has to be an appropriate tissue feedback during activation which normally can be expected when the parameters of distraction according to Ilizarov are followed (Ilizarov, 1989a, b). However these parameters (latency phase, rate and amount of distraction) can be varied within a certain range with respect to age, soft tissues and bone quality without



drawback. It is the surgeon's responsibility to integrate the different factors in order to achieve a satisfying and stable clinical result.

Overall TPD is considered to be a reliable technique with a low rate of complications. Loosening or loss of devices, asymmetric expansion, dental and periodontal damages have been described as typical side effects of TPD (Mommaerts, 1999; Verlinden et al., 2011). In 2001 Gunbay described loosening of some devices which required surgical revision in a series of ten patients who were treated with the Surgitec "Classic" TPD (Gunbay et al., 2008). The design of the follower device, the TPD "All-in-one" that has been introduced later has obviously been improved as loosening or loss of devices did not occur in our series despite long intraoral persistence.

Apart from the observed tooth loosening no other damage of dental structures were recorded or declared. Systematic periodontal evaluation was not performed as with concomitant fixed orthodontic appliances periodontal effects cannot be assigned to the TPD's. If asymmetric maxillary expansion is not intended and cannot be corrected during orthodontic treatment or secondary orthognathic surgery this effect can be rated as complication or failure. Due to our surgical approach with controlled intraoperative removal of interfering bone during device activation asymmetric maxillary expansion could be avoided when it was not intended. Severe discrepancies in dental midlines of upper and lower jaw after orthodontic closure of the diastema were corrected during orthognathic surgery if needed. In this series TPD has been successfully applied to four paediatric patients affected by massive crowding during mixed dentition (Fig. 3a–d). Although there is few literature about early TPD in selected cases it's application seems conclusive in order to generate additional bone stock if massive growth disturbance is present or has to be expected.

## 5. Conclusion

According to our experiences in 50 patients transpalatal distraction can be assessed as a state of the art procedure for the individual correction of transverse maxillary deficiency. It allows for individually adapted maxillary expansion by selection and positioning of appropriate devices in combination with intraoperative testing of maxillary movements and controlled bone removal. The diversity of commercially available devices contributes to that fact. Photo documentation proved to be the most effective method in order to monitor the changes caused by TPD.

## Conflict of interest statement

All authors disclose any financial interest and personal relationship to organisations and companies that are mentioned in the article.

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