One-Step Transversal Palatal Distraction and Maxillary Repositioning: Technical Considerations, Advantages, and Long-Term Stability

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Background: Transversal maxillary hypoplasia in adolescence is a frequently seen pathology, which can be treated with a combination of surgery and orthodontic treatment to widen the maxilla in skeletally matured patients.

We evaluated the advantages of a new surgical technique: Le Fort I distraction osteogenesis using a bone-borne device. Because relapse is one of the main problems in surgical maxillary expansion, long-term stability of this new technique was evaluated.

Methods: Data from 4 adult patients with maxillary restriction, class III malocclusion, or maxillary malposition were collected preoperatively, 4 months after distraction, and 5 years after distraction. Measurements were recorded on dental models to detect palatal expansion at dental level; cephalograms by lateral and posteroanterior plane were analyzed to detect maxillary movements.

Results: Maxillary measurements were substantially stable 5 years after distractions. Only minor dental movements occurred at the dental analysis after 5 years related to a lack of orthodontic contention without any compromise of the dental result (no crossbite relapse and class I stability).

Conclusions: Le Fort I with down-fracture for expansion and repositioning by bone-borne distractor device cannot be used to simultaneously widen, advance, and vertically reposition the maxilla without causing healing problems, particularly using a rigid distraction device. Long-term stability can be achieved; however, further studies with a larger number of patients will be necessary for better evaluation.

Key Words: LFI-E, SARME-dental, SARME-bone, LFI-DO–dental, LFI-DO–bone, LFI-DO–bone rigid

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Transversal maxillary hypoplasia in adolescence and adults is a pathology frequently seen with substantial effects on dental occlusion manifesting with crossbite malocclusions and dental crowding, breathing with nasal airflow limitations, buccal corridors evident when smiling, and temporomandibular joint dysfunctions.

Treatment of these dysmorphisms consists of maxillary expansion, which is commonly performed during the growing age by orthodontic appliance (Hyrax and Haas), promoting growth at the suture through deposition of new bone at the margin of the suture by the adjacent cellular layer.[1] After maxillary skeletal maturity has been reached, orthodontic treatment cannot provide a stable widening of the constricted maxilla. Even if the available literature is inconclusive and in conflict regarding time of closure of the palatal suture ranging from the possibility to easily separate the intermaxillary and palatine sutures at an age as late as 35 years,[2] in clinical practice skeletal correction via orthopedic appliance is considered successful until the age of skeletal maturation (14–15 years). After this age, a combination of surgery and orthodontic treatment is suggested to widen the maxilla in skeletally matured patients.

Up to 2 years ago, there were 3 kinds of different techniques for maxillary correction in adult patients after maturation of the facial skeleton has occurred: the segmental Le Fort I osteotomy (segmented Le Fort I with down-fracture with expansion [LFI-E]),[3–7] the surgically assisted rapid maxillary expansion by a tooth-borne device (Hyrax) (SARME-dental), and the surgically assisted rapid maxillary expansion by bone-borne devices (SARME-bone).[3,8–10]

The first technique allows a simultaneous correction in the 3 planes of the space in 1 surgical operation, but it is considered one of the least stable orthognathic procedures.[6,11] Other negative aspects of this technique consist of difficulties in obtaining a large amount of expansion because of palatal fibromucosa traction, bone fragment tipping, root damage risks in 3-piece segmentation, vascular risks of bone necrosis of the premaxilla fragment after wide deperiostation of the palatal bone to allow segmental movements, and difficulties in bone fragment management at the fixation time during surgery.[11–13]

Other unfavorable occurrences associated with the LFI-E are severe intraoperative and postoperative hemorrhage after transsectioning of the descending palatine or other large blood vessels,[11] oroantral or oronasal fistulas, permanent mobility of the maxillary fragments,[11] and loss of gingival papillae following a large immediate widening of the bone fragments.

The second technique, SARME-dental, requires a 2-step surgery for maxillary advancement: rotation or occlusal plane variation accomplished by a complete Le Fort I osteotomy. Advantages of this technique consist of new bone formation achieved by osteodistraction and new soft tissue gain achieved by distraction histogenesis, particularly useful at the palatal fibromucosa site to avoid resistance in the expansion movement. Disadvantages of this technique are related to the tooth-borne forces (cortical fenestration with

parodontal defects, dental root resorption, dental tipping, and relapse.[14]

The third technique, SARME-bone, also requires a 2-step surgery for expansion and tridimensional maxillary position correction. This technique avoids the tooth-related disadvantages of the SARME-dental that are due to the use of a tooth-borne device.[9,15–18]

Several bone-borne distractor devices have been projected and used in this kind of surgery in the last few years; the most widely used are the transpalatal distractor (TPD) device by Mommaerts[8] and the Rotterdam distractor. The TPD (CE 9001; Surgi-tec, Bruges, Belgium) was developed in 1999. The module consists of a 2-cylinder screw attached to abutment plates fixed to the palate with screws. The Rotterdam palatal distractor (CE-0297; KLS Martin, Tuttlingen, Germany) is a bone-borne distractor made of titanium grade II based on the mechanical design of a carjack. The 2 abutment plates (5 × 12 mm) contain 6 nails, each 2 mm long. The activation part consists of a small exagonal activation rod, positioned directly behind the maxillary central incisors. By activating the distractor, the nails of the 2 abutment plates penetrate the bone, and the device is stabilized automatically, and no screws are necessary to fix the distractor to the bone.

Major advantages of the bone-borne devices are that the forces are directly applied to the bone near the center of resistance of the maxillary bone, avoiding dental tipping and keeping the segmental bone from tipping to a minimum level. Relapse of maxillary expansion after distraction or segmented Le Fort I is a widely recognized risk.[19]

Problems concerning the use of the aforementioned 2 types of palatal distractors are related to the poor stability of the device, the poor retention on the palatal site, and the poor rigidity of the device itself. From our experience with these devices, problems were related to the absence of fixation screws on the palatal vault and to the possibility of movement of the expansion module, with the plates connected to the palatal vault.

According to the Paley classification, this can cause 2 kinds of complications: detachment of the appliance from the palatal vault with swallowing risks and loss of control of the distraction vector during the expansion phase with asymmetric expansion[14] and three-dimensional malposition of the 2 maxillary fragments at the end of the distraction. To overtake these limitations, we developed a new device[20] named palatal distractor device (PDD).

DEVICE DESIGN

The functional components of the PDD are a Rematitan titanium expansion jackscrew (Dentarum, Pforzheim, Germany) welded with 2 titanium miniplates (Stryker Leibinger, Leibinger, Germany). These components are intended to combine a simple expansion system (titanium expansion screw) with a well-tested fixation system (miniplates and screws). A triangular bar is welded to the miniplates to allow proper expansion of the alveolar bone. The PDD is cast on patient models, and activation is performed transorally at its medial part, using a common key for the expansion screw. One full turn is equivalent to an expansion of 0.8 mm; the full expansion is 10 mm. The rationale for using a jackscrew for the activation system is to obtain a transversal activation system on a horizontal stable plane, to avoid inclination of the 2 maxillary bones during activation. With our PDD, it is possible to ensure stability of the 2 maxillary bones in the sagittal and horizontal planes during activation, with palatal distraction in association with an incomplete Le Fort I osteotomy. Advantages of this distractor in comparison to the 2 other palatal distractors (TPD by Mommaerts and Rotterdam palatal distractor) and other most common palatal distractors consist of its intrinsic stability in the 3 planes of the space because of the jackscrew expansion system and the 3 points of anchorage for each maxillary half (2 screws and 1 triangular bar for each side). Because of these characteristics, a segmental bodily movement is obtained with full control in the 3 planes of the space. On the other hand, the other types of palatal distractors cannot ensure stability because they do not provide any intrinsic rigidity and have only 1 point of application of the force. This is particularly important in SARME when no fixation systems are applied on the maxilla because only an incomplete Le Fort I is performed.

Another disadvantage of SARME-dental (with tooth-borne device) and SARME-bone (with bone-borne device) is the necessity of a second surgery step for three-dimensional maxillary repositioning by a complete Le Fort I osteotomy.

To overcome these problems and combine the best features of the 2 techniques (stability for osteodistraction osteogenesis and histogenesis by bone-borne appliance and 1-stage expansion and maxillary repositioning by a the LFI-E), we developed a new technique: a Le Fort I osteotomy for maxillary advancement and palatal distraction osteotomy in 1 stage.[11,20] The goal of this technique (LFI-DO–bone) was to obtain good stability in three-dimensional planes without limiting the transversal distraction by PDD.

AIM OF THE STUDY

The aim of this retrospective study was to analyze the long-term stability of the Le Fort I osteotomy for maxillary repositioning and transversal palatal distraction in 1 stage and LFI-DO–bone.

We applied the newly developed PDD in 4 adult patients with maxillary restriction and mild skeletal class III malocclusion or maxillary malposition who were considered candidates for surgical treatment.[20]

SURGICAL TECHNIQUE

Under general anesthesia administered through nasoendotracheal intubation, a Le Fort I osteotomy with down-fracture was performed in combination with a midpalatal osteotomy and palatal distractor setting (LFI-DO–bone).

For this operation, the Le Fort I osteotomy was conducted in the usual manner; however, before the down-fracture was performed, a midline osteotomy was created between the 2 central incisors root up to the posterior nasal spine using a small osteotome. The PDD is typically applied with an epimucosal fixation by four 8-mm screws after predrilling through the holes of the plates and the palatal mucosa. We used 8-mm screws after drilling the bone with a bur angle in a vertical direction to avoid the dental roots and any risk of screw release and swallowing, particularly in the posterior aspects of the palate, where cortical bone is very thin, and screw stability is sometimes poor. The proper screw position is over the root apex between the first and second bicuspids and between the first and second molars.

The PDD gives good stability on the horizontal plane, allowing easy management of the 2 fragments of the maxillary bones during the down-fracture procedure. It also facilitates fixation of the maxillary bones in a more advanced position to correct class III malocclusion or maxillary malposition after down-fracture. To allow maxillary expansion when activating the PDD, we performed fixation with 4 miniplates and only 8 screws (2 screws for each miniplate). The miniplates were torqued in the vestibular direction to allow maxillary expansion. The screws were inserted in a very high position in the upper part of the maxillary sinus walls. The goal of this technique was to achieve good stability in the vertical and anteroposterior directions without limiting transversal distraction.

After 7 days, the device was activated in 0.20-mm increments, 4 times a day until adequate expansion was achieved. Overexpansion was avoided, because we expected an almost pure skeletal movement without dental share.

TABLE 1. Occlusal Relationship[20]

	Patient 1, mm	Patient 2, mm	Patient 3, mm	Patient 4, mm
ICDBD	32	31	31.5	33
ICDAD	34	34	33	33
ICDAD(5 y)	34	34	34	33
IPDBD	31	26	31	25.5
IPDAD	33.5	29	34.5	30.5
IPDAD(5 y)	33	29	34	30.5
IMDBD	40	37	41	37
IMDAD	43	40	47	39
IMDAD(5 y)	43	40	46	38
Molar expansion	+3	+3	+6	+2
Molar expansion (5 y)	+3	+3	+5	+1
Preoperative ovj	+1.5	−5	−4	−3
Postoperative ovj	+2.5	+2	+1.5	+2
Postoperative ovj (5 y)	+2.5	+2	+1.5	+2
Ovj increase	+1	+7	+5.5	+5
Ovj increase (5 y)	+1	+7	+5.5	+5

ICDBD indicates intercanine distance before distraction; ICDAD, intercanine distance after distraction; IPDBD, interpremolar distance before distraction; IPDAD, interpremolar distance after distraction; IMDBD, intermolar distance before distraction; IMDAD, intermolar distance after distraction; Ovj, overjet.

Once proper maxillary expansion was obtained, the expansion screw of the device was blocked for 4 months, after which the device was removed under local anesthesia.

In general, when a complete Le Fort I osteotomy is performed in association with a midpalatal distraction, the intrinsic stability of the system is important, because, in this way, it is possible to put 4 miniplates for maxillary fixation, taking under proper control the occlusal plane stability particularly in the posterior aspect of the maxilla.

During this surgical step, an inferior molar vestibular torque may happen for the decompensation of the lingual inclination of the lower molars. This movement may happen because of the new pattern of the bite forces on the buccal cuspids of the lower molars after crossbite resolution and for the orthodontic effects of the device. When this situation occurs, a little widening of the inferior arch appears with the consequent necessity of further maxillary expansion. If this situation happens in cases treated with a segmented LFI-E, a new operation is necessary to obtain further maxillary expansion. In cases treated with the SARME-dental technique in association with Hyrax or other tooth-borne appliance, a restart of the expansion system is at risk for tooth-borne problems related to the application of expansion forces on teeth against an increased resistance because of the initial consolidation of the osteotomies.

With our PDD, tooth-borne risks are avoided, and resistance forces may be easily overcome because of the bone-borne and rigidity device characteristics, which also ensure a bodily bone fragment movement with full control in the 3 planes of the space.

To detect palatal expansion at the dental level, measurements were recorded on dental casts at the intercanine distance (canine cusp), interpremolar palatal cusps, and intermolar mesiopalatal cusps before surgery, 5 months after surgery, and 5 years after surgery (Table 1). To detect maxillary movements on the anteroposterior plane by lateral cephalograms, Steiner cephalometric analysis was performed before surgery, 4 months after surgery, and 5 years after surgery (Table 2). To detect palatal expansion at the basal bone level, cephalometric analysis was performed on frontal cephalograms before surgery, 4 months after surgery, and 5 years after distraction.

According to the method used by Chamberland and Proffit,[19] measurements were taken on posteroanterior cephalograms: Nasal cavity width was measured between the left and right points at the maximum concavity of the piriform rim; maxillary width was measured between the left (JL) and right jugal point (JR), with jugal point defined as the location on the jugal process at the intersection of the outline of the maxillary tuberosity and zygomatic process (Table 3).

Table 1 shows data related to the occlusal relationship before and after surgery. Table 2 shows the data of maxillary movement in the posteroanterior and vertical direction, and Table 3 shows the maxillary movement and transversal direction.

Patient 1 was a 20-year-old woman with monolateral crossbite and left deviation of superior midline who underwent surgery

TABLE 2. Maxillary Movement in Anteroposterior Plane (Lateral Cephalograms)[20]

	Patient 1	Patient 2	Patient 3	Patient 4
Preoperative				
SNA, degrees	86	81	74	81
SNB, degrees	84	80	78	82
ANB, degrees	2	1	−4	−1
SN bispinal plan, degrees	10	13	12	7
NA incisive sup (distance), mm	2	0	8	7
NB incisive inf (distance), mm	5	5	3	4
Postoperative				
SNA, degrees	87	86	78	82
SNB, degrees	84	84	79	81
ANB, degrees	3	2	−1	1
SN bispinal plan, degrees	8	10	12	8
NA incisive sup (distance), mm	4	4	6	8
NB incisive inf (distance), mm	4	5	3	4
Postoperative (5 y)				
SNA, degrees	87	86	78	82
SNB, degrees	84	84	79	81
ANB, degrees	3	2	−1	1
SN bispinal plan, degrees	7	10	12	8
NA incisive sup (distance), mm	3	4	6	8
NB incisive inf (distance), mm	5	5	3	4

According to Steiner cephalometric analysis.

SNA indicates sella-nasion-A point angle; SNB, sella-nasion-B point angle; ANB, A maxillary point-nasion-B mandibular point; SN bispinal plan, SN plane-maxillary anterior and posterior spine plane angle.

TABLE 3. Maxillary Movements on Transversal Plane Frontal Plane Cephalograms*

	Patient 1	Patient 2	Patient 3	Patient 4
Preoperative, mm				
JJ	59	58	57	64
NN	31	29	30	33
Postoperative, mm				
JJ	62.5	63	64	66
NN	34.5	32	34	35
Postoperative (5 y), mm				
JJ	62.5	63	64	66
NN	34.5	32	34	35

JJ indicates interjugal distance; NN, nasal width.
*According to Chamberland and Proffit.[19]

for Le Fort I with down-fracture for expansion and repositioning (LFI-DO–bone). Patient 2 was a 22-year-old woman with a bilateral crossbite, class III malocclusion, and superior midline deviation; she underwent surgery for Le Fort I with down-fracture for expansion and repositioning (LFI-DO–bone). Patient 3 was a 33-year-old woman with bilateral cross-bite, class III malocclusion, and deviation of the superior midline. She underwent surgery for Le Fort I with down-fracture for expansion and repositioning (LFI-DO–bone). This technique was particularly useful in this patient because she had 2 dental prostheses in the upper molar regions that were unavailable for tooth-borne devices. Patient 4 was a 34-year-old man with bilateral cross-bite, class III open bite, and mild superior midline deviation; he underwent surgery for midfacial Le Fort I with down-fracture maxillary expansion and repositioning (LFI-DO–bone) plus bilateral sagittal osteotomy for mandibular setback and correction of his open bite in a single surgical procedure.[20]

RESULTS

All the cases exhibited good results with total correction of the posterior crossbite and class 1 occlusion at the dental level immediately after operation. Results were stable 5 years after distraction. Only minor dental movements occurred at the dental analysis after 5 years related to lack of orthodontic contention without any compromise of the dental result (no crossbite relapse and class 1 stability) (Table 1; Figs. 1 and 2).

Also, cephalometric analysis in lateral view for anteroposterior and vertical movements and posteroanterior view for transversal movements showed substantially stable measurements at 5 years after distraction. Posteroanterior cephalograms showed improvement with nasal width in all the cases (NN = nasal width measured from most lateral points of the piriform rim at the Le Fort I osteotomy site).

In agreement with other reports that analyzed the dental and skeletal stability after LFI-DO and repositioning, we found a substantial stability of the distracted basal bones resulting in considerable stability of the expanded upper dental arches.

DISCUSSION

Transverse maxillary deficiency is a common pathology among adults in treatment by orthodontic therapies; this deficiency can be treated with several different surgical therapies, but relapse is one of the main problems in maxillary expansion technique.

There is no consensus in the literature regarding the cause and amount of relapse and whether overcorrection during the distraction phase is necessary. Relapse occurs because of scar tissue contraction after distraction. A consolidation period of 3 months is generally accepted to be sufficient to avoid most of the relapse due to scar contraction. Another factor to consider in relapse is the mode of distraction.

It has been suggested that relapse increases when a tooth-borne rather than a bone-borne distractor is used. An explanation for this might be the tipping of the elements due to the tooth-borne fixation of the expander. Another factor might be the tipping of the maxillary segments instead of parallel expansion due to the different position of the tooth-borne and bone-borne distractors relative to the "center of resistance." This center of resistance is a combination of the area where the maxillary halves are still connected to the skull after the corticotomy, the pterygoid region, and the resistance of the surrounding soft tissues.

Surgical maxillary expansion can be accomplished by several different techniques, which can be classified in the following:

1. segmented Le Fort I with down-fracture with expansion and three-dimensional maxillary repositioning (LFI-E)
2. surgically assisted rapid maxillary expansion by incomplete Le Fort I osteotomy with dental-borne devices Hyrax (SARME-dental)

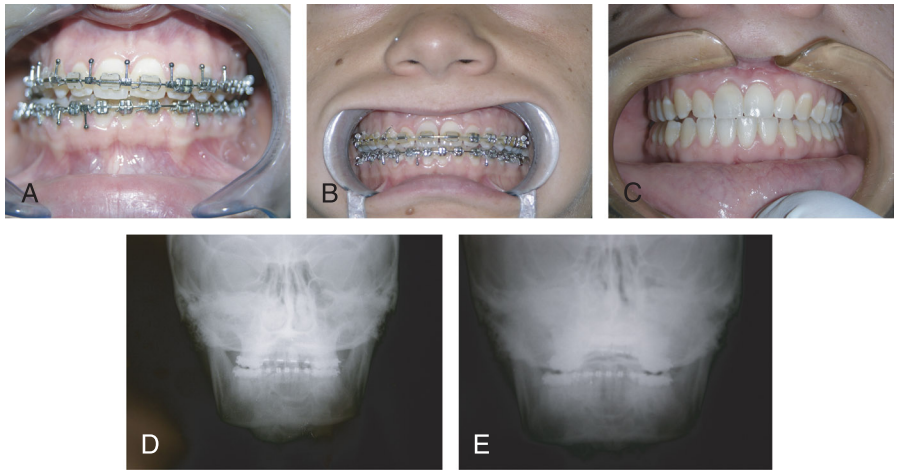

FIGURE 1. Patient 1: (A) preoperative frontal view, (B) year 1, postoperative frontal view, (C) year 5 postoperative frontal view, (D) preoperative posteroanterior cephalogram x-ray, (E) year 5 postoperative posteroanterior cephalograms x-ray.

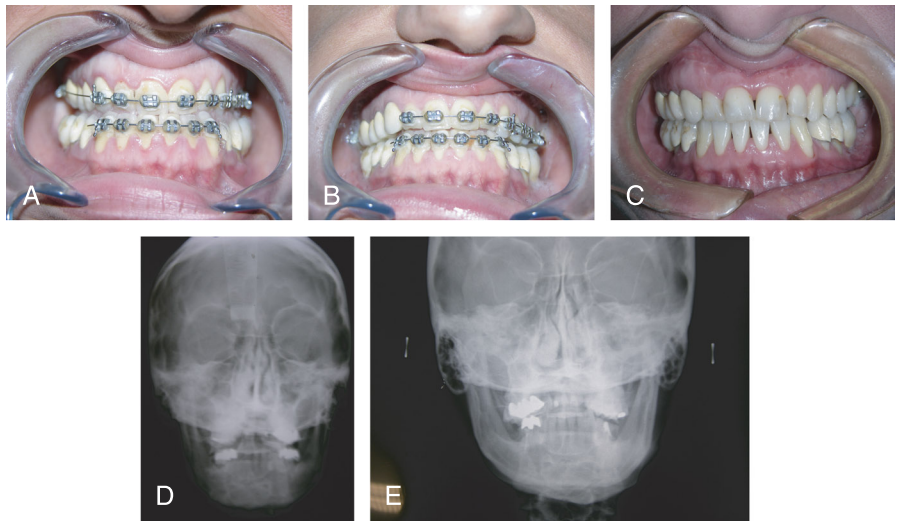

FIGURE 2. Patient 3: (A) preoperative frontal view, (B) month 4, postoperative frontal view, (C) year 5, postoperative frontal view, (D) preoperative RX posteroanterior cephalogram, (E) year 5, post operative RX posteroanterior cephalograms.

3. surgically assisted rapid maxillary expansion by incomplete Le Fort I osteotomy with bone-borne devices (SARME-bone)
4. Le Fort I osteotomy with down-fracture, three-dimensional maxillary repositioning, and distraction osteogenesis with dental-borne device (LFI-DO–dental)
5. Le Fort I osteotomy with down-fracture, three-dimensional maxillary repositioning, and distraction osteogenesis with bone-borne devices (LFI-DO–bone)
6. Le Fort I osteotomy with down-fracture, three-dimensional maxillary repositioning, and distraction osteogenesis with rigid bone-borne devices (LFI-DO–bone-rigid)[3,11]

Because of frequent association between maxillary anterior-posterior and vertical deformities with transversal discrepancies, a subsequent orthognathic surgery is necessary in all SARME procedures, with consequent costs and risks of an additional procedure under general anesthesia. In contrast with LFI-E, it is possible to obtain palatal expansion and the desired three-dimensional movements, but it is considered one of the least stable orthognathic procedures.[11]

Even if surgical complications are infrequent, in LFI-E, severe intraoperative or postoperative hemorrhage, difficulties in positioning and stabilizing the bone segments, oroantral or oronasal fistulas, permanent mobility of maxillary segments, and loss of gingival papillae for underlying periodontal defects have been reported.[12,13] With SARME-dental, all the aforementioned problems related with LFI-E are avoided, but teeth-borne related problems (periodontal defects bone and root resorption) may occur, and a double-stage surgery is necessary when a three-dimensional maxillary repositioning is required. With SARME-bone, related tooth-borne problems are avoided, but a double-stage surgery is necessary if required for a three-dimensional maxillary malposition correction. With a complete Le Fort I osteotomy with down-fracture, associated with distraction osteogenesis by tooth-borne devices (LFI-DO–dental), it is possible to associate the advantages of the 1-step surgery by LFI-E with the advantages of the SARME-dental, avoiding the surgical-related problems of LFI-E. With an LFI-DO–bone, using a bone-borne distractor device, it is possible to avoid the teeth-related problems of a tooth-borne device.

In 2 studies, short-term results were reported for LFI-DO.[3,11] In 1 study, an LFI-DO–bone with TPD device conceived by Mommaerts was performed on 9 patients: A more posterior expansion was achieved through the positioning of the TPD plates on the palatal vault as posteriorly as possible (at the level of the second bicuspid of the first molar).[3] Stability of results in 9 cases was satisfying, and only 1 patient showed moderate relapse for dental orthodontic movements.

In another study, an LFI-DO–dental with a dental-borne device Hyrax was performed: the dental findings showed a nonparallel maxillary expansion with a greater increase anteriorly and inferiorly; also, at the basal bone level in posteroanterior analysis on cephalograms, a triangular pattern of expansion with a greater amount of movement at the dental level and a lower amount toward the nasal area was reported.[11]

Explanation of this movement pattern was given because of the force application point on the teeth well below the center of resistance, which is thought to be positioned at the level of zygomatic buttresses on a line passing through the distal contacts of the maxillary first molars.[11]

With an LFI-DO–bone rigid PDD, using a bone-borne distractor device, it is possible to avoid the problems related to the use of a nonrigid device such as the possibility of asymmetric maxillary expansion and the detachment of device components, which may cause swallowing and/or chocking risks.[14,21]

Because the rigid PDD holds the maxillary segments rigidly like a single unit, advantages include the related convenience in positioning and stabilizing the bone segments at the maxillary fixation time during surgery and the possibility to perform further palatal expansion if required in case occlusal changes in the lower dental arch occur.

In our technique, by the use of a rigid tooth-borne palatal distractor with a semirigid contention system (4 miniplates with only 2 screws for each miniplate), it is possible to obtain a variation of the occlusal plane, particularly useful when an improvement of the posterior maxillary height is required.

In our study, it was possible to verify the long-term stability of our cases at 5 years at the dental and basal bone levels. Findings achieved by dental measurements on dental models and basal bone measurements on posteroanterior and lateral cephalograms showed substantial stability of the cases.

CONCLUSIONS

The results of our study suggest that a 1-stage resolution of two- or three-dimensional maxillary anomalies associated with

transverse deficiency is possible with our LFI-DO–bone rigid technique and that the results of the long-term stability at the dental and basal bone level are satisfying.

Our procedure using a rigid tooth-borne distractor device (TDD) has some advantages in comparison to other nonrigid tooth-borne devices because it does not cause asymmetric maxillary expansion and it is not afflicted by difficulties in positioning and stabilizing the bone segments at the maxillary fixation step during surgery.

Small sample size, limited records, and potential treatment bias on LFI-DO studies limit the findings; future studies with a large number of patients with records taken before and after surgical and orthodontic treatment are necessary to better evaluate surgical and orthodontic long-term stability of this new procedure.

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