European Journal of Musculoskeletal Diseases
ISSN 2038-4106 print - ISSN 2975-044X online

BPI

Case Report

AUTOMATIC SAGITTAL-TRANSVERSAL MAXILLARY EXPANSION: ORTHOGNATHODONTIC EVOLUTION

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ABSTRACT

The outcome of daily clinical practice in interceptive orthognathodontics is influenced by the severity of the pathology. It also heavily depends on the paediatric patient's ability to cooperate. The need to choose between dentoalveolar and skeletal expansion using fixed appliances arises from the necessity to achieve a predictable result in the shortest time possible and grant optimal patient growth, even in the absence of cooperation. However, the transposition of the typical three-way steel screw from removable appliances to fixed ones complicates expansion treatments, especially for the patient's parents, forcing the dental professional to perform frequent checks relative to expansion's activations. The introduction of an automatic one-way nickel-titanium expansion screw in the shape of a crossbow, to be intended as an evolution of the one-way steel screw present in traditional rapid expanders, has paved the way for a new interceptive orthognathodontics paradigm. Daily clinical practice makes skeletal transversal maxillary expansion substantially independent of patient cooperation. In this paper, a new device is presented, with the aim to further refine the concept of independence present in contemporary one-way crossbow-shaped expansion screw appliances, simply introducing three undersized crossbows made from nickel-titanium. This design can exert efficient expansion simultaneously in three directions, making maxillary expansion automatic both sagittally and transversally, minimizing the need for patient cooperation, and reducing parents' concerns.

KEYWORDS: *automatic, nickel-titanium, class III, expansion, simplicity, efficiency*

INTRODUCTION

In paediatric interceptive orthognathodontics, transversal skeletal maxillary expansion is one of the most frequent needs. The choice among the various expansion methods is primarily based on the skeletal and dental characteristics of the patient's malocclusion. Although vertical and horizontal skeletal growth components interact in shaping the final morphological framework of the dentoskeletal structures, the influence of transversal skeletal width is decisive. Morphological changes along the transversal plane of skeletal structures often induce skeletal modifications in

Received: 18 April 2024
Accepted: 19 May 2024

ISSN 2038-4106 print
ISSN 2975-044X online

the sagittal plane. In contrast, compensatory capacities in the sagittal plane are mainly expressed through dental alterations, as the dentition effectively absorbs any structural anomalies of skeletal growth (1).

Furthermore, the individual response to transversal expansion is determined by the patient's sutural activity: true sutural growth stimulation is possible only in patients who have not reached their pubertal growth peak (2). Moreover, a slight reduction in diameters at both molar and premolar levels is observed after transversal expansion, but the new occlusal relationships remain stable (3). Therefore, an early and accurate diagnostic evaluation is fundamental to classifying paediatric orthognathodontic patients based on age and type of malocclusion so that the most appropriate expansion protocol can be applied.

Malocclusion, resulting from skeletal deficit, may or may not involve the basal structure and thus present in dentoalveolar, skeletal, or more often mixed forms (4-6). The dentoalveolar deficit is often linked to problems in the eruptive sequence. It occurs mostly due to palatal inclination of the teeth in the upper arch and their alveolar processes in the absence of a transversal deficit in the upper jaw (4). The skeletal deficit consists of a reduction at the basal level of the maxilla, both at sagittally and transversally. It is associated with insufficient transversal development of the middle third of the face (4, 6, 7). The transversal skeletal deficit is thus characterized by a reduction in the width of the upper jaw, absolute or relative to the mandible, a reduction in the width of the nasal fossae, and, in most cases, overdevelopment of the lower third of the face in the presence of correct dental axes (8).

Therefore, based on the above considerations, for Class I and II malocclusions resulting from dentoalveolar, skeletal, or mixed maxillary deficits, transversal expansion combined with subsequent intra or extraoral appliances is appropriate to resolve imbalances. For Class III malocclusions, sagittal-transversal expansion combined with subsequent intra or extraoral appliances is necessary. Specifically, Class III malocclusion may be associated with either upper base retrusion, lower base protrusion, or a combination of the two anomalies. The upper jaw, when retrognathic, is often also characterized by a reduction in its transversal diameter (9). Therefore, careful evaluation of the transversal relationships between the arches and the maxillae is mandatory in the treatment planning of Class III malocclusion (10).

Finally, the favorable outcome of the chosen expansion for any malocclusion, even when selecting the most appropriate clinical protocol, depends on the cooperation of the child, which, paradoxically, is more difficult to achieve today despite well-known psychological approach techniques (11). This category of patients often has negative experiences due to an emergency intervention following trauma or some carelessness and/or lightness due to inexperience. These events generate a real phobia in the young patient, leading to a refusal of dental care and a tendency to reject any figure in the medical field, sometimes requiring pharmacological pretreatments as the only viable approach (11-15).

Having defined the theoretical concepts of interceptive orthognathodontic expansive treatment, resulting from more than a century of research, it is necessary to translate these considerations into orthognathodontic clinical practice. Such practice developed with the first interceptive orthognathodontic treatment of transversal skeletal maxillary expansion dating back to 1860 from an idea by Emerson C. Angel (16) through a prototype largely dependent on patient cooperation and operator skills. It was refined through Andrew J. Haas's work in 1961 (17), transforming the prototype into a Rapid Maxillary Expander (RME). It required almost a hundred years due to diverging opinions throughout the first half of the 20th century. Substantial modifications were not conceived until the end of the last century, despite the increasingly evident dependence of interceptive orthognathodontic treatment on patient cooperation, requiring frequent checks by the dental professional.

Since the 2000s, new ideas have emerged, among which tripartite expansion for fixed appliances, both transversally and sagittally, is perhaps the most interesting. However, this approach, realized through the welding of three steel screws expandable in three directions, entails complications in the treatment process, making its efficiency completely dependent on the dentist and the paediatric patient (17-19). In 2013, continuous technological progress and research produced a new clinically effective expander independent of patient cooperation, at least in terms of transversal expansion. This device, named the Leaf Expander (LE), was developed as a reactivatable expander equipped with a one-way steel screw combined with a Ni-Ti MEMORIA® crossbow spring. It allows for the expansion of the maxilla, predominantly through dentoalveolar remodeling, automatically without needing paediatric patient cooperation (20). The Leaf Expander (LE) has become the main expander in contemporary orthognathodontic clinical practice for treating transversal deficits, thanks to its high efficacy in the absence of cooperation, essentially making the therapy automatic. Building on the proven efficiency of the results found in the literature for this treatment protocol, the authors propose the use of the one-way steel screw combined with the Ni-Ti MEMORIA® crossbow spring in all three directions, automating the expansion both transversally and sagittally.

In this paper, a new device is presented through a pilot clinical case. This device emerges from the authors' desire to automate every scenario requiring expansive orthognathodontic treatment, both transversal and sagittal, simplifying the process of achieving high clinical efficacy without dependence on patient cooperation, excluding self-harm. This appliance can be easily combined with any auxiliary third-class extra-oral orthopaedic traction, just like any Rapid Maxillary Expander (RME) or Leaf Expander (LE).

MATERIALS AND METHODS

Patients' case preparation involves traditional hygienic and health standards, conducting the initial visit, followed by the collection of initial photographic documentation, analogic and digital occlusal documentation, and radiographic exams (orthopantomography, lateral and postero-anterior teleradiographs). Subsequent digital measurements of the mandibular inter-canine distance (starting from the cusp apex) and inter-molar distance (starting from the buccal intercuspidal groove) are registered, combined with the digital measurement of the maxillary inter-incisive distance (starting from the distal margin of the lateral incisors) and inter-molar distance (starting from the palatal side of the mesiovestibular cusp), and are followed by the execution of a pre-treatment diagnostic cephalometry and a prognostic cephalometry according to a hypothetical post-treatment condition.

Data collection and processing allow for precise planning regarding dentoskeletal expansion needs in the sagittal and transversal directions, thereby drafting the fundamental diagnosis for an interceptive orthognathodontic treatment. Initially, authors adopted this prototype appliance on paediatric patients suffering from Class III malocclusions characterized simultaneously by bilateral crossbite and reverse bite. Subsequently, having observed good results, it was decided to expand the case studies to paediatric patients still suffering from Class III malocclusions but with unilateral crossbite and without reverse bite, treating 38 patients with this new orthognathodontic appliance.

This device consists of three one-way steel screws combined with a Ni-Ti MEMORIA® crossbow spring welded together: two are placed posteriorly in the transversal direction, and one is located anteriorly in the sagittal direction. For paediatric patients in the early age, two transversal screws of 450g each with an expansion capacity of 6mm are used, as they are associated with the possible compression of the nickel-titanium crossbow spring via the steel screw, and one sagittal screw with a force of 900g, also with an expansion capacity of 6mm. For paediatric patients in the prepuberal age, a force of 900g in all three directions with an expansion capacity of 6mm was chosen. The two posterior screws, welded together, are anchored distally to two steel bands placed on the first molars.

Palatally, expansion arms are welded to the same bands, while buccally, arms with hooks for potential third-class extraoral orthopaedic traction are attached. Finally, the anterior sagittal screw, welded to the two posterior ones, rests mesially on the palatal side of the incisors through a steel trapezoidal-like structure (Fig.1).

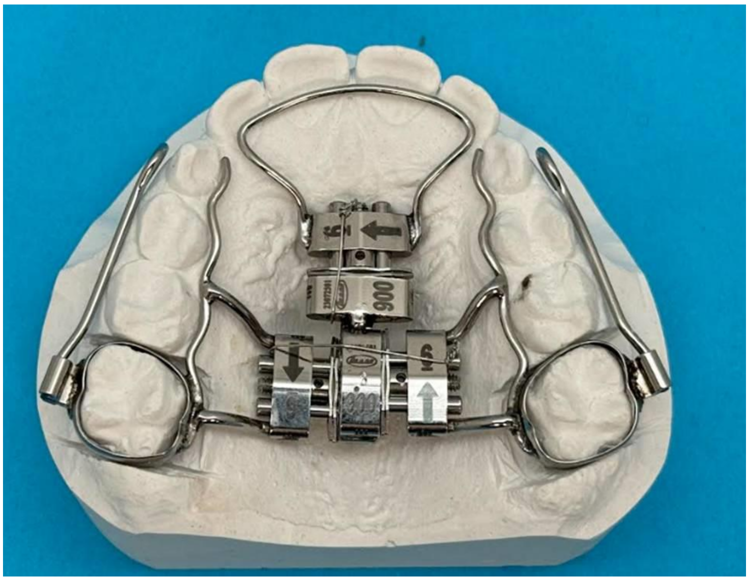

Fig. 1. *Construction of the new appliance.*

Therefore, based on the case studies conducted on the selected patients and the development of the new orthognathodontic appliance, a procedural protocol was planned, which includes:

- placement of the appliance (Time 0);
- first check after three weeks to verify the expansive efficiency of the Ni-Ti crossbow springs (Time 20 days);
- second check after one and a half months to assess the dentoskeletal expansive results achieved (Time 45 days);

- third check after three months to verify the result's stability, to observe the neuromuscular occlusal readjustment to the result, and to deliver the third-class extraoral traction associated with a reactivation of the expansion screws through the contraction of the Ni-Ti crossbow springs by 1mm (Time 90 days);
- fourth check after an additional three months to verify the efficiency of the third-class extraoral traction associated with a further reactivation of the expansion screws through the contraction of the Ni-Ti crossbow springs by another 1mm (Time 180 days);
- fifth check after another three months to assess the achieved result and subsequent removal of the appliance, followed by the creation of a rigid third-class myofunctional retention (Time 270 days).

RESULTS

Pilot case and case study

A 9-year-old paediatric patient characterized by prepubertal somatic, skeletal Class III malocclusion, dental Class III malocclusion, normodivergence, medium dentoalveolar discrepancy, mild hypomaxillia, medium hypermandibulia, bilateral crossbite, reverse bite, endoinclination of incisors, horizontal interincisal distance (-1.5mm), vertical interincisal distance (1mm), rectangular palate, concave profile, upper lip distance (1mm), lower lip distance (2mm), normal hourly growth, and phoniatric anomaly with mild sigmatism was enrolled (Fig. 2-12).

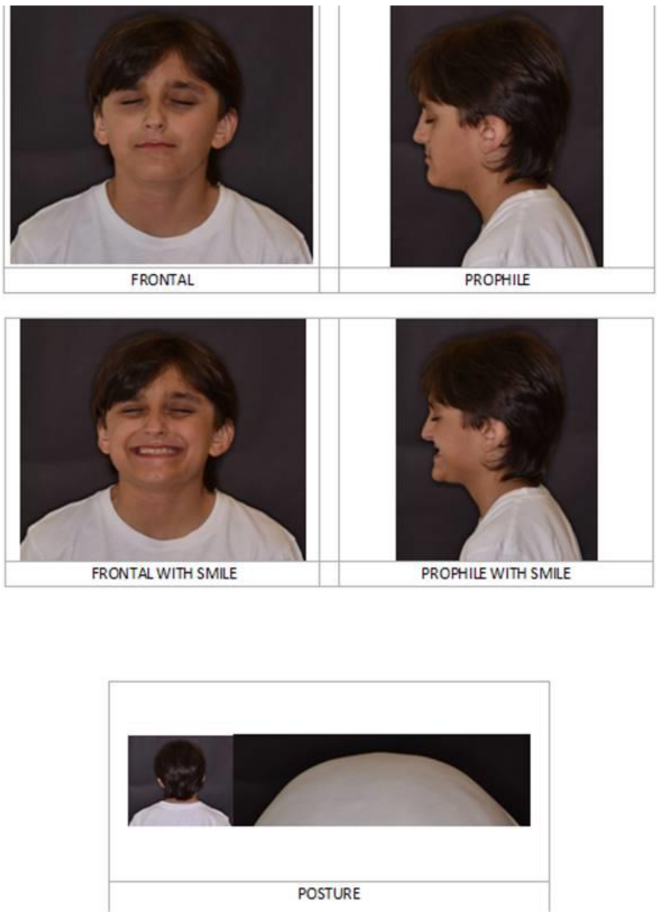

Fig. 2. *Extraoral photos.*

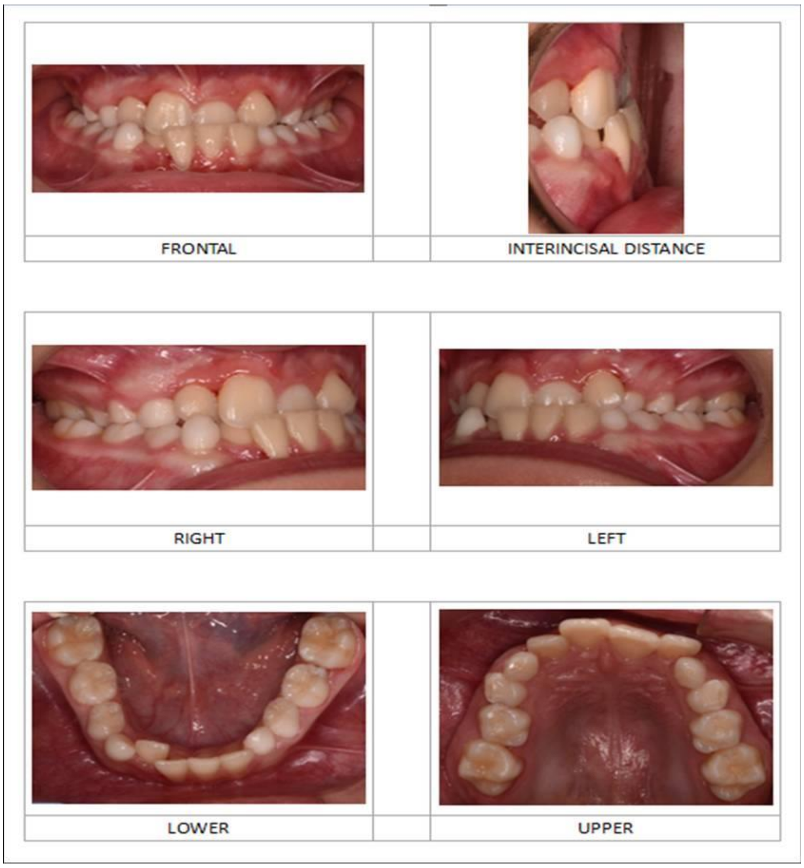

Fig. 3. *Intraoral photos.*

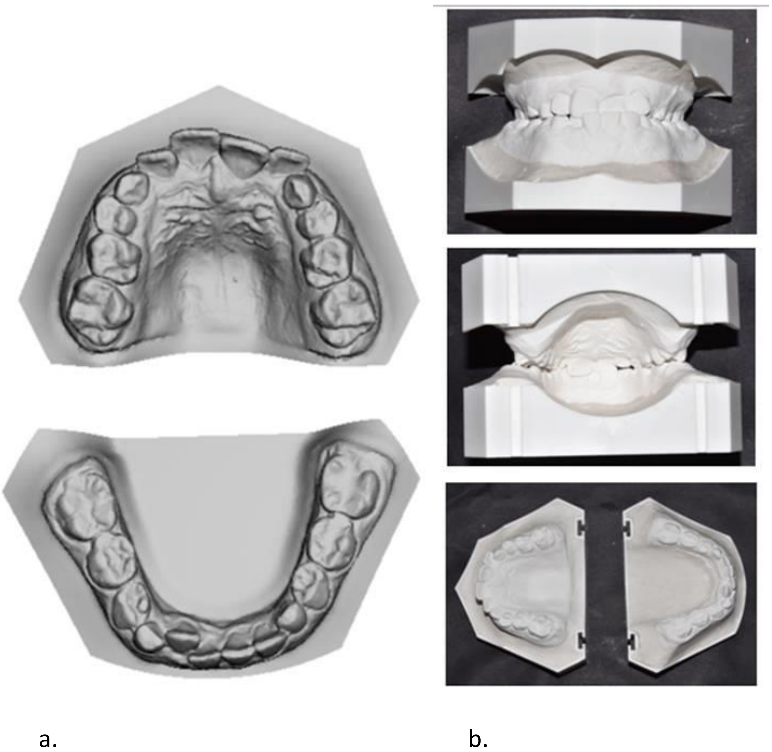

Fig. 4. ***A****): digital models* ***B****): analog models.*

Fig. 5. *Orthopantomography and lateral teleradiograph.*

Sigla	Descrizione	Misura	U.M.	Normale	D.S.Sup.	D.S.Inf.	Int. di Tolleranza	Discrepanza	Valutazione
SNA	S-N-A	84,58	°	82,00	2,00	2,00	[80.00,84.00]	+0,58	Protrusione del mascellare superiore
SNB	S-N-B	86,48	°	80,00	2,00	2,00	[78.00,82.00]	+4,48	Prognazia o protrusione della mand.
ANB	A-N-B	-1,90		2,00	2,00	2,00	[0.00,4.00]	-1,90	III classe scheletrica
CM	S-N ^ Gog-Me	26,40	°	32,00	3,00	3,00	[29.00,35.00]	-2,60	soggetto ipodivergente
AJ	Sna-Snp ^ Gog-Me	24,03	°	26,00	1,00	1,00	[25.00,27.00]	-0,97	angolo ipodivergente
OM	p.Occl ^ Gog-Me	15,56	°	16,00	1,00	0,00	[16.00,17.00]	-0,44	angolo ipodivergente
II	Inc.sup. ^ Inc.inf	137,69	°	131,00	5,00	5,00	[126.00,136.00]	+1,69	Endoinclinazione incisivi
SIS	Sna-Snp ^ Inc.sup.	113,81	°	109,00	5,00	5,00	[104.00,114.00]		Normoinclinazione incisivi sup.
MII	Gog-Me ^ Inc.inf	84,48	°	90,00	5,00	5,00	[85.00,95.00]	-0,52	Endoinclinazione incisivi inf.
GI	Gog-Me ^ Gog-N	69,84	°	73,00	2,00	2,00	[71.00,75.00]	-1,16	tendenza anterotazione mand.
GS	Gog-N ^ Gog-Pc	55,42	°	53,00	2,00	2,00	[51.00,55.00]	+0,42	tendenza anterotazione mand.
GO	Gog-Me ^ Gog-Pc	125,25	°	126,00	4,00	4,00	[122.00,130.00]		tendenza normorotazione mand.
SGNC	S-Gn ^ S-N (asse Y)	59,40	°	67,00	1,00	1,00	[66.00,68.00]	-6,60	crescita mand. preval. antero-post.
NBH	N-B ^ Ls-PgC (linea H)	174,77	°	8,00	1,00	1,00	[7.00,9.00]	+165,77	profilo convesso
APgIi	A-Pg - Inc.inf	0,57	mm	1,00	2,00	2,00	[-1.00,3.00]		normoposizione incisivi inf.
OB	Overbite	0,92		2,00	2,00	2,00	[0.00,4.00]		morso coperto
OJ	Overjet	-1,39		2,00	2,00	2,00	[0.00,4.00]	-1,39	III classe incisiva
SN	S - N	58,97	mm						
GogMe	Gog - Me	65,44	mm	57,22	0,00	0,00	[57.22,57.22]	+8,22	
r1	(S-Gog) / (N-Me)	68,86	%	62,00	3,00	3,00	[59.00,65.00]	+3,86	
SLS	Stiramento Ls	-11,05							
W	Indice di WITS	-5,16		0,00	2,00	2,00	[-2.00,2.00]	-3,16	III classe scheletrica

Fig. 6 A1. *Pre-treatment cephalometric data and hypothetical post-treatment.*

Sigla	Descrizione	Misura	U.M.	Normale	D.S.Sup.	D.S.Inf.	Int. di Tolleranza	Discrepanza	Valutazione
SNA	S-N-A	88,71	°	82,00	2,00	2,00	[80.00,84.00]	+4,71	Protrusione del mascellare superiore
SNB	S-N-B	86,48	°	80,00	2,00	2,00	[78.00,82.00]	+4,48	Prognazia o protrusione della mand.
ANB	A-N-B	2,23		2,00	2,00	2,00	[0.00,4.00]		I classe scheletrica
CM	S-N ^ Gog-Me	26,40	°	32,00	3,00	3,00	[29.00,35.00]	-2,60	soggetto ipodivergente
AJ	Sna-Snp ^ Gog-Me	23,76	°	26,00	1,00	1,00	[25.00,27.00]	-1,24	angolo ipodivergente
OM	p.Occl ^ Gog-Me	15,56	°	16,00	1,00	0,00	[16.00,17.00]	-0,44	angolo ipodivergente
II	Inc.sup. ^ Inc.inf	137,69	°	131,00	5,00	5,00	[126.00,136.00]	+1,69	Endoinclinazione incisivi
SIS	Sna-Snp ^ Inc.sup.	114,07	°	109,00	5,00	5,00	[104.00,114.00]	+0,07	Esoinclinazione incisivi sup.
MII	Gog-Me ^ Inc.inf	84,48	°	90,00	5,00	5,00	[85.00,95.00]	-0,52	Endoinclinazione incisivi inf.
GI	Gog-Me ^ Gog-N	69,84	°	73,00	2,00	2,00	[71.00,75.00]	-1,16	tendenza anterotazione mand.
GS	Gog-N ^ Gog-Pc	55,42	°	53,00	2,00	2,00	[51.00,55.00]	+0,42	tendenza anterotazione mand.
GO	Gog-Me ^ Gog-Pc	125,25	°	126,00	4,00	4,00	[122.00,130.00]		tendenza normorotazione mand.
SGNC	S-Gn ^ S-N (asse Y)	59,40	°	67,00	1,00	1,00	[66.00,68.00]	-6,60	crescita mand. preval. antero-post.
NBH	N-B ^ Ls-PgC (linea H)	177,42	°	8,00	1,00	1,00	[7.00,9.00]	+168,42	profilo convesso
APgIi	A-Pg - Inc.inf	-0,93	mm	1,00	2,00	2,00	[-1.00,3.00]		normoposizione incisivi inf.
OB	Overbite	1,22		2,00	2,00	2,00	[0.00,4.00]		morso coperto
OJ	Overjet	3,94		2,00	2,00	2,00	[0.00,4.00]		I classe incisiva
SN	S - N	58,97	mm						
GogMe	Gog - Me	65,44	mm	57,22	0,00	0,00	[57.22,57.22]	+8,22	
r1	(S-Gog) / (N-Me)	68,86	%	62,00	3,00	3,00	[59.00,65.00]	+3,86	
SLS	Stiramento Ls	-6,32							
W	Indice di WITS	-1,89		0,00	2,00	2,00	[-2.00,2.00]		I classe scheletrica

Fig. 6 A2. *Pre-treatment cephalometries and hypothetical post-treatment.*

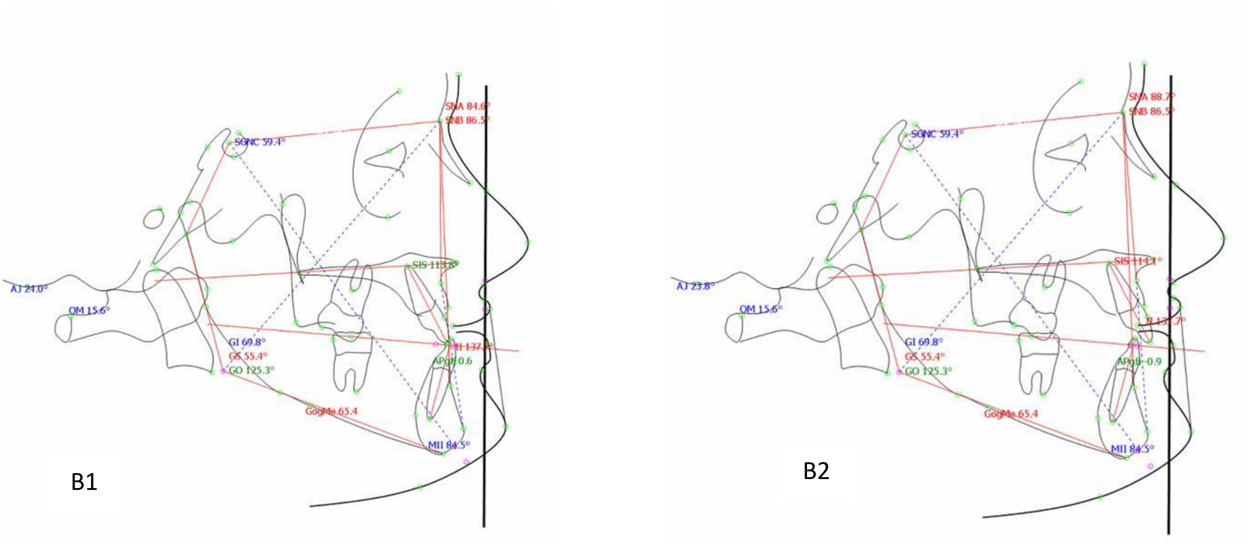

Fig. 6. B1, B2. *Pre-treatment cephalometries and hypothetical post-treatment*

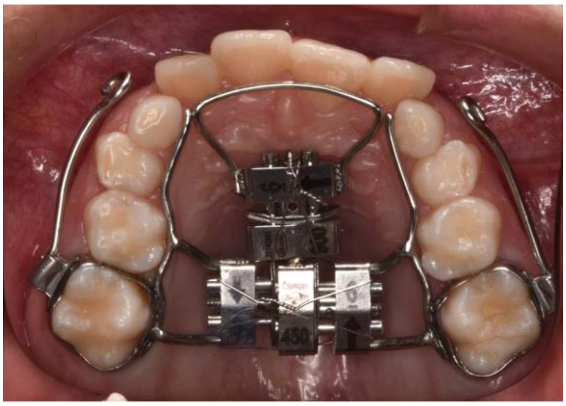

Fig. 7. *Time 0 with appliance.*

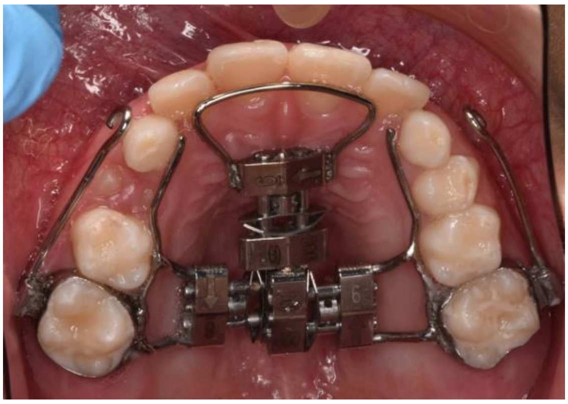

Fig. 8. *Time 45 days.*

Fig. 9. *Time 0 without appliance.*

Fig. 10. *Time 90 days with no appliance.*

Fig. 11. *Time 0 reverse bite and bilateral crossbite.*

Fig. 12. *Time 90 days resolution of reverse bite and bilateral crossbite.*

DISCUSSION

Based on the achieved results, it is possible to highlight the extreme simplicity of such treatment compared to contemporary treatments with appliances consisting of non-automatic three-way steel screws, which are completely dependent on the collaboration between the doctor and the paediatric patient (16-18).

From the assembly of the appliance, nothing needs to be done by either the dentist or the parents during the first three months, as the treatment is efficiently automated. Thus, excluding self-harm, no patient cooperation is required. However, for the subsequent auxiliary third-class extraoral orthopaedic traction during the following semester, the new device encounters typical issues related to wear, patient oral hygiene, and patient cooperation. Therefore, while reiterating the extreme simplicity of treatment execution at least in the first three months and being aware of possible unforeseen issues during the subsequent semester, it is suggested to provide precise post-orthognathodontic instructions upon delivery of the appliance (for instance, avoiding hard foods to protect the Ni-Ti crossbow springs). At the end of the first three months, it is advised to disassemble and reassemble the appliance to check its integrity.

During the following semester, more frequent checks are recommended should any of the aforementioned issues arise (for example, poor patient cooperation in using extraoral elastic bands). Finally, it is recommended to construct the appliance directly with three welded one-way steel screws combined with a Ni-Ti MEMORIA® crossbow spring with a force of 900g and an expansion capacity of 6mm, both for paediatric patients in the early somatic stage and the pre-pubertal somatic stage, as the greater resistance of these screws guarantees higher efficiency to the appliance (21).

Additionally, the ability to fabricate increasingly personalized appliances by exploiting digital technology and making them more stable through absolute skeletal anchorage can further enhance their effectiveness and efficiency in the future.

CONCLUSIONS

Following a pragmatic clinical logic, just as the Leaf Expander (LE) revolutionized transversal maxillary orthognathodontics in 2013 by substantially automating it, the newly presented device aims to be its evolution. It completes the capacity for automatic transversal expansion with an automatic sagittal expansion, with the goal of becoming the appliance of choice for patients suffering from Class III malocclusion associated with the simultaneous presence of mono or bilateral crossbite and reverse bite.

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