International Orthodontics 2024; 22: 100868

Websites:
www.em-consulte.com
www.sciencedirect.com

Case Report

Is significant mandibular advancement possible after the peak of puberty? Dento-osseous palatal expansion and the STM4 technique (Skeletal Therapy Manni Telescopic Herbst 4 miniscrews): A case report

Antonio Manni [1,2], Andrea Boggio [1,2], Giorgio Gastaldi [1], Mauro Cozzani [1,2]

Available online:

1. Postgraduate Program in Orthodontics, Vita-Salute San Raffaele University, Milan, Italy
2. Istituto Giuseppe Cozzani, La Spezia, Italy

Correspondence:
Andrea Boggio, Vita-Salute San Raffaele University, Via Olgettina 60, 20132 Milan, Italy.
andreaboggio90@gmail.com

Keywords
Class II
Herbst appliance
Skeletal anchorage
TADs

Summary

Introduction > Treatment of skeletal class II growing patients often requires the use of functional appliances, aimed at promoting mandibular advancement. Among these, Herbst appliance is recommended for its effectiveness, efficiency, and reduced need for compliance. Despite its skeletal favourable effects, well-known dental compensations can occur, especially when the appliance is not used close to the pubertal peak: upper incisors retroclination, lower incisors proclination, upper molars distalization and lower molars mesialization could reduce the overjet needed for a proper mandibular advancement. To counteract these unfavourable effects skeletal anchorage could be crucial.

Aim > The aim of this case report is to describe and evaluate the effects of using a skeletally anchored Herbst appliance in an 18-year-old (CVM5) male patient with skeletal Class II malocclusion and a convex profile.

Treatment protocol > The treatment started with a tooth-bone-borne palatal expansion, then the upper arch was bonded with pre-adjusted ceramic brackets. After 2 months, a Manni Telescopic Herbst (MTH) supported by 4 miniscrews (two in the maxilla and two in the mandible) was applied. To avoid anchorage loss, TADs were connected with elastic chains to the arches. Nine months later, the Herbst was removed, the lower teeth were bonded and the patient wore class 2 elastics to stabilise the occlusion.

Results and conclusions > After 24 months the treatment goal was achieved with a considerable improvement of the profile and a clinically significant mandibular advancement (Pogonion moved forward 7 mm). A one-year follow-up lateral X-rays showed a good stability of the result.

tome 22 > n°2 > 2024
10.1016/j.ortho.2024.100868

Introduction

Class II is a very common malocclusion affecting about 20% of the worldwide population, with significant racial and geographic differences [1]. This percentage rises to 36–48% considering Caucasian patients requiring orthodontic consultation [2,3].
This malocclusion is generally characterized by prognathic maxilla or retrognathic mandible or a combination of them. However, mandibular retrognathism is the most common variant, with a prevalence of 90% [4].
There are many treatment options available for patients suffering from Class II malocclusion: removable or fixed functional appliances, buccal or lingual multi-bracket appliances combined with elastics, etc. The aim of these appliances is to correct the intermaxillary relationship and reduce the overjet. Fixed functional devices include Herbst: a non-compliance device for Class II skeletal correction [5,6]. This appliance has both skeletal and dental effects, such as enhanced sagittal displacement of the mandible, reduction of sagittal growth of the maxilla, anterior movement of the mandibular arch and distalization of the maxillary arch.
While skeletal results are always favourable, dental effects may not be so; generally, they are due to anchorage loss with poor control of the upper and lower incisors, mesialization of mandibular molars and distalization of maxillary ones. In particular, the proclination of lower incisors and retroclination of the upper ones could decrease the mandibular growth response due to rapid reduction of the overjet [7,8]. On the contrary, a better control of these unfavourable teeth movements may result in a greater skeletal mandibular advancement [9,10].
Thereby, several modifications of the original Herbst design have been proposed at this purpose [11].
The Manni Telescopic Herbst (MTH) appliance (American Orthodontics, Sheboygan, WI) consists of a maxillary fixed transpalatal arch linked to a mandibular acrylic splint with two telescopic rods, allowing a lateral excursion movement of the mandible of about 12°. The splint is aimed at reducing the flaring of lower incisors and can be partially removed to allow hygiene procedures to the patient [12]. Moreover, the MTH Herbst Appliance is generally associated with limited emergencies, complications and failures, if compared with the traditional one [13].
Despite the benefits provided, this system alone is not effective to completely prevent labial tipping of lower incisors; for this reason, some authors considered the effects of combining Herbst appliance with two Temporary Anchorage Devices (TADs) in lower arch to prevent the undesired anchorage loss [14–17]. Only one study [18] analysed the effects of using Herbst appliance anchored to four buccal miniscrews, two in the upper and two in the lower arch (Skeletal Therapy Manni Telescopic Herbst 4 TADs – STM4), obtaining a greater Pogonion advancement, less distalization of upper molars and a reduced flaring of lower incisors, compared with the use of just two lower TADs.
Another significant prognostic factor is represented by the skeletal maturation of the patient, which is important to decide the ideal timing of class II treatment [19,20]. According to the cervical vertebral maturation (CVM) method, the period among CVM3 and CMV4 is considered the best to increase the skeletal effects of an orthopaedic appliance [21]; from this point onwards, the growth potential gradually decreases, limiting the efficacy of the treatment.
However, the orthodontist does not always have the opportunity to treat patients during this favourable time window; moreover, some patients, despite no longer showing mandibular growth, refuse the ideal combined orthodontic and orthognathic treatment.
Although some authors have considered the use of the Herbst appliance without skeletal anchorage in adult patients with good results, there are no general recommendations for the use of fixed functional appliances after the peak puberty [22,23].
Therefore, the aim of this case report is to evaluate the effects of combining skeletal anchorage and Herbst appliance in an 18-year-old (CVM5) male patient with Class II malocclusion, who refused an orthodontic treatment combined with orthognathic surgery.

Diagnosis and aetiology

An 18-year-old male patient (CVM 5) presented with a chief complaint of unattractive smile, dental crowding and retrusive chin.
The macro-aesthetic analysis showed convex profile with severe mandibular retrusion and normal nasolabial angle (*figure 1*).

FIGURE 1

Pretreatment extraoral photographs

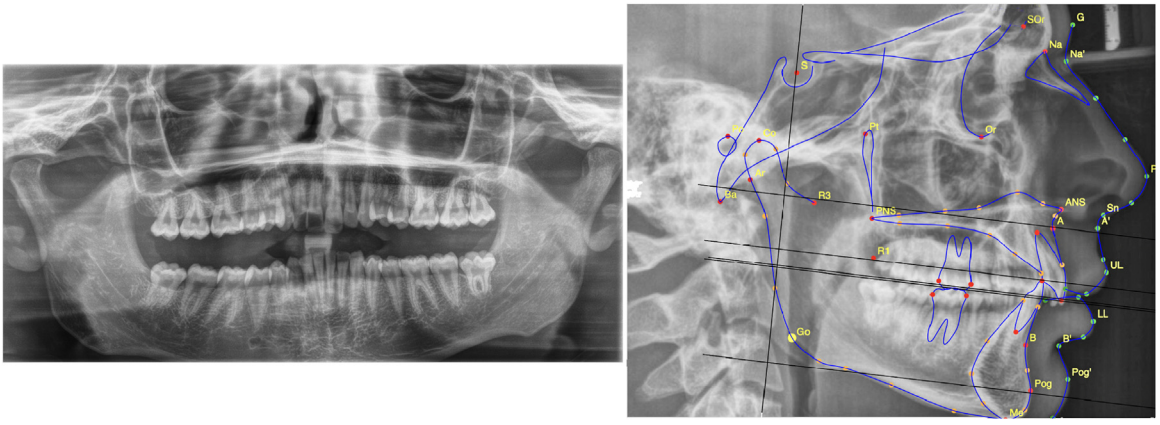

FIGURE 2

Pretreatment panoramic radiograph and lateral cephalogram

The cephalometric analysis confirmed a skeletal Class II malocclusion (SNA = 87.5°, SNB = 81°, ANB = 6.5°) and an hypodivergent skeletal pattern (Sn/GoGn = 21°). Maxillary incisors were retroclined (Is/PP = 106.5°) and mandibular incisors proclined (Ii/GoGn = 100°) before the treatment (*figure 2*).

Intraoral examination showed a class II malocclusion, with increased overbite and dento-skeletal reduction of transverse maxillary diameter, evidenced even more by simulating mandibular advancement. The upper incisors, except for the right central incisor, were retroclined. The result was a forced mandibular retroposition with deviation visible on panoramic and lateral ceph (the condyles were asymmetrical and there was a duplication of the right ramus and the gonial angle). In addition, the curve of Spee was more pronounced on the right side, where the class II was more severe and the mandible more retropositioned. A small supernumerary tooth was observed on the buccal side of the upper left second molar, (*figures 3 and 4*).

FIGURE 3
Pretreatment intraoral photographs

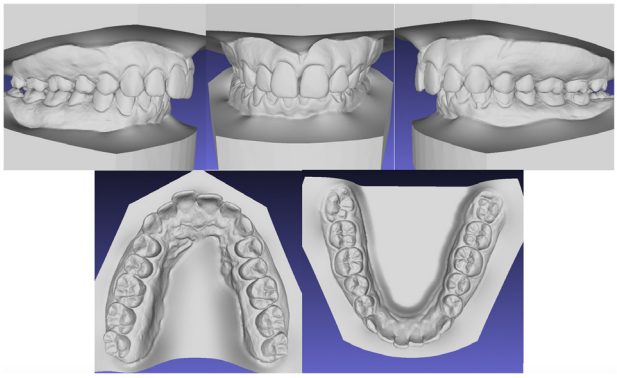

FIGURE 4
Pretreatment models

Treatment objectives

The main treatment objective was to convert the skeletal class II in Class I, reducing the convex profile and encouraging a significant mandibular advancement, rather than maxillary distalization, limiting the side effect of opening the nasolabial angle. To achieve these goals a transverse control of the upper arch (with dento-skeletal increase of maxillary diameter) and a vertical and sagittal control of the position of both the maxillary and mandibular incisors were required.

Treatment alternatives

In such adult skeletal class II patients, the first-choice option, which is able to totally correct the skeletal malocclusion, is the orthognathic surgery: bilateral osteotomy of the mandible (with possible extractions of two lower premolars) helps improve the facial aesthetic and correct the skeletal pattern. However, the patient refused this treatment option.

Another option is represented by camouflage with upper premolars extractions or upper distalization (with palatal or infrazygomatic TADs), even though limited effects on skeletal pattern are possible. Similarly, the use of class II elastics on fixed orthodontic appliances leads only to dental compensations and this approach is not recommended at the end of the growth.

Although the reduced residual growth (the patient was CVM5), the use of Herbst appliance anchored to four TADs in upper and lower arches (STM4) could represent an effective option to get some favourable skeletal outcomes and to limit adverse dental effects.

Treatment progress

Considering that microimplant-assisted rapid palatal expansion (MARPE) has been demonstrated successfully in maxillary expansion in late adolescence and adulthood [24], treatment started with a palatal expansion through Hyrax Rapid Palatal Expander anchored to two palatal miniscrews (placed in the T-zone [25,26]) and bands on upper first molars, so to improve the dento-skeletal transverse deficiency. Upper TADs were titanium, with length of 11 mm and diameter of 2 mm (Leone, Sesto Fiorentino Italy, TAD for expanders D2 L11 mm). They were inserted with a CBCT-guided workflow.

The activation protocol for maxillary expansion was 1 turn per day (0.2 mm each activation) until the planned expansion was completed. At the same time, the upper arch was bonded with

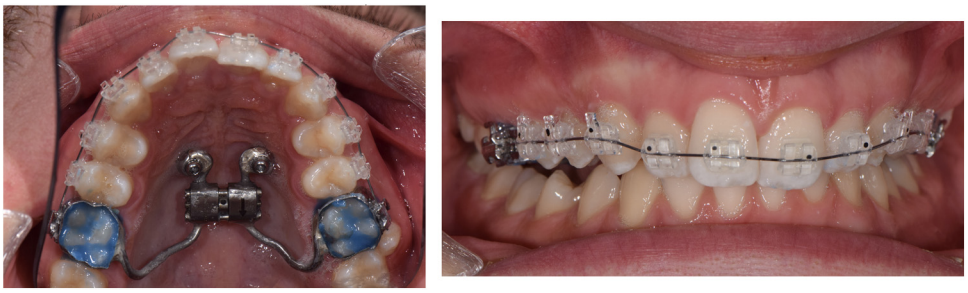

Figure 5

Miniscrew-Assisted-Rapid Palatal Expander and brackets in the upper arch

Figure 6

Manni Telescopic Herbst (MTH) appliance

Figure 7

Elastic chains connecting TADs to the arches to increase anchorage

pre-adjusted straight-wire ceramic brackets (0.022-inch slot size, MBT Prescription, American Orthodontics, Sheboygan, Wis) and a 014NiTi archwire was inserted to increase overbite and overjet with proclination and relative intrusion of upper incisors [27] (*figure 5*). Archwire sequence then included 16 × 22NiTi, 17 × 25NiTi. After two months, RPE appliance was replaced with a fixed palatal arch on upper first molars and a Manni Telescopic Herbst (MTH) was applied (*figure 6*).

To prevent the typical anchorage loss in the upper arch (distalization of upper molars and lingual tipping of the incisors), a second transpalatal arch was placed onto the same miniscrews used for the expansion and bilateral elastic chains (150/200 g for each side. Memory Chain, American Orthodontics, Sheboygan, Wis) were placed connecting the two palatal arches. Similarly in the mandible, after 15 days, auxiliary buttons were bonded on the buccal surface of the lower cuspids and two 1.4 mm × 8 mm TADs (Osstem, Seoul, Korea) were placed bilaterally between second premolar and first molar in the attached gingiva, with an insertion angle of 45°. Elastic chains (150/200 g for each side – Memory Chain; American Orthodontics, Sheboygan, Wis) were applied between the buttons and the lower miniscrews to limit the proclination of lower incisors [19] (*figure 7*). Both upper and lower chains were replaced every 4 weeks. Meanwhile an 18 × 25SS arch was inserted in the upper arch.

After 9 months of Herbst therapy, a new lateral ceph was taken (*figure 8*) and the MTH appliance was removed.

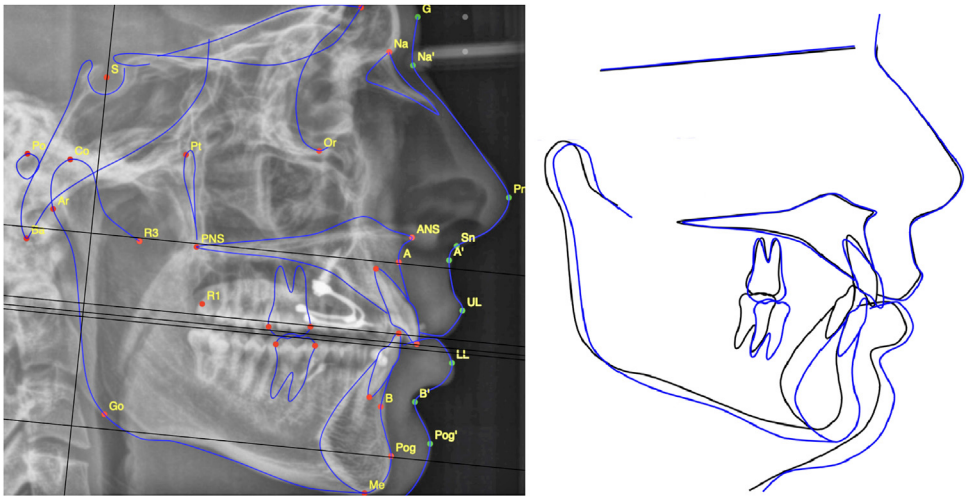

Figure 8

Lateral cephalogram at the end of Herbst phase and Pancherz's cephalometric superimposition (black: pretreatment; blue: end of Herbst

Figure 9

Occlusion stabilization after the Herbst

The lower arch was immediately bonded and the patient was instructed to use class 2 elastics of progressive strength (4.5 oz and 6 oz) to finalize a proper occlusion (*figure 9*). The small supernumerary germ was extracted during the treatment, even though, being in a buccal position, it did not interfere in any way with tooth movement.

Once the treatment was completed, brackets were removed and intraoral scans were taken to fabricate removable vacuum-formed retainers in both arches.

Treatment results

After the expansion and herbst phase the result was a proper skeletal class I, with considerable improvement of the profile and a clinically significant mandibular advancement with good control of both maxillary and mandibular incisors. After the multi-bracket phase, bilateral dental class I relationship with proper overbite and overjet was gained (*figures 10 and 11*).

No muscle or TMJ problems were reported. A panoramic radiograph, taken immediately before debonding, showed acceptable root angulation, no evidence of root resorption and stable bone levels (*figure 12*).

The final cephalometric analysis (according to Pancherz's analysis [28] and superimpositions [29]) showed an improvement of the sagittal jaw relationship (ANB angle reduced from 6,5° to 3°).

The A point remained almost stable [1.5 mm of difference between pre- (T0) and posttreatment (T2)] while a significant Pogonion advancement of 7 mm was registered at the end of the Herbst phase (T1) and after the orthodontic therapy (T2) (*figures 13 and 14*). Upper incisors slightly moved forward (1 mm) and their inclination varied from 106.5° to 105°. Lower

Figure 10

Posttreatment extraoral and intraoral photographs

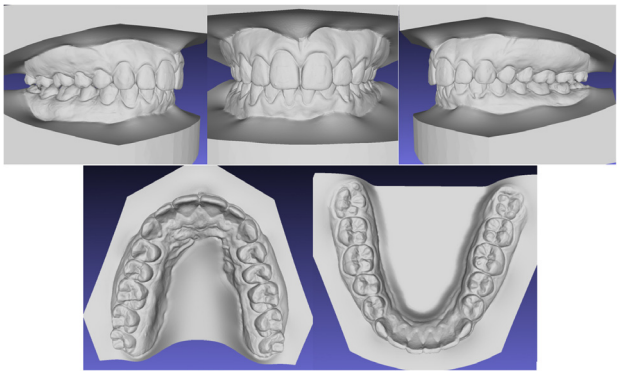

FIGURE 11
Posttreatment models

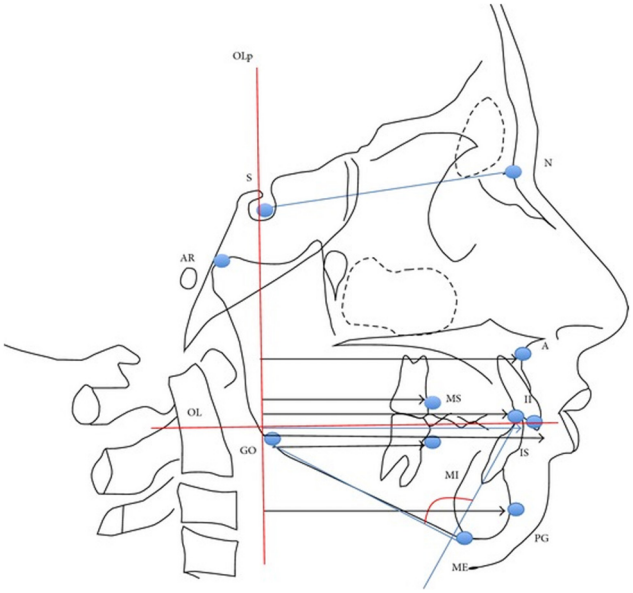

FIGURE 13
Pancherz analysis: measuring landmarks and distances

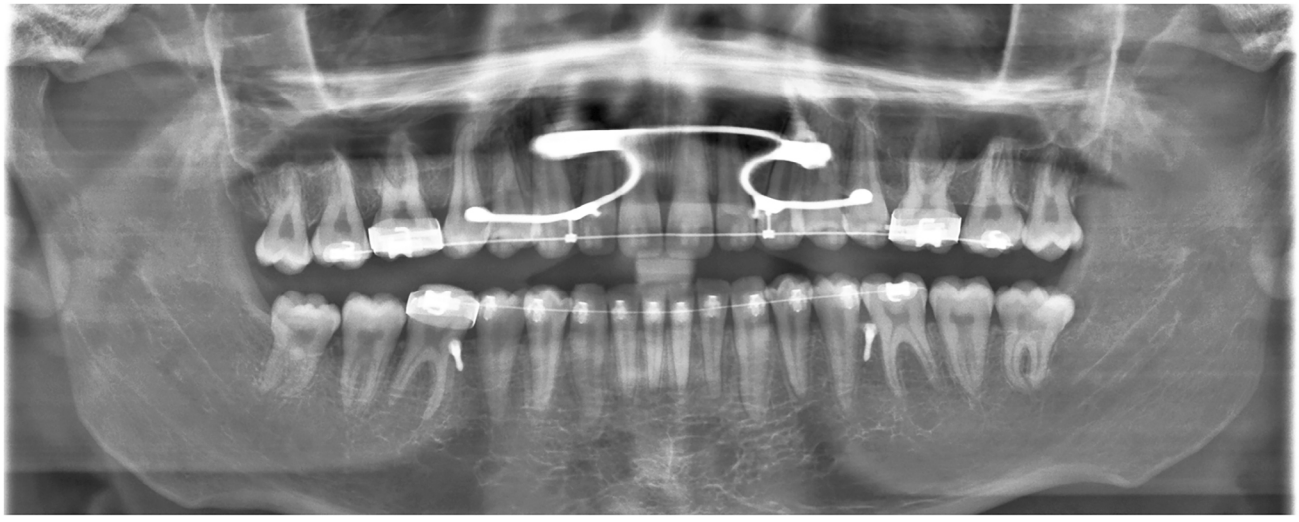

FIGURE 12
Final panoramic radiograph

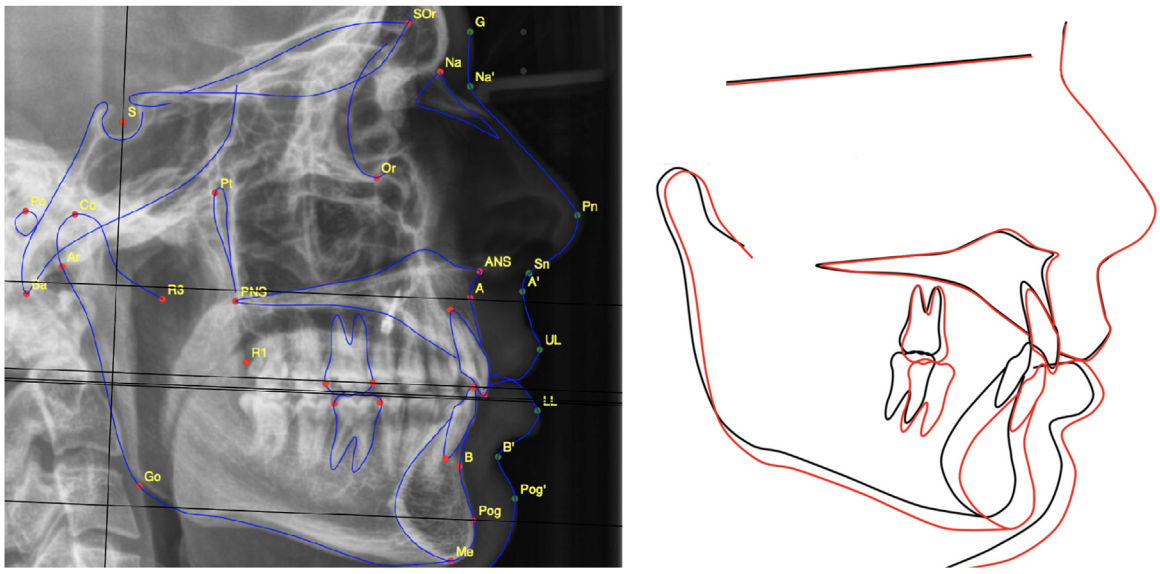

FIGURE 14

Posttreatment lateral cephalogram and Pancherz's cephalometric superimposition (black: pretreatment; red: posttreatment)

TABLE I

Dento-skeletal changes at T0 (pretreatment), T1 (after the Herbst phase), T2 (posttreatment), T3 (1-year follow-up). The head films were analyzed according to the method of Pancherz

	T0	T1	T2	T3
SNA°	87.5	87.5	88	87
SNB°	81	84.5	84	83.5
ANB°	6.5	3	3	3.5
SN/GoGn°	21	19	19	20
Is/PP°	106	116	105	109
Ii/GoGn°	100	101	101	102
A-OLP (mm)	89	90	90.5	90.5
Pg-OLP (mm)	87	94.5	94	94
Is-OLP (mm)	94	98	95	96
Ii-OLP (mm)	87	92.5	93	92.5
Ms-OLP (mm)	63.5	66.5	66	66.5
Mi-OLP (mm)	61	68	68	68
Overjet (mm)	7	4.5	2	3

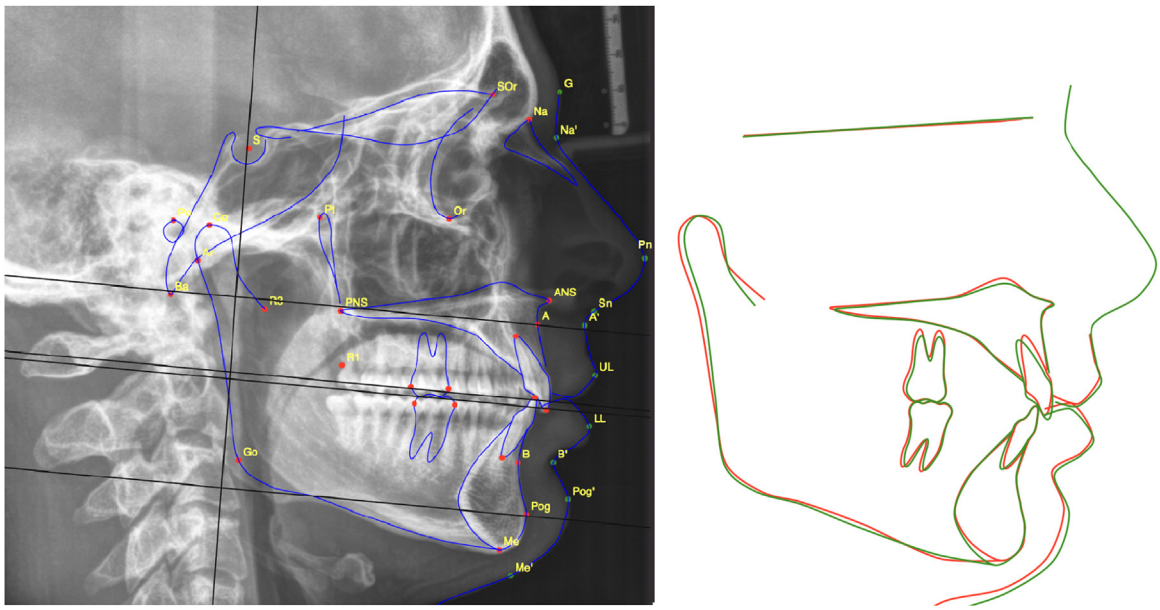

FIGURE 15

Follow-up lateral cephalogram and Pancherz's cephalometric superimposition (red: posttreatment; green: 1 year follow-up)

FIGURE 16

Extraoral and intraoral photographs after one year's follow-up

incisors were successfully controlled with limited change in their inclination (100° at T0, 101° at T2) and intrusion (*table I*).
After one year (T3), the result was stable with no signs of relapse (*figures 15 and 16*) (*table I*).

Discussion

The Herbst appliance is widely used to treat Class II malocclusion with retrusive mandible because of its efficacy and efficiency, without need of patient compliance. Despite its favourable, skeletal effects dental compensations (upper incisors retroclination, lower incisors proclination, upper molars distalization and lower molars mesialization) are often reported [7,8]. These can reduce the overjet required for mandibular advancement.
However, literature proved that these side effects could be partially controlled combining the use of Herbst appliance with temporary anchorage devices (TADs) and elastic chains [30,31].
In fact, in this patient the combination of lower TADs and elastic chains prevented labial tipping of lower incisors (T0 = 100°, T1 = 101°, T2 = 101°) and well controlled their sagittal position.
Similarly, the involvement of two palatal miniscrews provided a satisfactory control of upper incisors, even allowing their labial tipping during the whole Herbst phase (T0 = 106°, T1 = 116°). At the end of the treatment, despite a mild retroclination (T2 = 105°) attributable to the use of class 2 elastics, +1 mm of advancement was registered, without negative effects on the nasolabial angle. Moreover, point A remained almost stable comparing pre- and posttreatment values (+1.5 mm), while upper molars moved 2,5 mm forward. This kind of anchorage management in upper and lower arches, combined with good control of vertical dimension (SN/GoGn = −2° at T2), enabled a significant Pogonion advancement (+7 mm at T2).
To achieve such results elastic ligatures and the lower splint are essential.
The choice to connect miniscrews to teeth by means of power chains instead of stainless-steel ligatures wire has a biomechanical reason. Indeed, the TADs tend to slide towards the direction of traction [32] and a ligature wire could not fully prevent the migration of anchored teeth. Consequently, the reciprocal movement of molars and incisors in both arches, due to the Herbst appliance, might reduce the space available for mandibular advancement. On the contrary, an elastic power chain (changed every month), thanks to its elasticity, will produce on the anchored teeth a constant balancing traction directed towards the opposite side. The biomechanical result is no anterior anchorage loss.
Previous studies demonstrated the elastic chains to be more effective than metal ligatures in promoting a significant mandibular advancement with Herbst appliance [30].
In addition, the presence of a lower splint during the Herbst therapy can contribute to reduce the flaring of lower incisors [33,34]. In addition, it can stimulate the remodelling of the condyle-fossa complex by reciprocal retro-discal stretch forces [35] and better control the vertical dimension avoiding dental extrusion and promoting a counterclockwise rotation of the mandible [36].
This method of inserting the TADs in the upper and lower arches, in association with elastic chains and acrylic splint, could represent a good protocol in case of skeletal Class II malocclusion with mandibular retrusion while limiting the opening of nasolabial angle. In addition to establishing a good occlusal relationship, the achievement of aesthetically valid and relevant results (reduction of the profile convexity without opening of the nasolabial angle) should, in accordance with the soft tissue paradigm, be one of the main goals of orthodontic treatment. In fact, this approach might overcome the limits of traditional therapies (intermaxillary elastics with multi-bracket appliance, teeth extraction, distalization, etc.), which could only determine a dental camouflage of the malocclusion (proclination of lower incisors, retroclination of the upper ones, clockwise rotation of the occlusal and mandibular planes) with a small effect on the skeletal frame.
However, fixed functional appliances are generally indicated in growing patients before the pubertal peak [19,20]; later only orthognathic surgery could lead to the complete correction of the skeletal malocclusion, but this option is not always well accepted by the patient, as it happened in this case. On the contrary, the use of Herbst appliance anchored to 4 miniscrews (2 in the upper and two in the lower arch, STM4), providing a great control of dental compensations, might increase the skeletal and aesthetic outcome of the treatment after the pubertal peak. Moreover, since this technique avoids dental compensations, a possible surgical reintervention is facilitated [37] in case of failure.
On the other hand, the achievement of such a skeletal outcome in a subject with very low growth potential (CVM 5) might open new scenarios on the possibilities of orthopaedic correction in non-growing patients, however more studies are necessary to confirm this promising result. Moreover, it leads us to reconsider the role of the cervical vertebral maturation (CVM) method in the choice of the ideal timing for the treatment of skeletal class II with this appliance. In fact, it is possible, as already observed in previous studies, that this patient, despite the vertebral stage, still had a small residual growth potential with a sagittal mandibular repositioning that has been favoured by orthodontics [38,39].

Conclusions

In this case report, the treatment goal was fully achieved, getting a proper skeletal and dental class I, a clinically significant Pogonion advancement and an improvement of the profile, despite the patient had a very low growth potential (CVM5).
This result leads us to the following conclusions, which certainly need further studies to be confirmed:

- the STM4 method, presented in this case report, could represent an effective and efficient protocol to treat skeletal class II patients with mandibular retrusion, also after the pubertal peak;
- when a Miniscrew-Assisted-Rapid-Palatal-Expansion is required before the Herbst phase, two palatal miniscrews could be inserted and combined with mandibular buccal TADs to better control the incisors position and counteract the appliance side effects in both the arches;
- the presence of a mandibular splint and elastic power chains (anchoring TADs to the arches) enhance the skeletal effects of the Herbst Appliance.

Contribution: Antonio Manni: conceptualization, methodology, investigation. Andrea Boggio: data curation, writing – original draft preparation, formal analysis. Giorgio Gastaldi: supervision, validation, writing – review and editing. Mauro Cozzani: supervision, validation, writing – review & editing.

Disclosure of interest: The authors declare that they have no competing interest.

References

[1] Proffit WR, Fields HW, Larson B, Sarver DM. Contemporary orthodontics. Chapter 1. 6th ed. St. Louis, Missouri, USA: Elsevier Health sciences, Mosby; 2018 [744 p.].
[2] Cozza P, Baccetti T, Franchi L, De Toffol L, McNamara Jr JA. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. Am J Orthod Dentofacial Orthop 2006;129:599.
[3] LaHaye MB, Buschang PH, Alexander RG, Boley JC. Orthodontic treatment changes of chin position in Class II Division 1 patients. Am J Orthod Dentofacial Orthop 2006;130:732–41.
[4] Pancherz H, Zieber K, Hoyer B. Cephalometric characteristics of Class II division 1 and Class II division 2 malocclusions: a comparative study in children. Angle Orthod 1997;67 (2):111–20.
[5] Pancherz H. The Herbst appliance: its biologic effects and clinical use. Am J Orthod 1985;87:1–20.
[6] Pancherz H. Treatment of Class II malocclusions by jumping the bite with the Herbst appliance. A cephalometric investigation. Am J Orthod 1979;76:423–42.
[7] Weschler D, Pancherz H. Efficiency of three mandibul aranchorage forms in Herbst treatment: a cephalometric investigation. Angle Orthod 2005;75:23–7.
[8] Pancherz H, Hansen K. Mandibular anchorage in Herbst treatment. Eur J Orthod 1988;10:149–64.
[9] Franchi L, Baccetti T, McNamara Jr JA. Treatment and posttreatment effects of acrylic splint Herbst appliance therapy. Am J Orthod Dentofacial Orthop 1999;115:429–38.
[10] Flores-Mir C, Ayeh A, Goswani A, Charkhandeh S. Skeletal and dental changes in Class II Division 1 malocclusions treated with splint-type Herbst appliances. A systematic review. Angle Orthod 2007;77:376–81.
[11] Manni A, Cerruto C, Cozzani M. Herbst appliance supported by four miniscrews. J Clin Orthod 2019;53(12):737–44.
[12] Manni A, Cozzani M, Mazzotta L, Fiore VP, Mutinelli S. Acrylic splint Herbst and Hanks telescoping Herbst: a retrospective study. Int Orthod 2014;12(1):100–10.
[13] Manni A, Mutinelli S, Cerruto C, Giraudo P, Romano R, Cozzani M. Comparison of complications in the conventional telescopic Herbst rod and tube and Manni telescopic Herbst: a retrospective clinical study. Angle Orthod 2018;88(4):377–83.
[14] Al-Dboush R, Soltan R, Rao J, El-Bialy T. Skeletal and dental effects of Herbst appliance anchored with temporary anchorage devices: a systematic review with meta-analysis. Orthod Craniofac Res 2022;25(1):31–48.
[15] Duggal I, Sidhu MS, Chawla A, Dabas A, Dhimole VK. Effects of miniplate anchored Herbst appliance on skeletal, dental and masticatory structures of the craniomandibular apparatus: a finite element study. Int Orthod 2021;19(2):301–9.
[16] Huang Y, Sun W, Xiong X, Zhang Z, Liu J, Wang J. Effects of fixed functional appliances with temporary anchorage devices on Class II malocclusion: a systematic review and meta-analysis. J World Fed Orthod 2021;10(2):59–69.
[17] Manni A, Pasini M, Cozzani M. Comparison between Herbst appliances with or without miniscrew anchorage. Dent Res J (Isfahan) 2012;9(Suppl. 2):S216–21.
[18] Manni A, Migliorati M, Calzolari C, Silvestrini-Biavati A. Herbst appliance anchored to miniscrews in the upper and lower arches vs. standard Herbst: a pilot study. Am J Orthod Dentofacial Orthop 2019;156(5):617–25.
[19] Pavoni C, Lombardo EC, Lione R, Faltin Jr K, McNamara Jr JA, Cozza P, et al. Treatment timing for functional jaw orthopaedics followed by fixed appliances: a controlled long-term study. Eur J Orthod 2018;40 (4):430–6.
[20] Perinetti G, Primo□i□ J, Franchi L, Contardo L. Treatment effects of removable functional appliances in pre-pubertal and pubertal Class II patients: a systematic review and meta-analysis of controlled studies. PLoS One 2015;10(10):e0141198.
[21] Baccetti T, Franchi L, McNamara Jr JA. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod 2005;11(3):119–29.
[22] Ruf S, Pancherz H. Dentoskeletal effects and facial profile changes in young adults treated with the Herbst appliance. Angle Orthodt 1999;69(3):239–46.
[23] Cançado RH, Janson G, Tompson B, Alvares JCC, Valarelli FP, Freitas KMS. Treatment effects of the Herbst appliance in Class II malocclusion patients after the growth peak. Eur J Dent 2021;15(1):39–46.
[24] Brunetto DP, Sant'Anna EF, Machado AW, Moon W. Non-surgical treatment of transverse deficiency in adults using Microimplant-assisted Rapid Palatal Expansion (MARPE). Dental Press J Orthod 2017;22(1): 110–25.
[25] Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative CBCT evaluation of palatal bone thickness for orthodontic miniscrew placement. Am J Orthod Dentofacial Orthop 2008;134(3):361–9.
[26] Wilmes B, Ludwig B, Vasudavan S, Nienkemper M, Drescher D. The T-Zone: median vs. paramedian insertion of palatal mini-implants. J Clin Orthod 2016;50(9):543–51.
[27] Manni A, Mutinelli S, Cerruto C, Cozzani M. Influence of incisor position control on the mandibular response in growing patients with skeletal Class II malocclusion. Am J Orthod Dentofacial Orthop 2021;159(5):594–603.
[28] You QL, Hägg U. A comparison of three cephalometric analysis on the evaluation of orthodontic treatment. Shanghai Kou Qiang Yi Xue 2002;11(2):97–100.
[29] Pancherz H. The mechanism of Class II correction in Herbst appliance treatment: a cephalometric investigation. Am J Orthod Dentofacial Orthop 1982;82:104–13.
[30] Manni A, Mutinelli S, Pasini M, Mazzotta L, Cozzani M. Herbst appliance anchored to miniscrews with 2 types of ligation: effectiveness in skeletal Class II treatment. Am J Orthod Dentofacial Orthop 2016;149(6):871–80.
[31] Von Bremen J, Ludwig B, Ruf S. Anchorage loss due to Herbst mechanics-preventable through miniscrews? Eur J Orthod 2014;37:462–6.

[32] Fritz U, Diedrich P, Kinzinger G, Al-Said M. The anchorage quality of mini-implants towards translatory and extrusive forces. J Orofac Orthop 2003;64:293–304.
[33] Bock N, Pancherz H. Herbst treatment of Class II division 1 malocclusions in retrognathic and prognathic facial types. Angle Orthod 2006;76:930–41.
[34] Howe RP. The bonded Herbst appliance. J Clin Orthod 1982;16:663–7.
[35] Voudouris JC, Woodside DG, Altuna G, Angelopoulos G, Bourque PJ, et al. Condyle-fossa modifications and muscle interactions during Herbst treatment. Part 2. Results and conclusions. Am J Orthod Dentofacial Orthop 2003;124:13–29.
[36] Schiavoni R, Grenga V. Management of the Herbst splint appliance in Class II malocclusion with different growth pattern. Prog Orthod 2009;10(1):48–57.
[37] Burk SM, Charipova K, Orra S, Harbour PW, Mishu MD, Baker SB. A surgeon's perspective on the uncorrected skeletal deformity. Part II: the role of esthetic surgery for orthognathic camouflage. Am J Orthod Dentofacial Orthop 2022;161(6):878–85.
[38] Perinetti G, Primozic J, Sharma B, Cioffi I, Contardo L. Cervical vertebral maturation method and mandibular growth peak: a longitudinal study of diagnostic reliability. Eur J Orthod 2018;40(6):666–72.
[39] Perinetti G, Braga C, Contardo L, Primozic J. Cervical vertebral maturation: are postpubertal stages attained in all subjects? Am J Orthod Dentofacial Orthop 2020;157(3):305–12.