International Orthodontics 2026; 24: 101113

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Case Report

Anchorage control with mandibular miniscrews in an adult severe high-angle Class II case treated by preadjusted lingual appliance, premolar extractions and orthognathic surgery

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Keywords
Class II
Anchorage
High-angle
Lingual
Orthodontic Appliance design
Orthognathic surgery

Summary

This case report describes a complex full-step Class II high-angle case in an adult patient treated with lingual straight-wire appliance, premolar extractions and orthognathic surgery. With the twofold aim of obtaining ideal occlusal relationship and aesthetic improvement, surgical treatment with appropriate biomechanical strategies, including anchorage control during extraction space closure, are needed to achieve the planned results. This case report demonstrates the possibility of solving successfully severe sagittal, transverse and vertical discrepancies in an adult patient with surgical treatment by means of a completely invisible technique. This report also underlines the need for precise biomechanical control, including set-up overcorrections and miniscrews to manage anchorage control, in cases of extraction in lingual orthodontics. A refinement with composite reconstructions was performed at the end to obtain the best aesthetic and functional result.

Introduction

Skeletal Class II high-angle cases with severely retrognathic mandible, full-step canine and molar Class II relationship and excessive overjet are among the most complex and difficult malocclusions to treat [1]. Treatment strategies depend on the amount of tridimensional discrepancies, facial appearance, airway, and patient chief complaint [2].

When sagittal and vertical discrepancies are extremely severe and orthognathic surgery is the only viable option, the treatment management is however challenging and the stability is critical. Several studies suggested that incidence of condylar

10.1016/j.ortho.2025.101113
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resorption is 20%–30% for patients with Class II high-angle [3–8], while Scheerlink et al. [9] demonstrated that orthognathic surgery of 10 mm of mandibular advancement can lead to condylar resorption in 67% of cases owing to increased mechanical stress to the TMJ.

During orthodontic preparation it is very important to normalize upper and lower incisor inclination, in order to establish the exact amount of surgical movements. Quast et al. reported that incisor decompensation is often insufficient in all three dimensions [10]. Martinez et al. reported that in 52% of surgical cases, the upper and lower incisor decompensation did not reach ideal values, hindering the achievement of complete skeletal correction [11]. Seker et al. attributed insufficient incisor decompensation in the sagittal dimension to a lack of premolar extractions [12].

Presurgical decompensation of the mandibular arch requiring premolar extractions in lingual orthodontics of Class II surgical patients can evidence the opposite problem. It must be managed properly in order not to be excessive, due to the high tendency of incisors retroclination [13].

This case report presents the orthodontic–orthognathic management of a severe skeletal Class II patient with a retruded mandible, hyperdivergent facial pattern, full-step Class II relationship and excessive overjet. The treatment involved orthodontic decompensation with fixed lingual appliances and miniscrews in the lower arch, in combination with maxillo-mandibular advancement, maxillary impaction, correction of asymmetry, transverse maxillary expansion and genioplasty. In the end, composite reconstructions were performed in order to obtain the best result.

Diagnosis and aetiology

A 20-year-old female presented with the request to have her teeth aligned by means of an esthetic appliance. From a frontal perspective, the face presented an increased lower third with a marked lip incompetence, a slight gummy smile with asymmetrical exposition and bilateral buccal corridors, a mandibular symphysis deviation toward the right side and divergent mandibular angles (*figure 1*). The patient exhibited a convex profile, a proportioned nose, an acute nasolabial angle, a marked labiomental sulcus, a severely retrusive lower jaw and a severe mentalis strain on lip closure (*figure 2*). In her medical history, significant snoring was reported at night.

The midlines were not coincident, with the lower deviated towards the right side (*figure 3*); negative torque of the buccal and posterior segments was evident in both arches, along with

FIGURE 1

Initial frontal, lateral and submental extraoral photographs

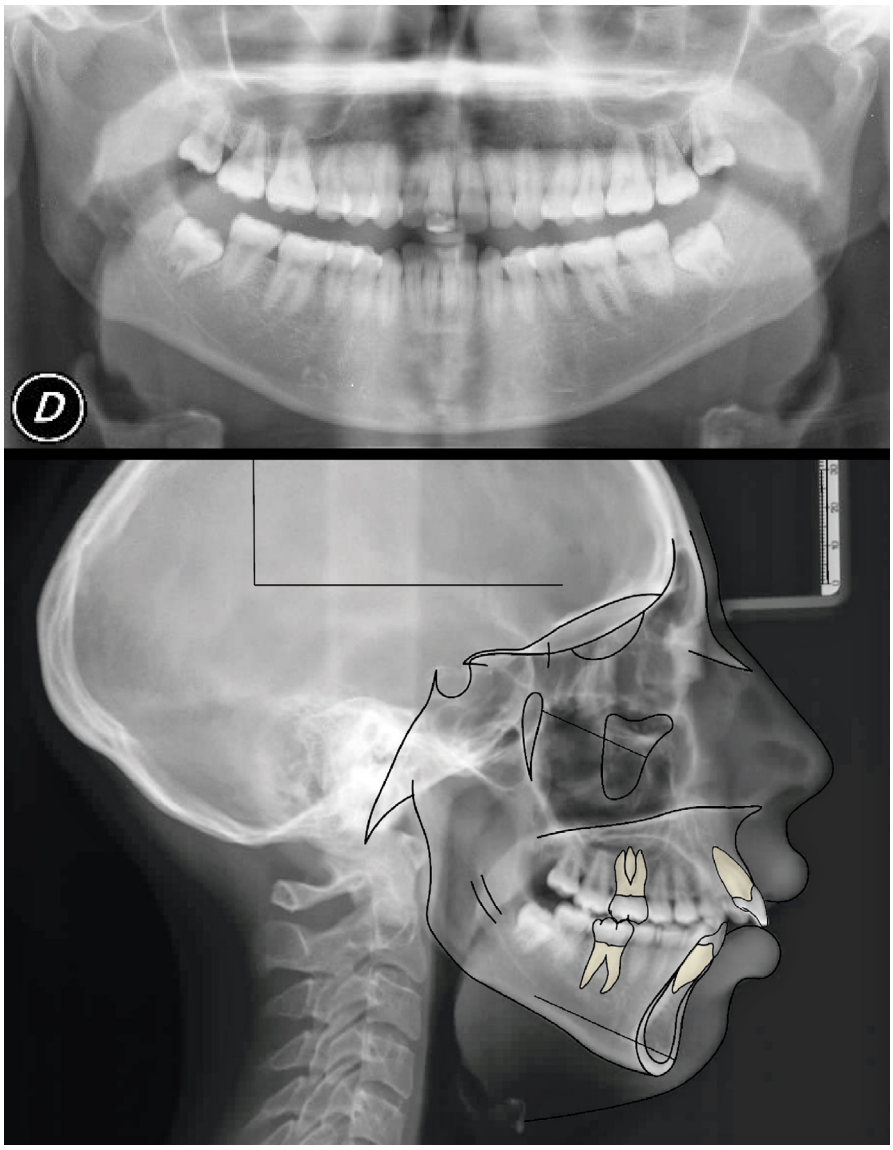

FIGURE 2

Initial radiographs (orthopantomography, lateral x-rays) and cephalometric analysis

an accentuated lower curve of Spee. The patient had bilateral full-step Class II canine and molar relationships, with constricted upper and lower arches. The lower lateral incisors were lingually displaced. The patient had an excessive overjet of 7.3 mm and an overbite of 0.9 mm. There were some anterior spaces in the upper arch and mild crowding with an arch-length discrepancy of 3.6 mm in the lower arch.

The periodontal biotype was thin (*figure 3*).

The panoramic radiograph showed the presence of all teeth, including the third molars. Cephalometric values pointed out a skeletal Class II relationship (ANB = 9°) with both the maxilla (SNA = 83°) and mandible (SNB = 74°) in retruded positions (*figure 2*; *table I*). The skeletal pattern was hyperdivergent (SN/MP = 43°), with a slightly counterclockwise-oriented occlusal plane. The upper incisors were proclined (U1/PP = 117°), while the lower incisors were normally inclined (L1/MP = 95°). There was no muscle pain, TMJ problems or discrepancy in condylar position between centric relation (CR) and centric occlusion (CO). The jaw-opening and jaw-closing movements were symmetrical and within normal limits.

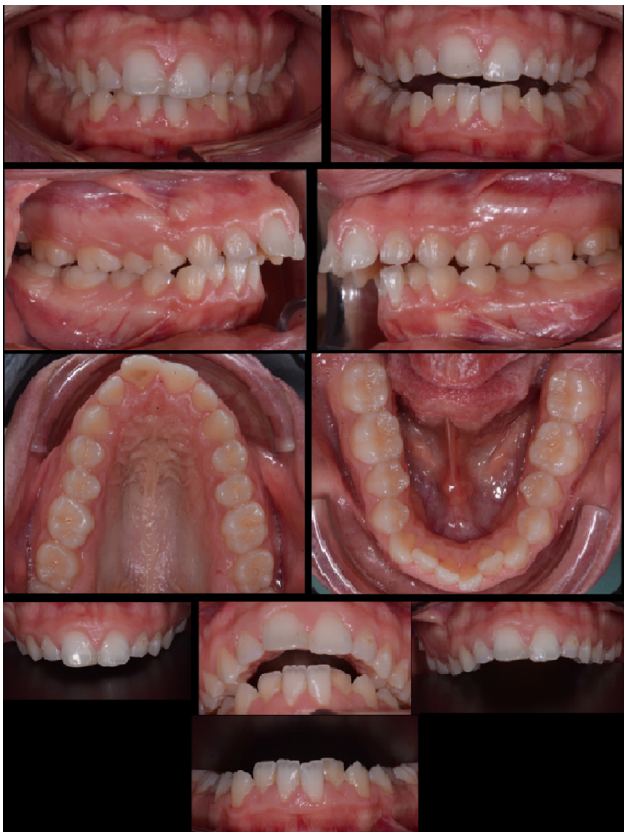

FIGURE 3
Initial intraoral photographs

Treatment objectives

The primary objectives were profile improvement by orthognathic surgery, dental Class II correction and vertical control. Additional goals were crowding correction, reduction of black buccal corridors during smile, ideal overjet and overbite achievement and aesthetic improvement at smile.

Treatment alternatives

Considering the patient's convex profile, the vertical excess and the severe mandibular retrusion, an orthodontic camouflage treatment with four premolar extractions would have adversely affected her facial balance.

Surgical orthodontic treatment including maxillo-mandibular advancement, maxillary impaction, correction of asymmetry, transverse maxillary expansion and genioplasty was recommended as the only possible solution. The upper- and lower-second premolars would be extracted to prepare the patient for the surgical correction.

Avoiding extractions in the lower arch could have determined an excessive lower incisor proclination as a consequence of crowding resolution and levelling, thus preventing the appropriate surgical advancement.

Treatment progress

Since the patient had asked for aesthetic treatment, a lingual appliance was used. The lingual biomechanics would avoid lower incisor proclination during levelling, as a result of the intrusion force passing closer to the lower incisors' centre of resistance [13].

Extraction tip and torque overcorrections were included in the manual set-up prescriptions for the preadjusted Ormco Stb™ brackets (*figure 4*). A slight canine Class II relationship was

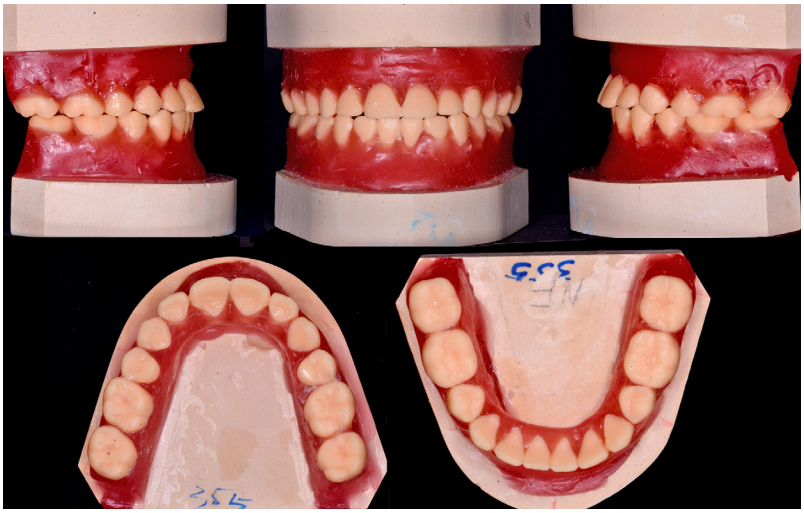

FIGURE 4
Manual set-up

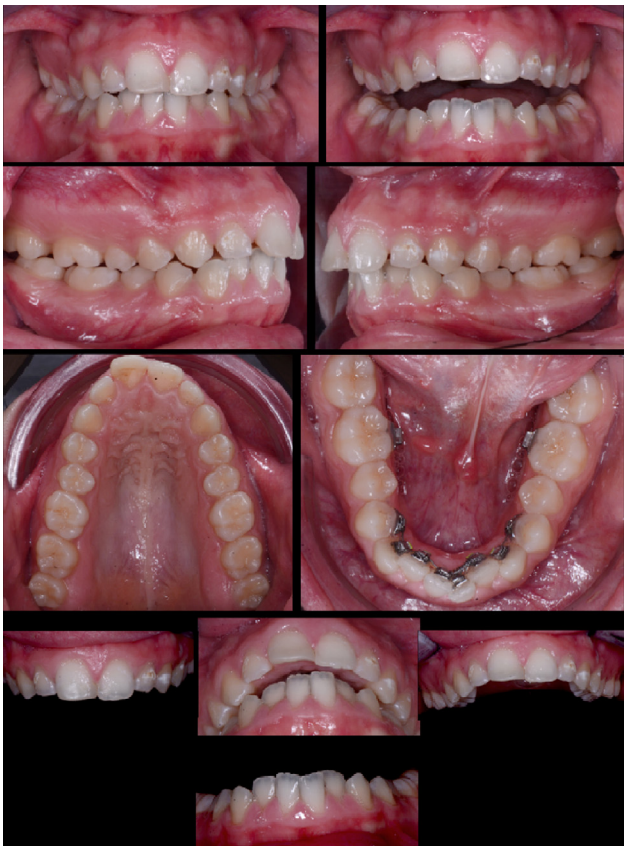

Figure 5

Lower arch bonding. Insertion of 0.013 CuNiTi LSW Small on lower arch. Insertion of open coil springs between the lower right central incisor and the lower left lateral incisor

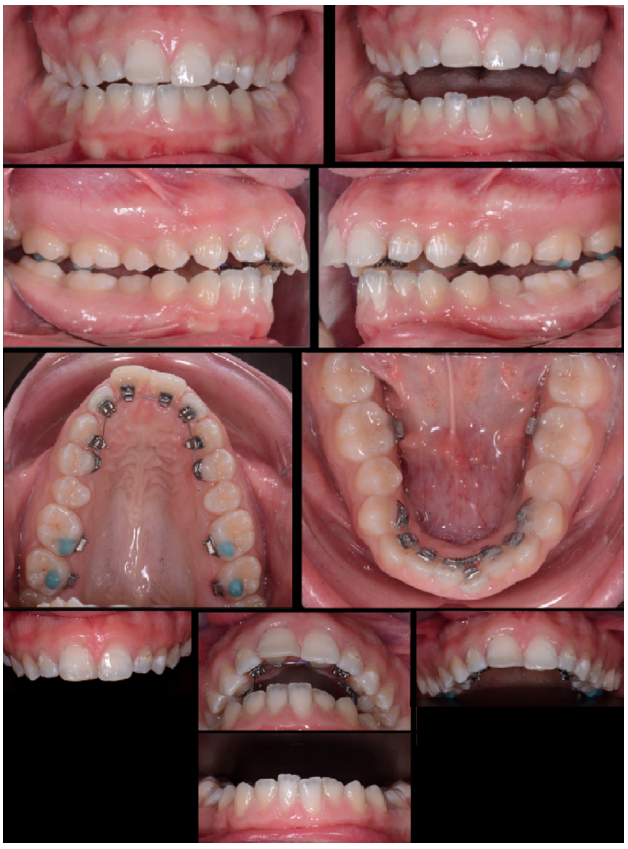

Figure 6

Upper arch bonding. Insertion of 0.013 CuNiTi LSW Small on upper arch. Insertion of build-ups on upper first and second molars. Bonding of provisional brackets on upper lateral incisors with the wire ligated gingivally. Reactivation of open-coil springs between the lower right central and left lateral incisor

recorded in the set-up on the right side with a minimal anterior midline discrepancy.

Due to the old composite restoration on the upper right central incisor and the demineralisation of the upper lateral incisors, composite reconstructions on the upper right central incisor and lateral incisors were planned with the patient for the end of treatment.

Indirect bonding was carried out with single jigs, according to the Komori KommonBase™ technique [14].

Lower arch was first performed, with the insertion of a 0.013 Copper NiTi LSW Small wire and an open-coil spring between the lower right central incisor and the lower left lateral incisor (*figure 5*).

One month later the upper arch was bonded and the same size of Stb™ archwire was placed (*figure 6*). Occlusal build-ups were added on the upper first and second molars to obtain a tripodic contact. Provisional brackets were bonded on the upper lateral incisors due to the reduced height of the crown in order to create the necessary space for the Stb™ bracket, ligating the wire in the gingival position, in order to promote their extrusion. The open-coil spring between the lower right central and left lateral incisor was reactivated.

Six months after the start of treatment, after lateral incisor Stb™ brackets bonding, the upper wire was changed to a Medium 0.018*0.018 Copper NiTi for levelling and torque establishment; in the lower arch, after space creation, bracket on the lower left central incisor was ligated (*figure 7*).

Following a period of seven months, after the extractions of upper second premolars, a 0.018*0.018 stainless steel upper archwire was inserted, with the addition of root-palatal torque from the upper right to the upper left lateral incisor; slight super-Spee and transverse antibowing compensation curves were added. A closed elastomeric chain was inserted between the upper second molars to start spaces closure. A Small 0.018*0.018 Copper NiTi was inserted in the lower arch for leveling and torque establishment (*figure 8*).

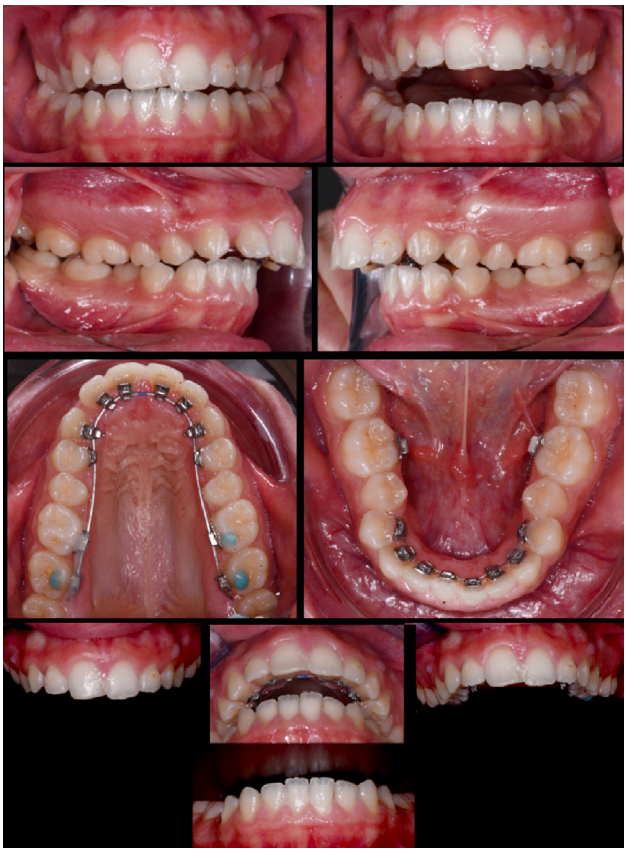

FIGURE 7

Insertion of a Medium 0.018*0.018 CuNiTi in upper arch. Ligation of Stb bracket on lower left central incisor. A closed elastomeric chain was inserted between the upper second molars to start space closure. Insertion of a Small 0.018*0.018 CuNiTi for levelling and torque establishment in the lower arch

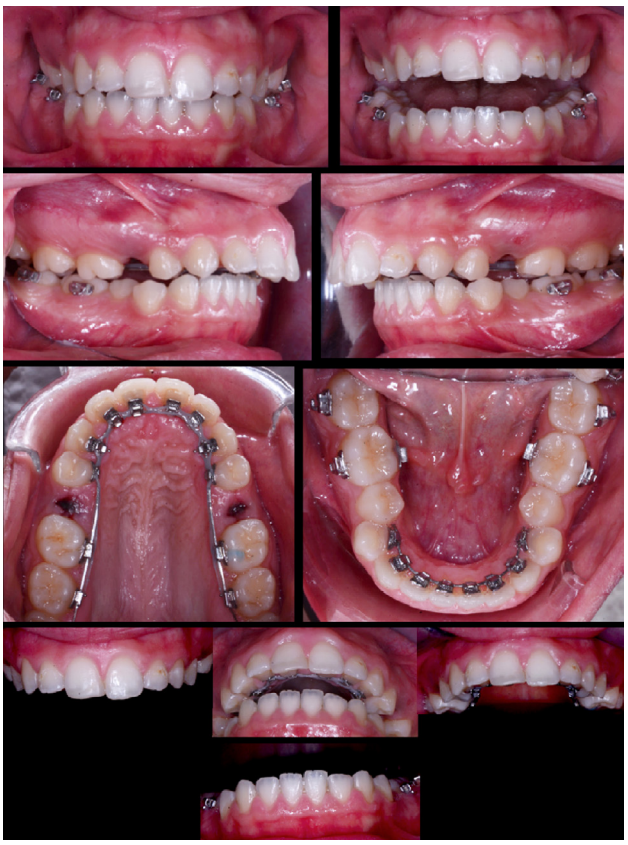

FIGURE 8

Insertion of a 0.018*0.018 stainless steel upper archwire, with the addition of root-palatal torque from upper right to upper left lateral incisor, super-Spee and transverse antibowing compensation curves. Insertion of a closed elastomeric chain between the upper second molars. Insertion of a Small 0.018*0.018 CuNiTi lower archwire

Four months later, after the extraction of the lower second premolars, a 0.018*0.018 stainless steel lower archwire was inserted. Buccal inter-radicular miniscrews were inserted on either side. Tubes on the lower first and second molars were bonded on buccal side, since the lingual surface of lower second molars was too small for lingual tubes positioning. 0.0175*0.0175 TMA with power arms were then inserted for molar protraction. Closed elastomeric chains were inserted between the upper second molars and lower first molars in order to achieve space closure. An auxiliary 0.016 SS spring was modelled and inserted for increasing upper central incisors palatal root-torque (*figure 9*).

Twenty-two months after treatment start, the auxiliary 0.016 SS spring was modified and reinserted for increasing upper left central incisor palatal root-torque, in order to correct the marginal height difference of the central incisors. Upper and lower closed elastomeric chains were substituted to continue space closure (*figure 10*).

One month later the auxiliary 0.016 SS spring was modified and reinserted for increasing upper left lateral incisor palatal root-torque, in order to correct the marginal height difference of the lateral incisors. Upper and lower closed elastomeric chains were substituted in order to continue space closure (*figure 11*).

After twenty-four months of treatment (one week before surgery), buccal buttons were bonded on the upper and lower canines and upper first premolars as attachments for postsurgical intermaxillary elastics (*figure 12*). Upper incisor lingual brackets were removed at the surgeon's request, in order to avoid any pre-contacts during the surgery. Two 0.0175*0.0175 TMA sectionals were inserted from canines to second molars.

The presurgical panoramic radiograph confirmed that root parallelism had been achieved. Cephalometric values evidenced a decrease in upper incisor torque from 118° to 110°, while lower incisor torque change was ideal (from 95° to 88°) for the sagittal mandibular advancement (*figure 13*; *table I*).

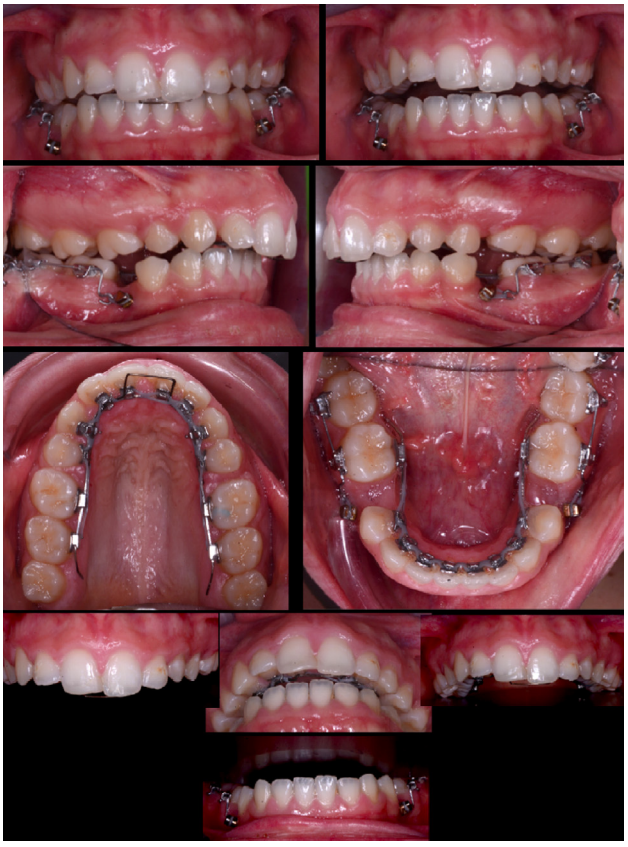

Figure 9

Insertion of a 0.018*0.018 stainless steel lower archwire. Insertion of inter-radicular miniscrews on either side. Bonding of buccal tubes on lower first and second molars. Insertion of 0.0175*0.0175 TMA sectionals with power arms. Insertion of closed elastomeric chains between upper second molars and lower first molars in order to obtain spaces closure. Modeling and insertion of an auxiliary 0.016 SS spring on upper central incisors

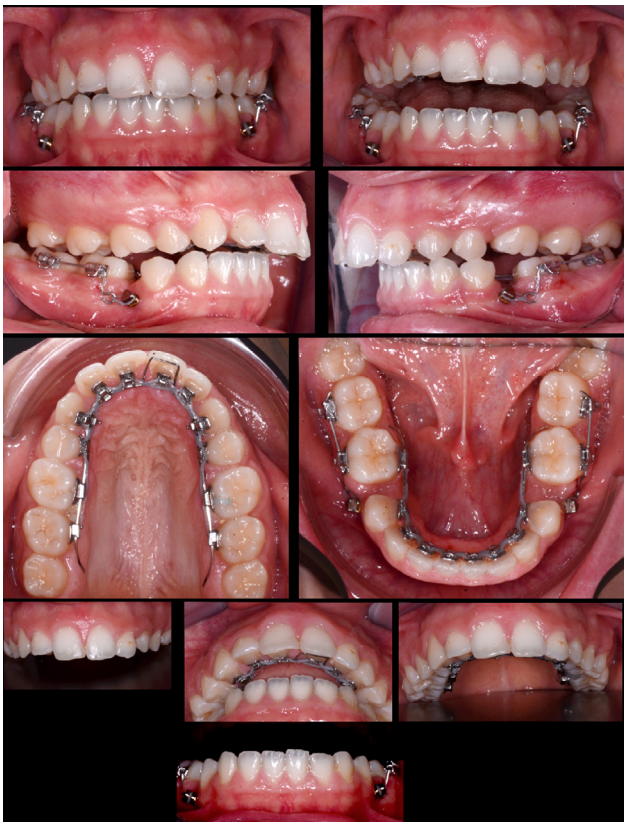

Figure 10

Modification and insertion of the auxiliary 0.016 SS spring on upper left central incisor. Substitution of upper and lower closed elastomeric chains

Maxillo-mandibular advancement was planned to improve the profile (with the addition of a genioplasty), posterior maxillary expansion and asymmetric maxillary impaction to improve the hyperdivergent pattern (*figure 14*). In addition, the correction of the maxillomandibular asymmetry was planned.

The maxillofacial surgery was performed after twenty-five months of orthodontic treatment. Three weeks later bilateral intercuspidation 3/16 6oz elastics were prescribed full-time with the aim of improving the obtained occlusion (*figure 15*). After two months, following upper incisor rebonding, a 0.013 CuNiTi Medium wire was inserted in the upper arch in order to align the anterior teeth and ligated as far as the first premolars, maintaining bilateral 0.0175*0.0175 TMA sectionals from the canines to the second molars (*figure 16*). Lower closed elastomeric chain and power arms were reactivated to continue space closure.

Following a period of two months, lower miniscrews were removed and inserted in the palate in inter-radicular position in order to complete Class II correction: a closed elastomeric chain was inserted from miniscrew to miniscrew passing from upper canines and incisors. 3/16'' 6 oz Class II elastics were prescribed on left side full-time. The auxiliary 0.016 SS spring was modified and reinserted for increasing upper left central incisor palatal root-torque, to correct the height discrepancy of the central incisors's marginal height, along with the insertion of the main 0.018*0.018 CuNiTi Medium wire. The lower second molars were directly bonded on the lingual side, while the lower third molars were bonded on the buccal side, with the insertion of a 0.019*0.025 NiTi sectional wire (*figure 17*).

Two months later the auxiliary wire was removed and upper and lower 0.0175*0.0175 TMA archwires were inserted in order to perform some finishing bends both in upper and lower arches. After third molars direct lingual bonding a closed elastomeric chain was inserted between the lower third molars to maintain

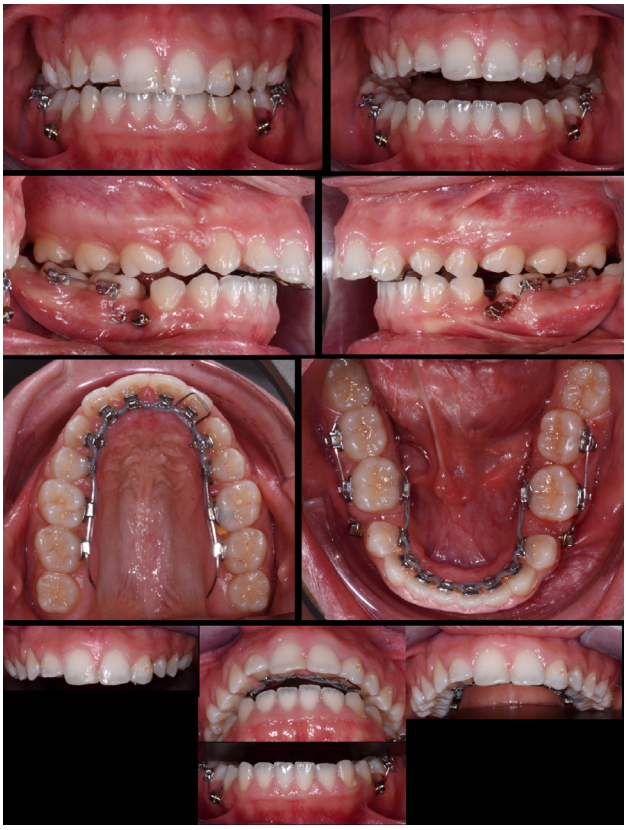

FIGURE 11

Modification and insertion of the auxiliary 0.016 SS spring on upper left lateral incisor. Substitution of upper and lower closed elastomeric chains

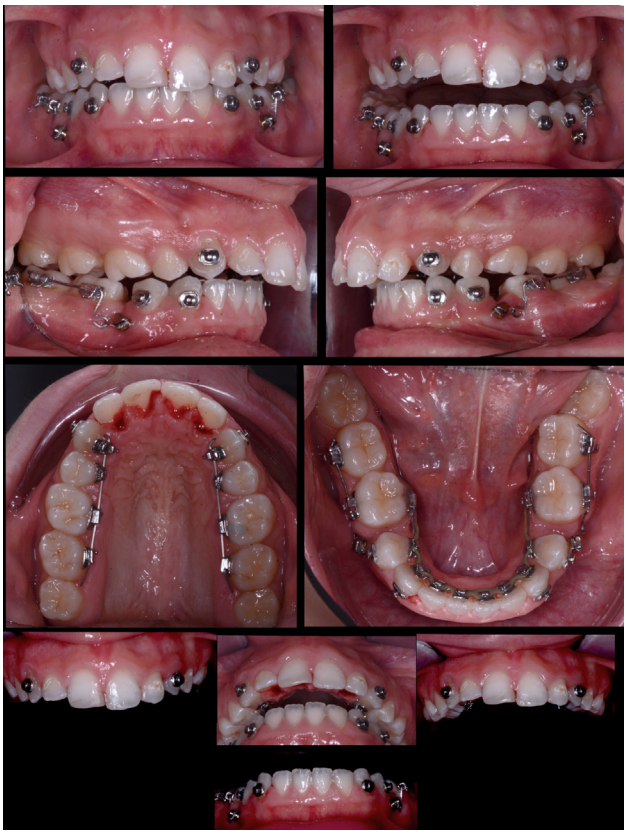

FIGURE 12

Bonding of buccal buttons were bonded on upper and lower canines and upper first premolars. Removal of upper incisors lingual brackets

space closure and correct lower posterior teeth rotations (*figure 18*).

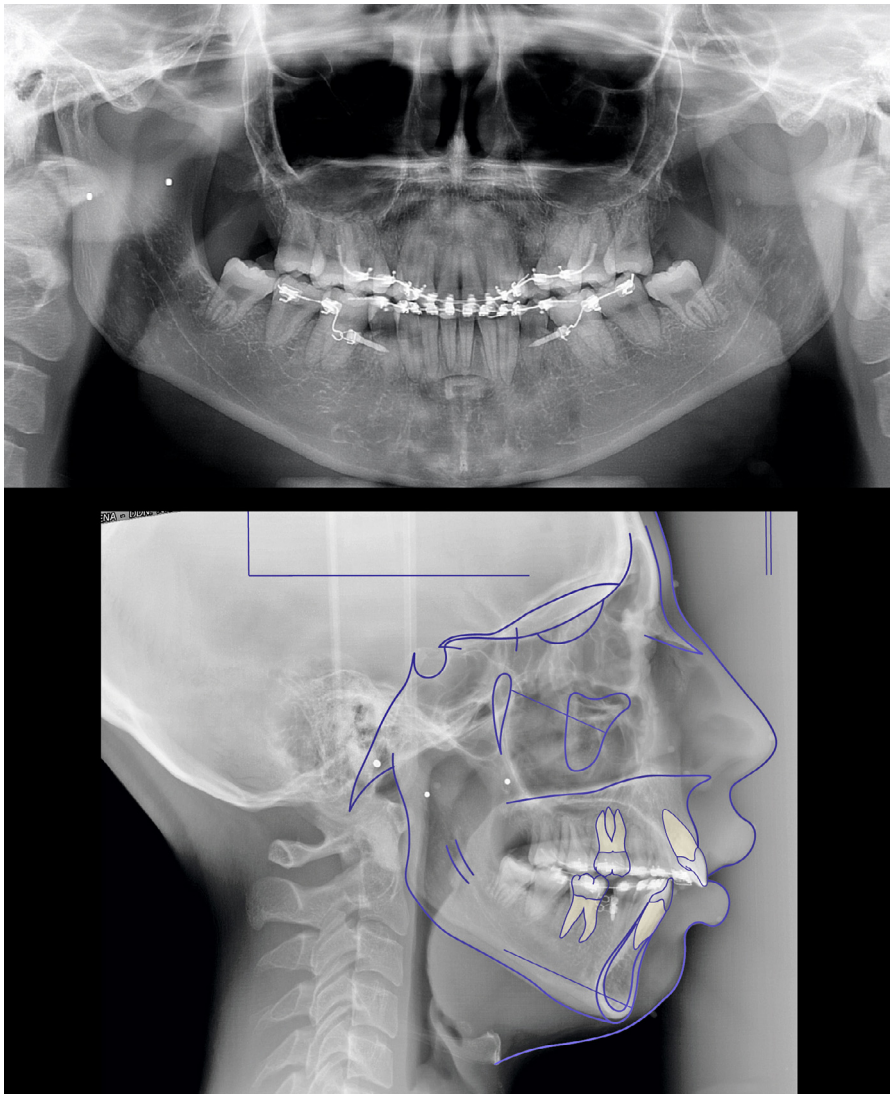

FIGURE 13

Progress pre-surgery radiographs (orthopantomography, lateral x-rays) and cephalometric analysis

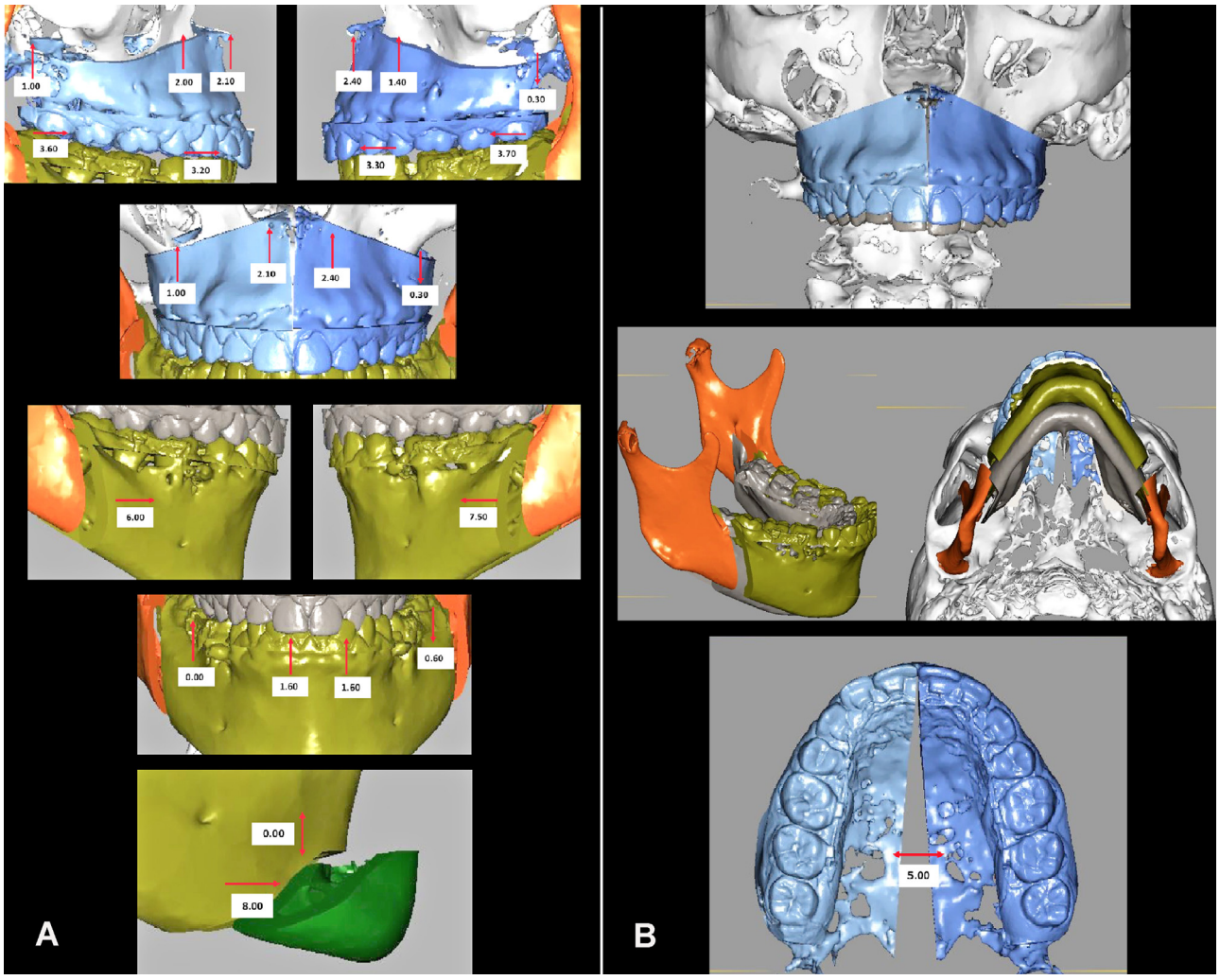

FIGURE 14

Surgical planning of sagittal, transverse and vertical movements. A. Sagittal, vertical and genioplasty quantification. B. Transverse quantification and 3D maxillomandibular visualisation

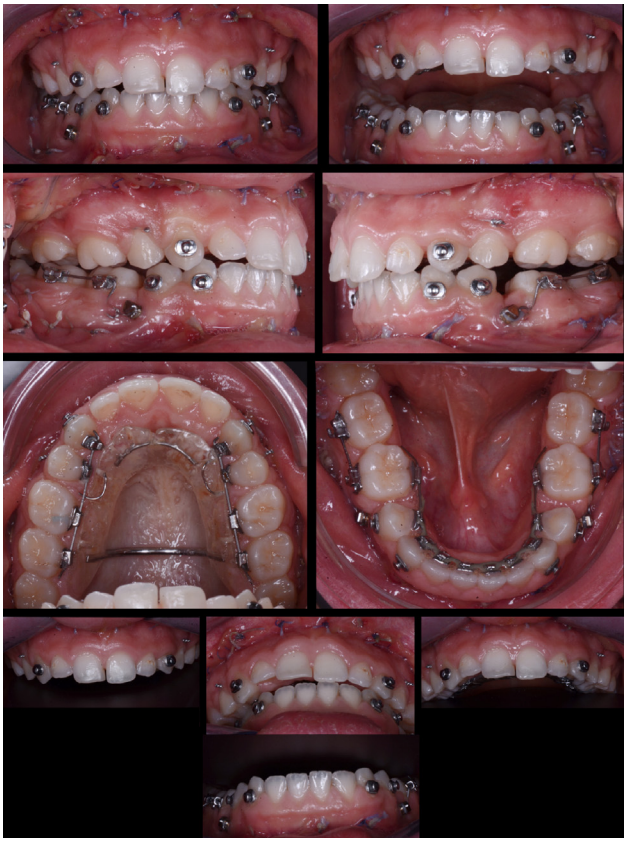

Figure 15

3/16 6oz elastics were prescribed full-time in order to improve the obtained occlusion

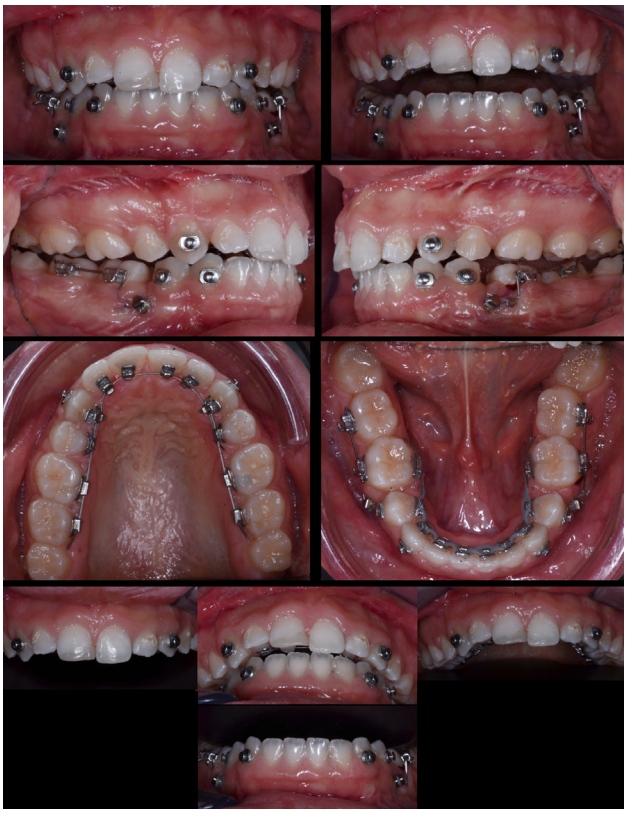

Figure 16

Rebonding of upper central and lateral incisors. Insertion of a 0.013 CuNiTi Medium wire in the upper arch until first premolars, maintaining bilaterally from canines to second molars the 0.0175*0.0175 TMA sectionals. Insertion of upper and lower closed elastomeric chains. Reactivation of power arms

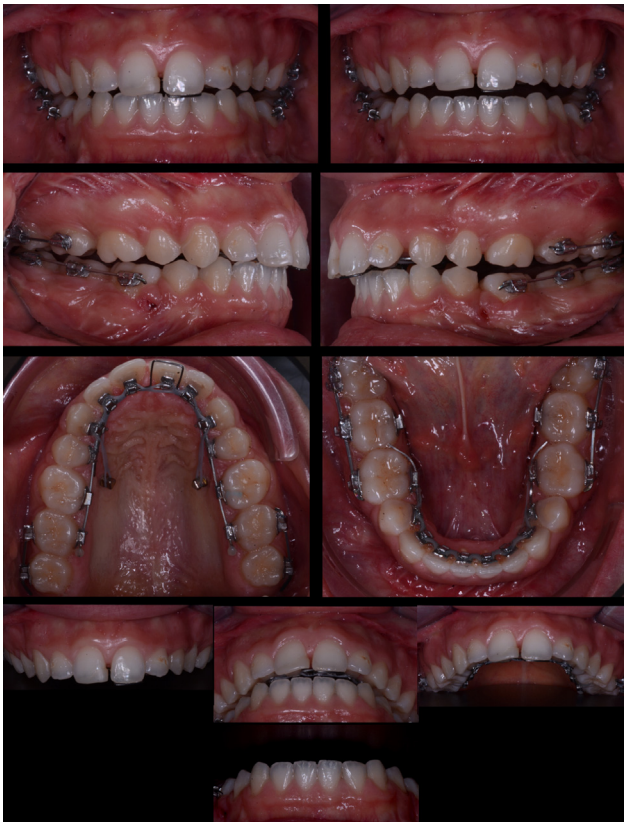

Figure 17

Removal of lower miniscrews and insertion in the palate in inter-radicular position. Modification and insertion of the auxiliary 0.016 SS spring on upper left central incisor, along with the insertion of the main 0.018*0.018 CuNiTi Medium wire. Insertion of a closed elastomeric chain from miniscrew to miniscrew passing from upper canines and incisors. Direct bonding of lower second molars on lingual side and of lower third molars on buccal side. Insertion of a 0.019*0.025 NiTi buccal sectional wire on lower posterior teeth 3/16" 6 oz Class II elastics prescribed on left side full-time.

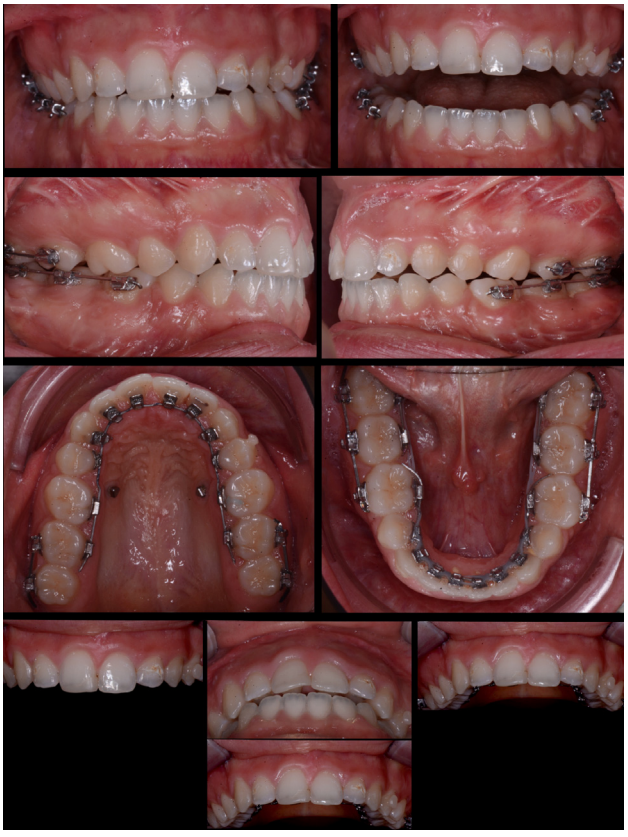

Figure 18

Removal of the auxiliary wire. Insertion of upper and lower 0.0175*0.0175 TMA archwires. Finishing bends both in upper and lower arches. Direct third molars lingual bonding. Insertion of a closed elastomeric chain between the lower third molars

Treatment results

Fixed appliances were removed 36 months after the start of treatment (*figure 19*) and upper and lower essix retainers were delivered.

A solid Class I canine and molar relationship was obtained on both sides, while overjet and overbite were corrected, the lower curve of Spee was flattened, and ideally minimal upper and lower curves of Wilson were attained. The resulting light contact was ideal.

Facial balance was achieved by means of the improved maxillo-mandibular projection; a pleasant smile arc and harmonious profile were evident, and the asymmetry was corrected (*figure 20*). Midline coincidence was achieved and the occlusal plane cant was corrected.

Upper composite reconstructions were performed on the upper right central incisor and lateral incisors, in order to obtain the best aesthetic and functional result (*figures 21 and 22*)

The final orthopantomography showed the root parallelism with moderate signs of root resorption, in particular affecting lower incisors. No signs of bone resorption were evidenced. Cephalometric analysis showed that the upper incisor torque had reduced to 102°, and the lower incisor inclination was normal (94°), (*figure 23*, *table I*). The Ricketts E-line [15] and Merrifield Z-line [16] were congruent, substantiating the surgical treatment decision. Superimposition of pre- and post-treatment cephalometric tracings carried out according to the methodology described in the image captions, as developed by Björk and Skieller [17,18] shows that the correction was obtained by surgical movements, in particular by mandibular advancement (*figure 23*). Upper incisors were slightly retroclined as a consequence of the premolar extractions, while the lower incisors were correctly inclined. A good light contact had been achieved.

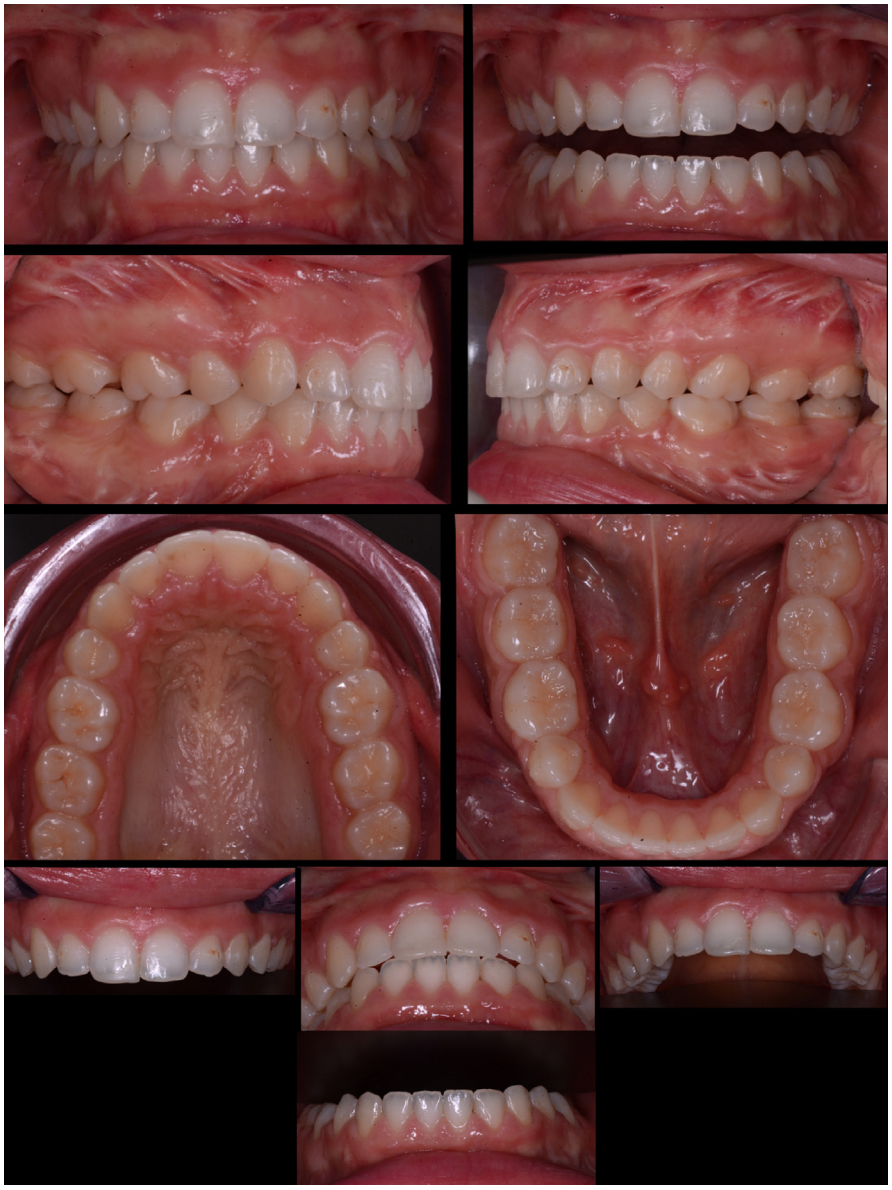

Figure 19

End of treatment intraoral frontal and lateral, occlusal and particular photographs

The upper molars were slightly intruded, while the lower ones were mildly extruded due to curve of Spee flattening (*figure 24*).
A moderate maxillary impaction, both for anterior and posterior parts, was evidenced.
The patient reported a significant improvement in breathing and snoring at night.

Two month later upper and lower lingual retainers were bonded and new upper and lower essix were delivered.
Treatment results remained stable at fourteen-month follow-up appointments (*figures 25 and 26*).

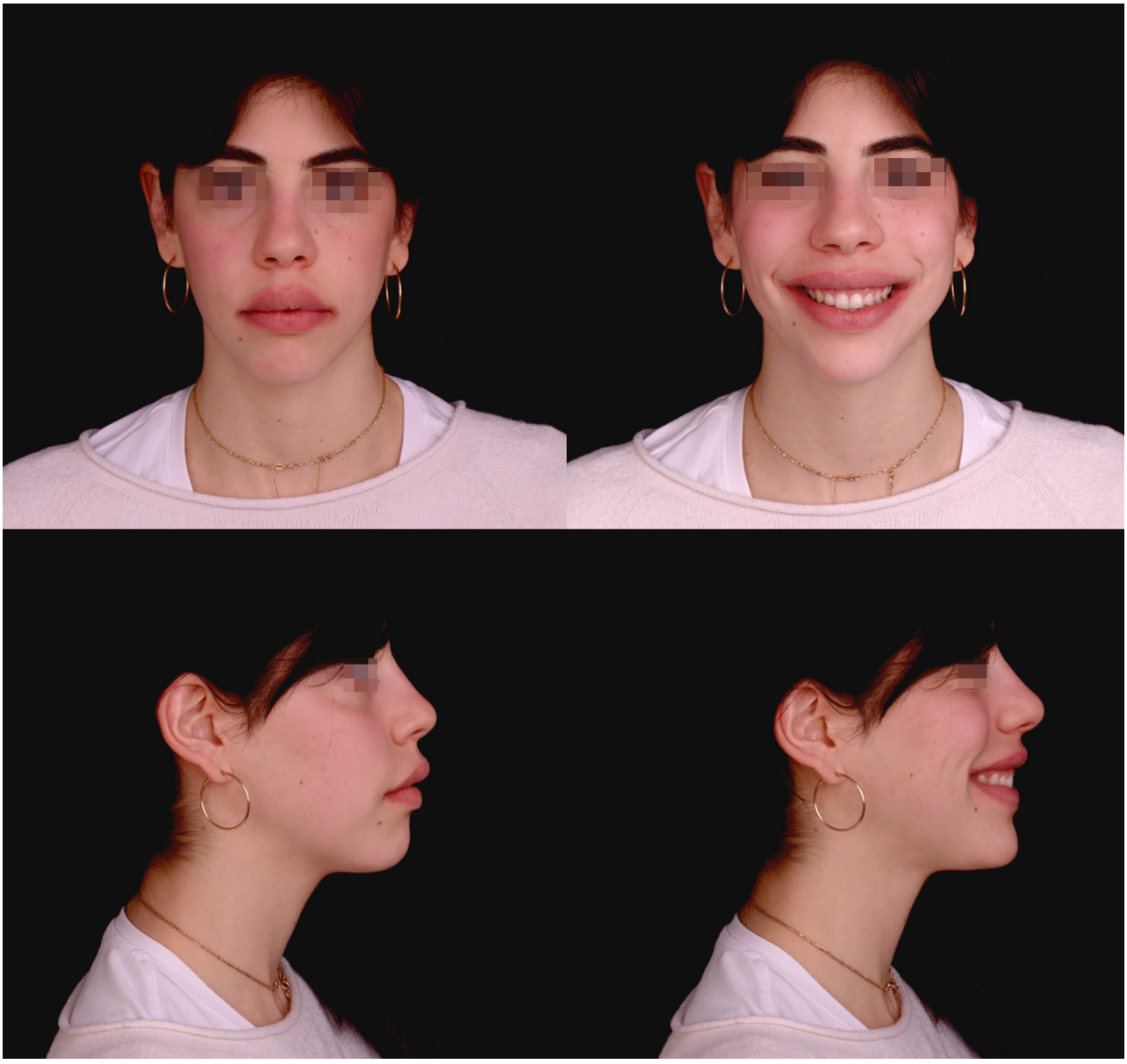

FIGURE 20

End of treatment frontal and lateral extraoral photographs

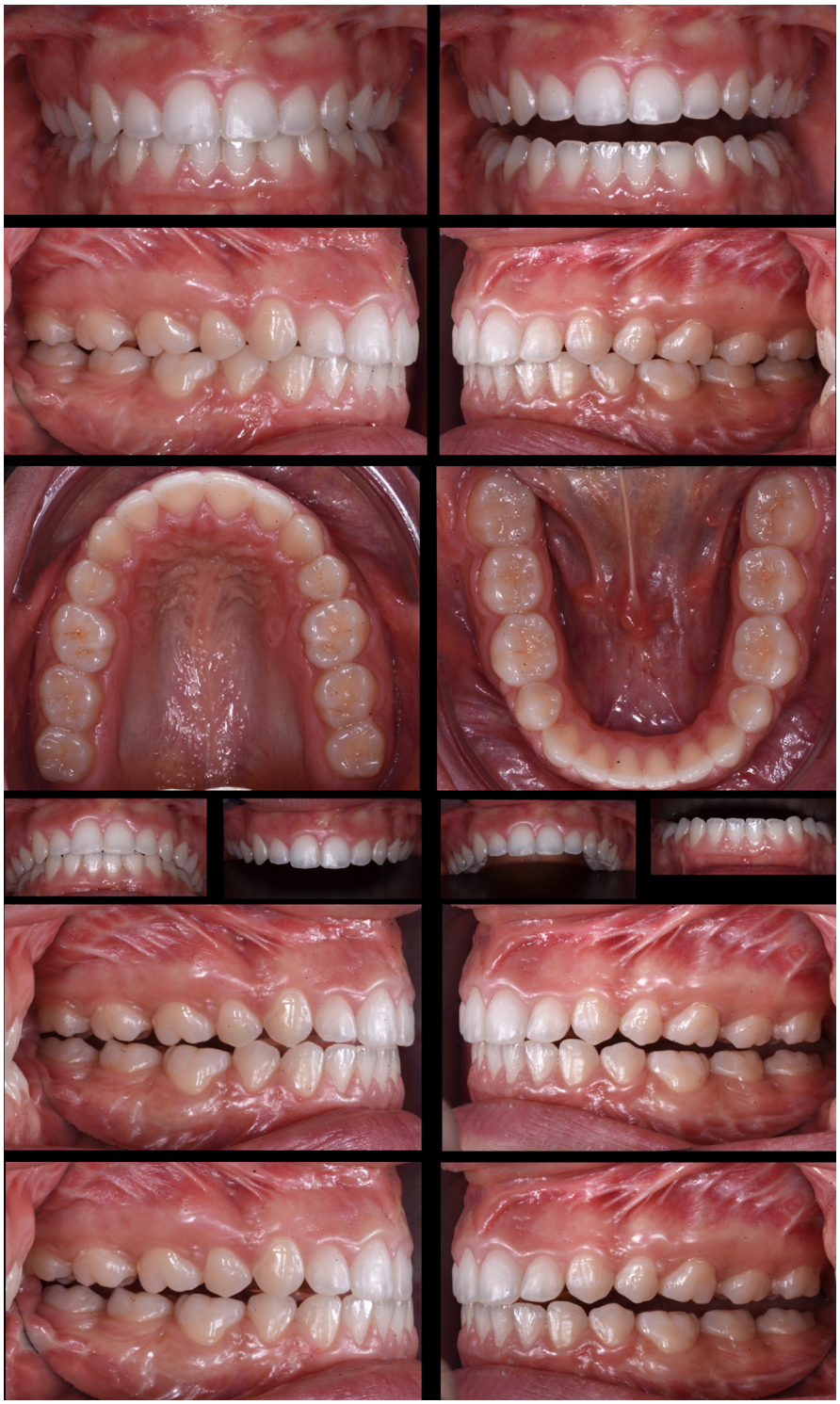

FIGURE 21

End of treatment intraoral frontal and lateral, occlusal and particular photographs after composite reconstructions

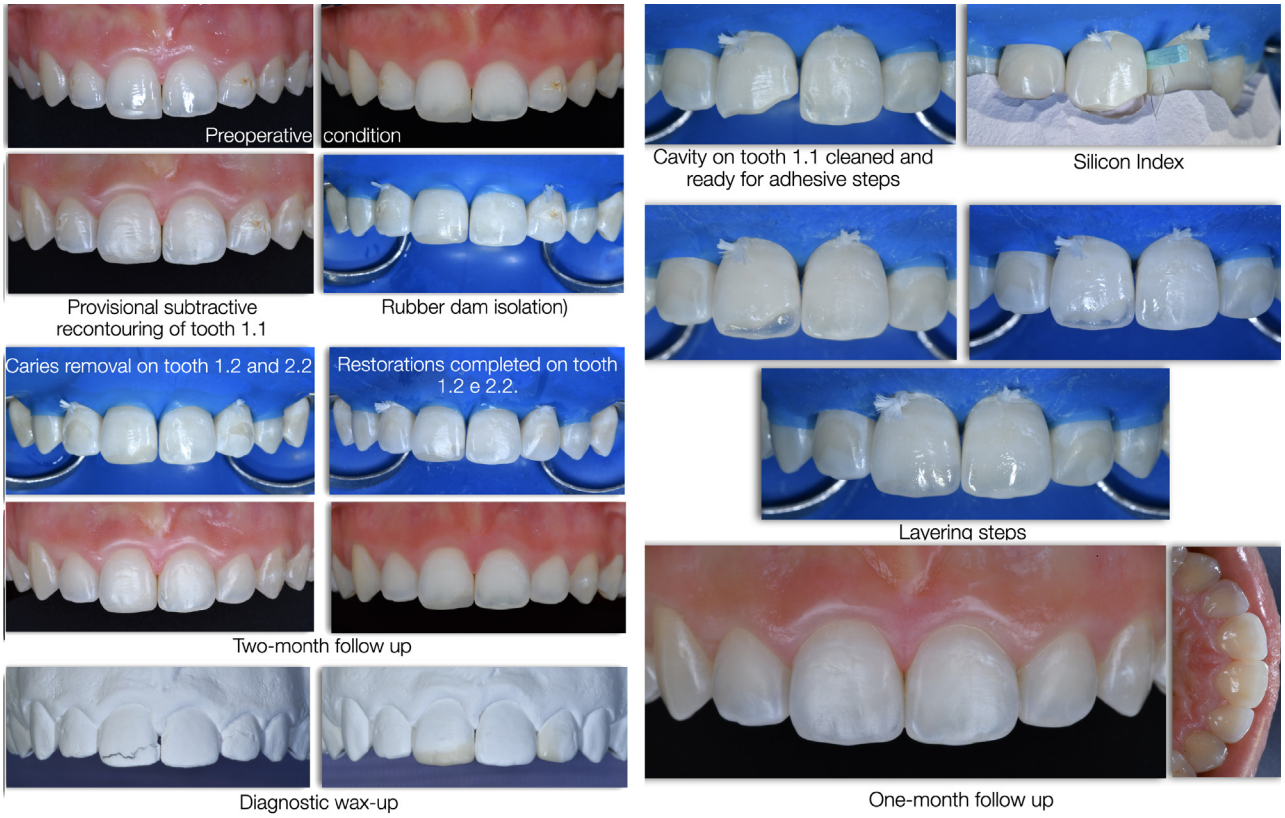

FIGURE 22

Composite reconstruction sequence

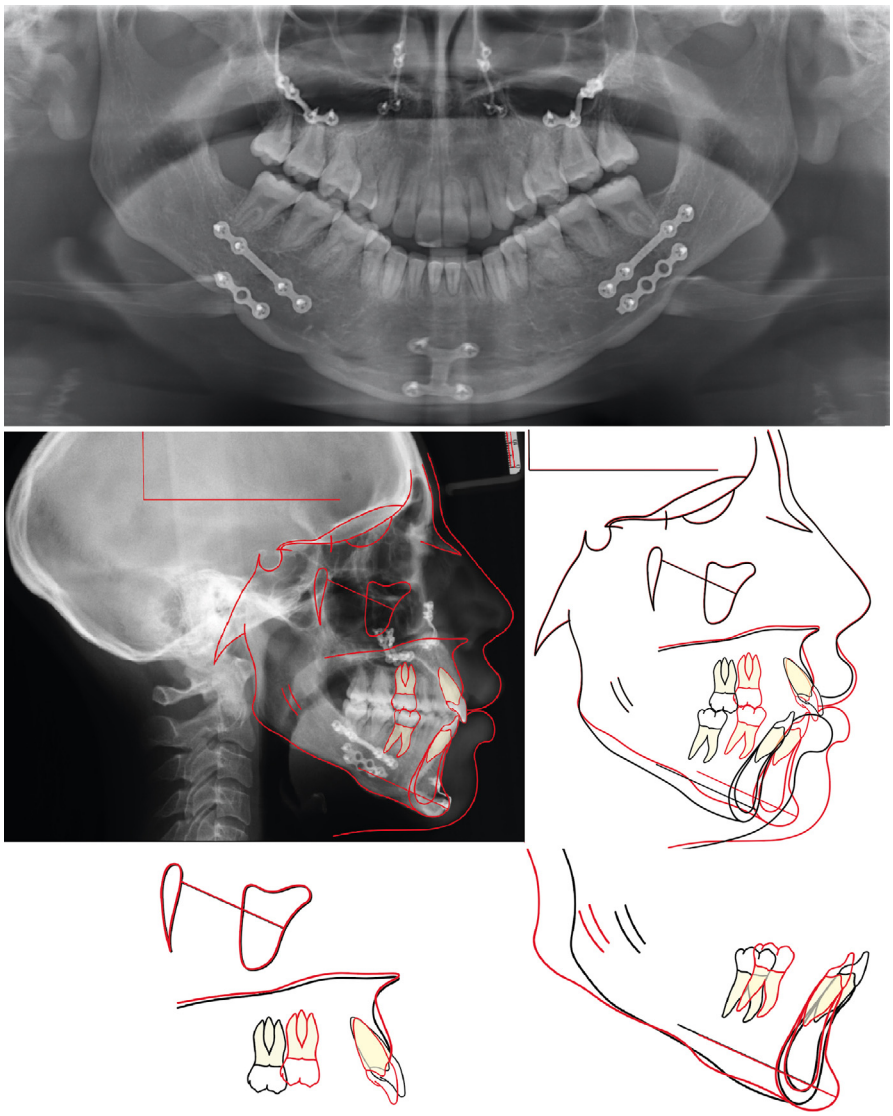

FIGURE 23

End of treatment radiographs (orthopantomography, lateral x-rays), cephalometric analysis, general, maxillary and mandibular sectorial superimpositions

Table I
Cephalometric morphological assessment.

	Pre-treatment	Pre-surgery	Post-treatment	Mean SD	Pre-treatment
Sagittal skeletal relations					
Maxillary position S-N-A	82.5°	82.7°	83.7°	82°	± 3.5°
Mandibular position S-N-B	73.8°	73.5°	80.1°	80°	± 3.5°
Sagittal jaw relation A-N-B	8.8°	9.2°	3.6°	2°	± 2.5°
Vertical skeletal relations					
Maxillary inclination S-N/ANS-PNS	4.5°	5.4°	0.9°	8°	± 3.0°
Mandibular inclination S-N/Go-Gn	42.9°	43.2°	41.1°	33°	± 2.5°
Vertical jaw relation ANS-PNS/Go-Gn	38.4°	37.8°	40.2°	25°	± 6.0°
Dento-Basal relations					
Maxillary incisor inclination 1–PP	117.9°	110.5°	101.8°	110°	± 6.0°
Mandibular incisor inclination 1–Go-Gn	95.1°	88.0°	93.6°	94°	± 7.0°
Mandibular incisor compensation 1-A-Pg (mm)	4.0 mm	1.1 mm	3.8 mm	2	± 2.0
Dental relations					
Overjet (mm)	8.9 mm	11.2 mm	1.5 mm	3.5	± 2.5
Overbite (mm)	0.9 mm	2.2 mm	1.7 mm	2	± 2.5
Interincisal angle 1/1	108.6°	123.7°	124.5°	132°	± 6.0°

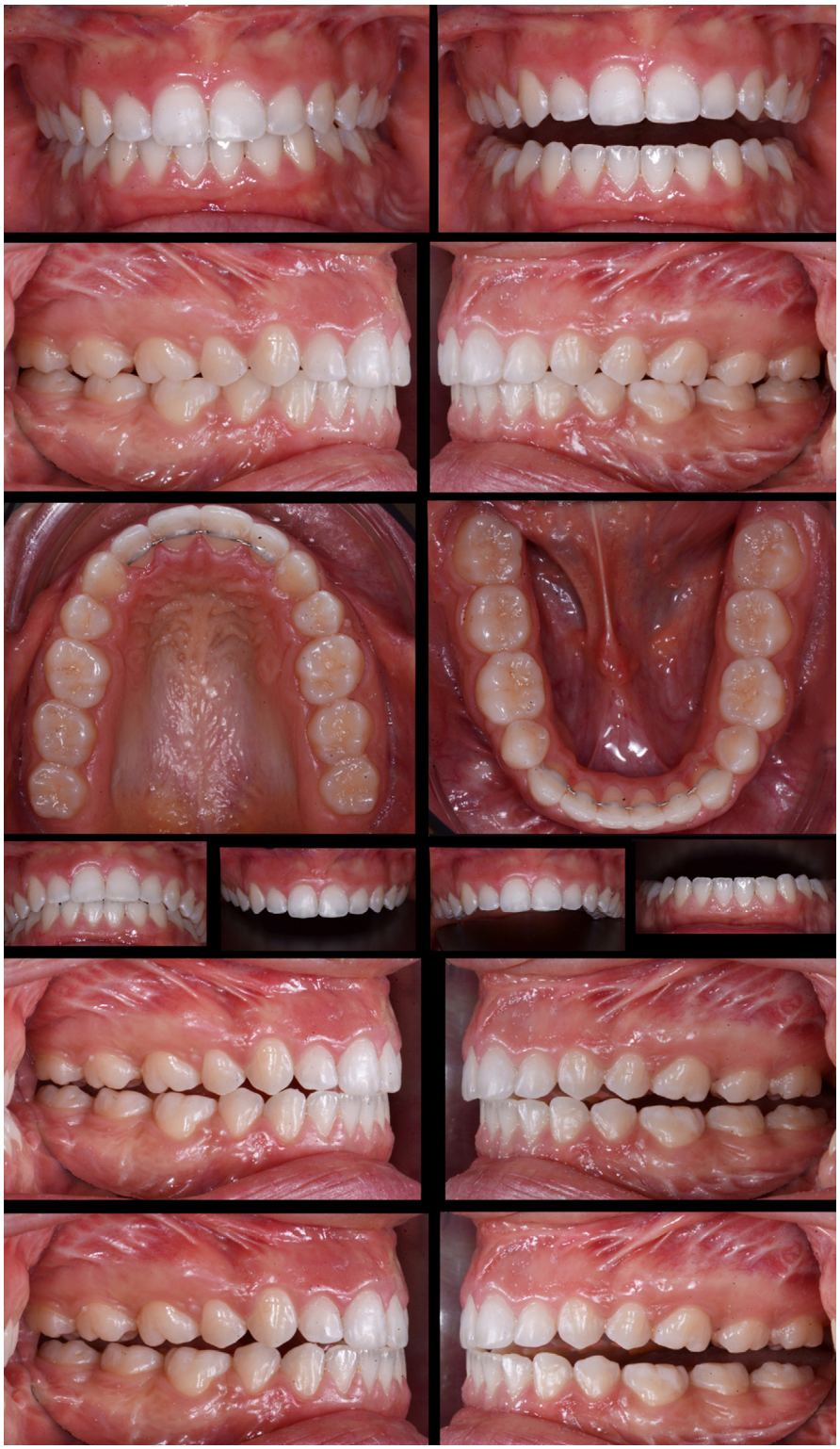

FIGURE 24

Follow-up (after eight months) intraoral frontal, lateral, occlusal and particular photographs

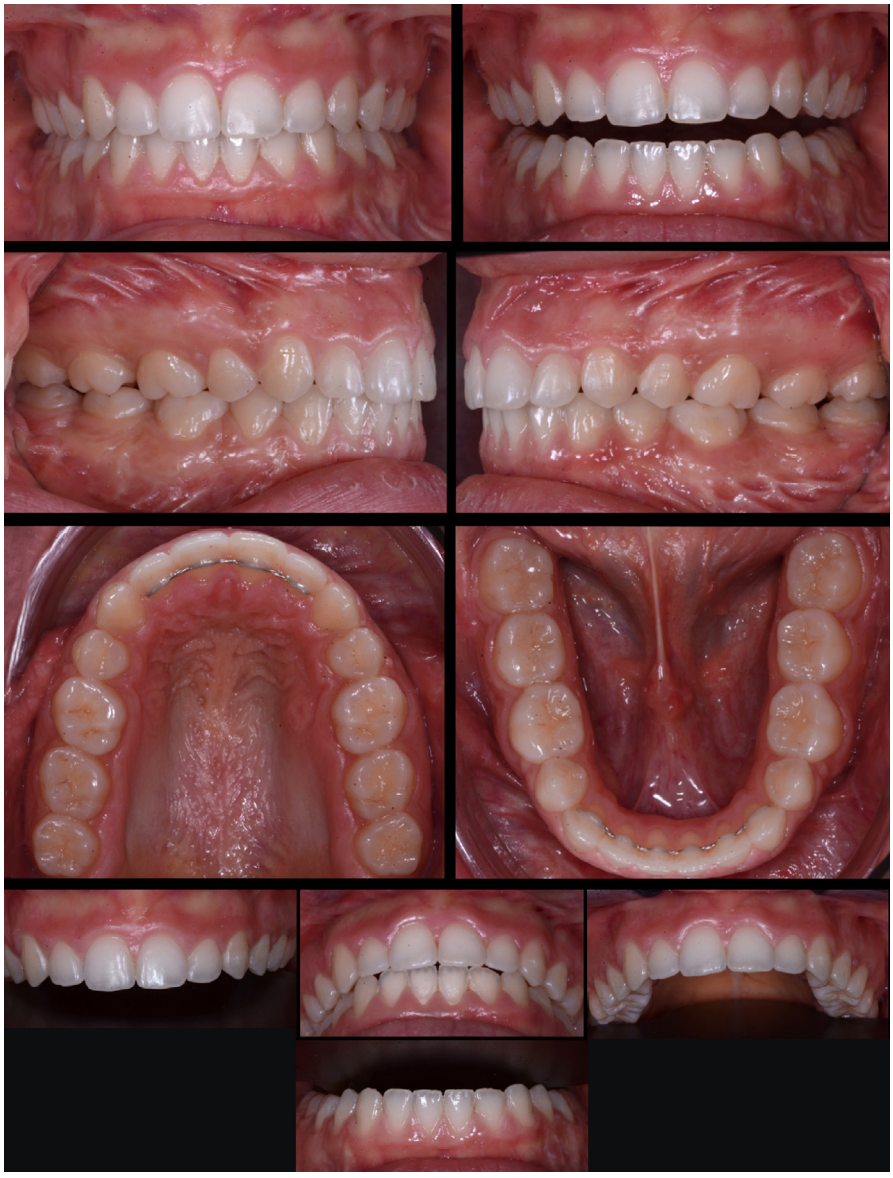

FIGURE 25

Follow-up (after fourteen months) intraoral frontal, lateral, occlusal and particular photographs

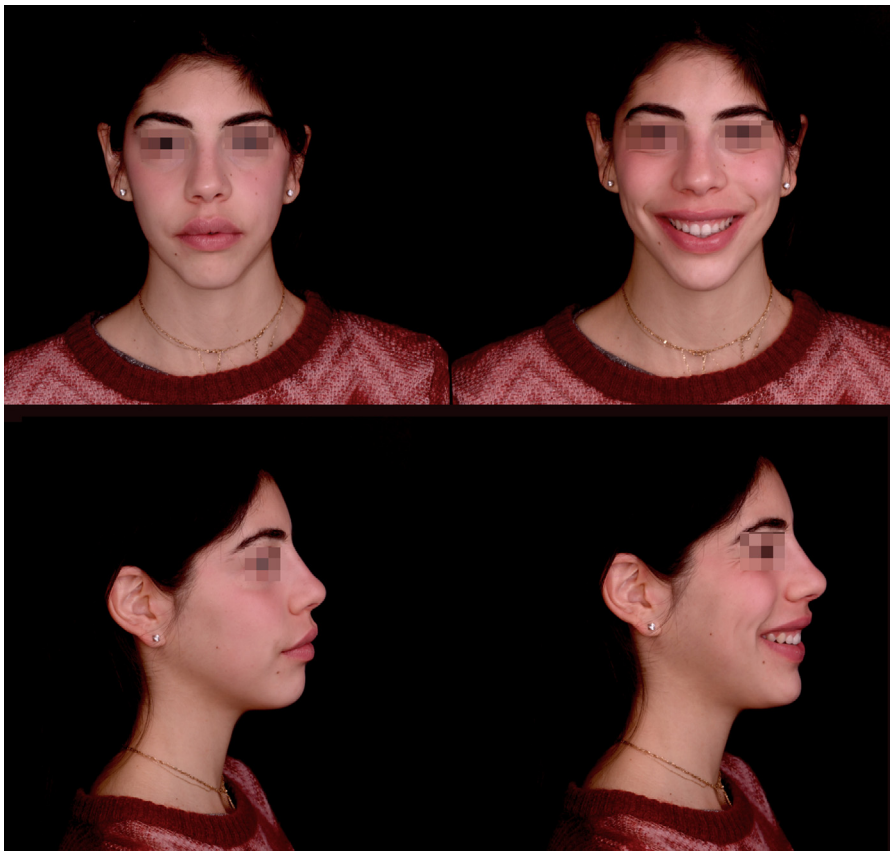

Figure 26

Follow-up (after fourteen months) frontal and lateral extraoral photographs

Discussion

In the present case report, a severe skeletal Class II high-angle malocclusion with retrognathic mandible was treated by a combination of orthodontic and orthognathic surgery with lingual straight-wire appliances and miniscrews.

Skeletal Class II high-angle patients frequently present mandibular deficiency combined with downward and backward rotation of the mandible and excessive maxillary vertical growth. Surgical treatment for these patients by maxillo-mandibular advancement, superior repositioning of the maxilla and occlusal plane inclination correction can produce a more ideal skeletal relationship than orthodontic camouflage, with the mandibular incisors in a more correct position relative to the basal bone [19]. Maxillary advancement and asymmetrical impaction, with improvement of the nasolabial angle and correction of the facial asymmetry, were planned in combination with mandibular advancement and genioplasty. The facial profile and lip support were significantly improved, and the mentalis strain was reduced.

Bimaxillary surgery reduced the excessive vertical dimension of the lower face by maxillary impaction and promoted antero-rotation of the mandible. These surgical movements, considered to be stable by several research [20,21], resulted unchanged one year after the end of treatment.

The mandibular advancement improved not only the facial aesthetics but also the occlusal function and upper airway [22], resulting in an improvement in the patient's snoring condition. Additionally, the chin augmentation contributed to lip competence, facilitating nose breathing [23,24].

The surgical planning considered the short teeth, the gummy smile and the retrusion of the chin. At rest, the exposure of the upper incisors was 6 mm associated with high mobility of the upper lip.

In the surgical planning the upper incisors were slightly impacted, maintaining the vertical position of the molars. This was intended to create a counterclockwise rotation of the occlusal plane in order to improve chin advancement. A greater impaction of incisors was avoided in anticipation of the lengthening of the lip with age. The alar base widening was checked with the alar base cinch suture.

Orthodontic preparation with premolar extractions for incisor torque normalization was essential in order to determine the

correct amount of skeletal correction. Space closure was performed in this case with a medium anchorage on both the upper and lower arches, in order to slightly reduce upper incisor inclination and decompensate lower incisors to create a proper overjet for skeletal movements.

Closed elastomeric chains were used on the upper arch. As reported by Papageorgiou et al., there is a decrease in anchorage loss of the first maxillary molar in lingual orthodontics during space closure [25], which allows for normalisation of the inclination of the upper incisors, which was initially 117° to 110°.

On the lower arch, the initial inclination was 95° and needed to be slightly reduced. When compared with the maxillary molars, the mandibular molars are more difficult to move mesially because of the presence of thick cortical bone and the extremely wide bucco-lingually molar roots [26]. In lingual orthodontics this is even more complex, since anchorage value of mandibular molars is particularly strong: when mandibular premolars are extracted, it is difficult to move the mandibular molars mesially [13], resulting in lingual tipping of the incisors.

The employment of miniscrews allowed molar mesialization, avoiding lower incisor extreme retroinclination and permitting a correct maxilla-mandibular amount of surgical correction: an excessive overjet and the consequent mandibular advancement could lead to a larger appearing lower face and a more prominent mandible, with prominent gonial angles [27,28]. In addition, an excessive decompensation could have determined the risk of a post-treatment relapse. After surgery, changes in Class II patients are more frequent in the long term than those of Class III patients [29], due to postsurgical condylar resorption and relapse, which entail consequent shortening of the mandible after mandibular advancement and reestablishing of positive overjet [30].

Miniscrews were placed in the mandible bilaterally in the buccal alveolar bone inter-radicular space between the premolars. The buccal position for lower molar protraction represents the gold standard in lingual orthodontics [31], along with sectionals on posterior teeth, due to easier accessibility and hygiene maintenance. Miniscrew placement is poorly invasive and uncomfortable, but the reported stability is lower than that of miniplates [32,33]. A high percentage of failure of 19.3% is reported in the literature for mandibular miniscrew loosening [34], with the highest increased tendency to fail after five months following load application [35].

In this case the miniscrews remained stable throughout the protraction phase. The accurate positioning and careful oral hygiene of the patient contributed to their stability. No significant tilting of miniscrews was reported, although an average of 0.4 mm has been reported in the literature [36].

The heads of the miniscrews were positioned lower than the clinical crown of the mandibular molars. For this reason, power arms were inserted in order to obtain bodily protraction. A slight mesial-rotation was researched by a set-up overcorrection, in order to prevent a gingival recession on the molars' mesial root, encouraged by the buccal biomechanics. The excessive rotational tendency of the first and second molars during protraction was prevented with a closed elastomeric chain from the lingual side of the first molars: this determined some desired lingual tipping of the mandibular incisors for surgical preparation.

Lower second molars were not bonded at treatment start due to the short clinical crown on the lingual side. However, their lingual bonding was necessary as the buccal sectional positioned on posterior teeth did not allow appropriate rotational control, despite the employment of a 0.019*0.025 NiTi wire. Their lingual bonding, as for third molars was performed directly, thus avoiding the need to modify the initial set-up for indirect preparation. Only closed elastomeric chains were employed to obtain correct second and third molar rotations, without the need for inserting the lower arch wire.

Stepovitch [37] studied edentulous ridges before and after space closure of mandibular first molar spaces, concluding that clinicians can close spaces of 10 mm or more in adults, but maintaining the closed spaces is difficult. Recent research highlighted a mean of 1.5 mm space reopening in 46% of subjects with bilateral premolar aplasia treated by push-and-pull mechanics [38]. In our patient the space closure remained stable one year after treatment and the final orthopantomography evidenced bodily lower first and second molar mesialization, with minimal root resorption and no evidence of fenestration or dehiscence [39].

On the other hand, although the maxillary and mandibular anterior teeth were retracted with light force to prevent further shortening of their roots, which were already slightly shorter, some further root resorption occurred. The entity of retraction was moderate: on the upper arch torque normalization was achieved, while in the lower arch miniscrews were inserted for molar protraction. It is possible that an additional incisor retraction could have determined a higher rate of root resorption. No signs of bone resorption were highlighted.

For surgical preparation only six buccal buttons were bonded to prescribe the patient intermaxillary elastics one week before the intervention: this contributed to avoiding a significant inaesthetic impact, even in the period adjacent to orthognathic surgery.

After surgery, the patient presented a slight dental Class II malocclusion. For this reason, once the lower space had been closed, the mini-screws were transferred to the upper arch for en-mass distalisation [40].

Torque control in lingual orthodontics is obtained in many extraction cases with good predictability [41,42]. However, in some others the tendency of lingual crown tipping is higher, often with different expressions despite the employment of symmetrical mechanics [43,44].

In this case, anterior torque was managed using overcorrections in the setup and manual torque bends in the archwires. Despite

the fact that the upper central and lateral incisors had symmetrical torque prescriptions and that the space closure mechanics were also symmetrical, at the end of space closure they evidenced a significantly different inclination between the right and the left sides.
Torque springs were employed in different phases in order to achieve an ideal and symmetrical torque, with alternated activations on pairs or single teeth.
The employment of auxiliary springs, in addition to set-up overcorrections, was successful in normalizing the upper incisors, since orthodontic appliances are less efficient in torque movements, due to limited moment [45].
When a different torque expression in adjacent teeth occurs in lingual orthodontics, the incisal margin height discrepancy is more pronounced in respect of buccal orthodontics, due to the longer distance of the tooth surface to the orthodontic wire [46].
Since the correction with a bend into the main wire was difficult, as a consequence of the unfavourable moment ratio [45], with a short distance for the couple of force application [47], an auxiliary 0.016 spring was modelled and activated by ligating the wire as an auxiliary one in addition to the main 0.018*0.018 SS.
The employment of an auxiliary spring with an auxiliary arch was necessary in order to obtain complete correction in place of torque insertion on the main wire, as a consequence of the entity of torque correction and the inter-bracket distance. The torque spring was first activated on the pair of central incisors [48], while later alternatively on single teeth of the upper left side.
Correct control of upper and lower incisor torque was crucial in this case in order to prepare the patient for maxillofacial surgery. The upper incisors, which were proclined (117°) at the start of treatment, needed to be reduced.
Upper incisor inclination obtained before surgery was 110°, while finished with slightly reduced inclination (102°), due to the change in the inclination of the surgical occlusal plane and the Class II mechanics to complete sagittal correction after surgery.
The lower incisors, which were normally inclined (95°) at the start of treatment, needed a reduction in torque to obtain the proper inclination for the surgical movements. Before the surgery their inclination turned out to be 88°, permitting the mandible to be advanced. At treatment end the lower incisors were normalized to 94°.
Presurgical upper and lower incisors were respectively 56° and 67° in respect to the occlusal plane, values that are considered ideal according to Arnett aesthetic treatment planning [49].
Since no upper incisors intrusion was highlighted at treatment end, a slightly increased gingival exposition remained: considering the patient age this aspect will improve over time. The asymmetrical exposure was surgically corrected.
The difficulty in this case was the very low height of the upper and lower tooth crowns. After the insertion of provisional brackets with gingival wire ligation on upper lateral incisors to promote their extrusion, no other difficulties were encountered. No brackets debonding occurred during the whole treatment and a correct overjet and overbite were ultimately achieved.

Conclusions

A severe sagittal and vertical skeletal malocclusion was corrected by lingual straight-wire treatment and orthognathic surgery, with significant improvement in facial profile, occlusion and function.
Anchorage was controlled in the mandibular arch by inter-radicular miniscrews, combined with posterior sectionals, in order to protract molars, thus avoiding excessive lower incisor decompensation.
Asymmetrical maxillary impaction permitted occlusal cant correction and promoted mandibular counter-clockwise rotation, thus leading to a vertical face height improvement.
Upper torque was managed by set-up overcorrections, bending in the archwires, full-size wire and application in sequence of torque springs, for the correction of asymmetrical torque expression between the upper right and upper left incisors.
Despite the very short clinical crown height, no other difficulties or bonding failures were registered, indicating that short clinical crowns do not represent an absolute contraindication for lingual orthodontics treatment, even in complex surgical extraction cases.

Author contributions: Dr. Enrico Albertini (orthodontics), Dr. Ugo Bacilero (maxillofacial surgery) and Dr Adamo Monari (conservative dentistry) treated the case. Dr. Paolo Albertini, Dr. Anna Colonna and Prof. Luca Lombardo contributed in the article preparation.

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

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