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Early treatment of a severe Class II malocclusion with the Forsus fatigue resistant device

ABSTRACT

Background *It is generally agreed that the ideal time for treating Class II malocclusions is adolescence, when the patient is approaching the pubertal growth spurt. Nevertheless, it has been reported in the literature that in the presence of what has been defined as a "socially debilitating" Class II malocclusion, characterised by severe overjet and mandibular retrognathism, a first phase of treatment should be provided already in the early mixed dentition phase, for the benefit of a positive psychologic effect. Such early treatment should first involve correction of the transverse dimension of the maxilla, to enable spontaneous forward movement of the mandible or mandibular advancement by functional appliances.*

Case report *This case report describes the early treatment of a severe Class II malocclusion, with major overjet and mandibular retrognathism. Treatment involved rapid maxillary expansion, followed by the use of the Forsus Fatigue Resistant Device (FRD; 3M Unitek, Monrovia, CA, USA) as a fixed functional appliance. Orthodontic records were taken before and after the early phase of treatment. Cephalograms and digital models were superimposed to evaluate the produced dento-alveolar and skeletal changes. The early phase of treatment was found to be effective at reducing the sagittal jaw discrepancy, controlling the patient unfavourable growth pattern, and improving the child aesthetics.*

Keywords *Class II malocclusion, Early orthodontic treatment, Forsus appliance.*

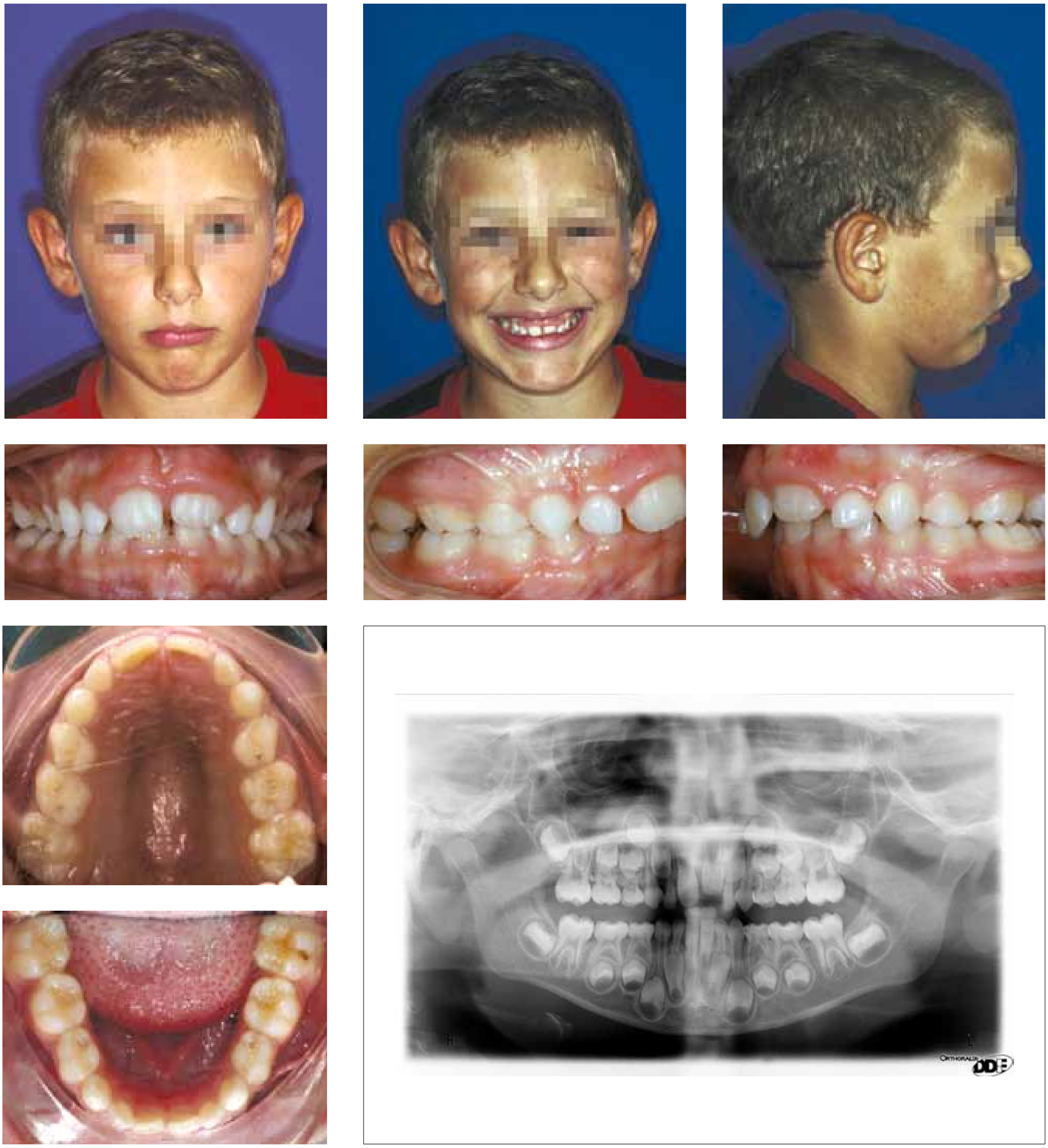
Introduction

A Class II malocclusion can result from the combination of various dento-alveolar and skeletal conditions [McNamara et al., 2012]. Current evidence suggests that orthodontic treatment of such malocclusion should generally be provided during adolescence [McNamara and Keim, 2014a; McNamara and Keim, 2014b; Sunnak et al., 2015]. However, early treatment of Class II has been advocated to reduce the risk of incisal trauma [Thiruvenkatachari et al., 2015], and in the presence of what has been called as a "socially debilitating Class II" [McNamara et al., 2012; McNamara and Keim, 2014a; McNamara and Keim, 2014b]. The latter condition refers to 7-9 year-old patients in early mixed dentition, exhibiting a major overjet and mandibular skeletal retrusion [McNamara and Keim, 2014b]. Under such condition, according to McNamara, the limitation of treating at a less-than-ideal time should be weighed against the benefit of a positive psychological effect [McNamara and Keim, 2014b]. For early treatment of Class II malocclusions McNamara recommends to first correct the transverse dimension of the maxilla, as this is often followed by spontaneous improvement in the sagittal relationship [McNamara et al., 2012; McNamara and Keim, 2014b]. Additionally, functional jaw orthopaedics can be provided, preferentially using a non-compliant device, such as the Herbst appliance [McNamara et al., 2012; McNamara and Keim, 2014b]. Among fixed functional appliances, the Forsus Fatigue Resistant Device (FRD; 3M Unitek, Monrovia, CA, USA) has gained increasing popularity since its introduction [Vogt, 2006], and was reported to be the most frequently utilised non-compliant appliance among clinicians in practice for less than 10 years [Jung, 2015; Keim et al., 2008].

This article presents a case of early treatment of a severe Class II malocclusion in which the therapeutic approach suggested by McNamara was followed and FRD was utilised as a functional appliance. Orthodontic records were taken before and after the early phase of treatment. Cephalograms and digital models were superimposed to evaluate the produced dento-alveolar and skeletal changes.

Case report

RT was 6-year, 9-month old when his parents brought him for the first orthodontic visit, with the chief complaint of unaesthetic appearance of the upper front teeth and of the profile. On the frontal view the



patient exhibited a symmetrical face, some strain of the mentalis muscle, and an excessive gingival display on smiling. The lateral head view showed a convex profile, with very retrusive lower lip and chin, as well as the unpleasant appearance of a double chin (Fig. 1). No sign or symptom of temporomandibular dysfunction was present. The intraoral exam revealed that the patient was in early mixed dentition and presented a Class II malocclusion, a constricted maxillary arch, excessive overjet, deep overbite with the lower incisors impinging upon the palatal gingiva, mesiolingually rotated upper first permanent molars. The patient also

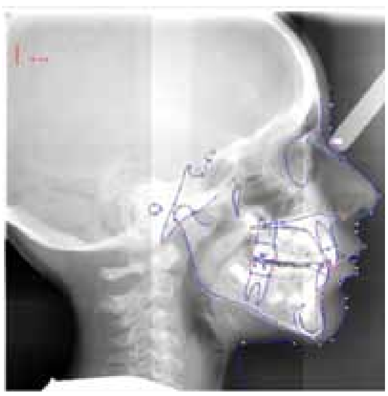


FIG. 1 A 6-year-old male patient with severe Class II malocclusion, deep overbite, convex profile, retrusive lower lip and chin, high angle growth pattern.

Measurement	Norm	Pre-treatment	Post-treatment
SNA (°)	82	77.9	76.6
SNB (°)	80	72.6	72.1
ANB (°)	2	5.3	4.5
SN - MP (°)	32	38	35,9
FMA (MP - FH) (°)	26	30.5	29.1
N - S - Ar (°)	123	128.5	128.6
S - Ar - Go (°)	143	137.2	141.1
Ar - Go - Me (°)	130	134.5	130.4
PFH / AFH (S - Go / N - Me) (%)	62-65	59.8	58.4
U1 - NA (mm)	4	-0.7	1.8
U1 - SN (°)	103	90.8	96
L1 - NB (mm)	4	1,9	3,9
L1 - MP (°)	95	82.6	95.1
Lower lip to E-plane (mm)	-2	-0.7	-1.6
Upper lip to E-plane (mm)	-4	-0.1	-4.4

TABLE 1 Cephalometric analysis.

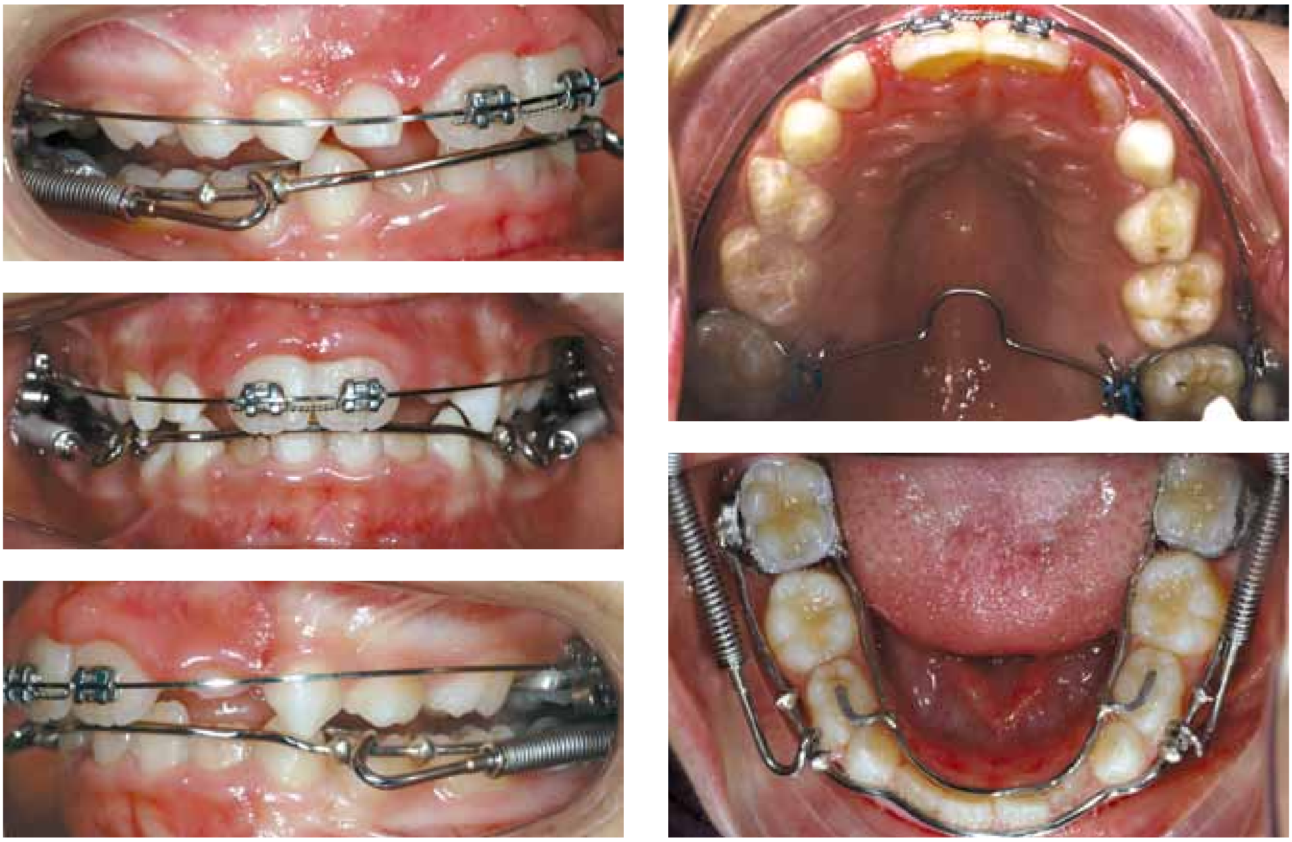
exhibited a brown discolouration of the enamel in the buccal fossa of the lower first permanent molar (Fig. 1). The panoramic radiograph disclosed that all the permanent teeth from second molar to second molar were normally developing, although the space analysis suggested that a condition of dental crowding was creating, particularly in the maxillary arch (Fig. 1). The cephalometric analysis pointed out that the patient had a skeletal Class II relationship, with severe mandibular retrusion and a high angle growth pattern. Upper and lower incisors were retruded and retroclined (Table 1).

In consideration of the maxillary constriction and crowding, severe mandibular retrusion and high angle growth pattern, and with a particular concern for the unpleasant soft tissue profile (Fig. 1), possibly affecting the developing personality of the child, an early orthopaedic-orthodontic treatment was proposed, with the intention to intercept and reverse the manifestly altered growth tendencies [McNamara et al., 2012; McNamara and Keim, 2014a; McNamara and Keim, 2014b].

Treatment objectives were to expand the maxillary arch, restrain the vertical growth of the maxilla and encourage a counterclockwise rotation of the mandible with growth. Expansion of the maxillary arch was thought to be desirable not only to relieve crowding, but also to accommodate the forward growth of the mandible [Guest et al., 2010; Maspero et al., 2015; McNamara et al., 2010; McNamara et al., 2012; McNamara and Keim, 2014a; McNamara and Keim, 2014b; Zhou et al., 2014].

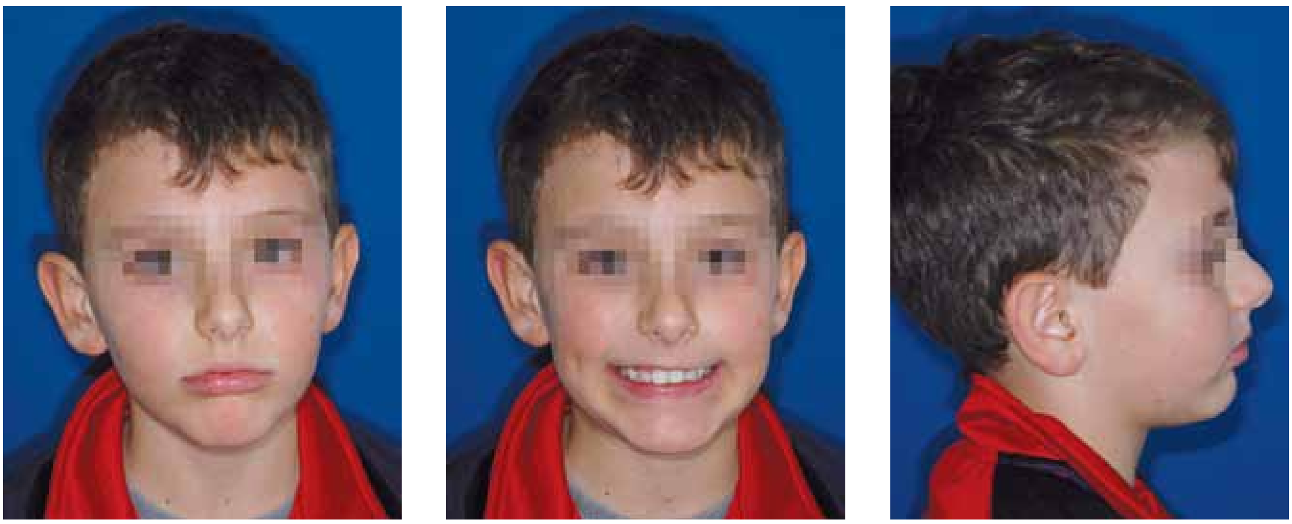
After having received a detailed description of the planned treatment, the parents of the young patient gave their consent to the therapy. The parents also authorised the use of clinical photographs and radiographs of their child in the present paper.

Treatment involved first the application of a Hyrax-type rapid palatal expander (RPE). The active phase of maxillary expansion lasted for 17 days and was followed by a 5-month period of stabilisation with the appliance in place. At the third month of treatment, stainless steel twin brackets with .022"x.028" slot (Victory Series, McLaughlin-Bennet-Trevisi prescription, 3M Unitek, Monrovia, CA, USA) were bonded on the upper central incisors and first deciduous molars. The deciduous teeth were bonded only for the purpose of archwire support. Leveling, aligning, and torque of the upper central incisors were obtained with the sequential use of .016" nickel-titanium, .016x.022" nickel-titanium, .017x.025" beta-titanium, and .019x.025 stainless steel sectional wires from first deciduous molar to first deciduous molar. At the fifth month of treatment the RPE was removed, bands were cemented on the upper first permanent molars and a transpalatal arch was inserted with the objective of correcting the molar mesiolingual rotation. At this stage the application of the FRD appliance was planned for mandibular advancement. Thereby, at 6 months of treatment bands were fit on the lower first permanent molars and an alginate impression was taken to allow the construction of a stainless steel ferrule-type arch for anchorage of the FRD coil-piston system. The coil was attached to the upper first molar bands through the 'EZ2' module, while the piston was hooked onto the outer bow of the double mandibular arch and rested against a soldered stop. The inner bow of the double lower arch presented an occlusal rest that was bonded onto the occlusal surface of the first deciduous molar (Fig. 2). The length of the piston was selected according to the manufacturer's instructions, having the patient bite in centric occlusion. In the upper arch the transpalatal arch provided anchorage to control the buccal flaring of



FIGG. 2 At 6 months into treatment, placement of the Forsus Fatigue Resistant Device with coils attached to upper first molar bands and pistons resting against soldered stops onto the outer bow of the double mandibular arch. Occlusal rests of the mandibular arch bonded to the first deciduous molars. Transpalatal arch for upper molars' anchorage.

the upper first molars, possibly resulting from the action of the pushing coils (Fig. 2). At 1 year into treatment the upper lateral incisors were also bonded to obtain their levelling, aligning, and torque. After 7 months of action the FRD was removed along with all the other fixed appliances (Fig. 3). A multibraided stainless steel splinting wire was bonded onto the lingual aspect of the upper incisors for retention purposes. At the same visit alginate impressions and a wax bite registration were taken to allow the construction of an upper removable retainer with a lingual flange to maintain the mandibular advancement (Fig. 3). The patient was instructed to wear



FIGG. 3

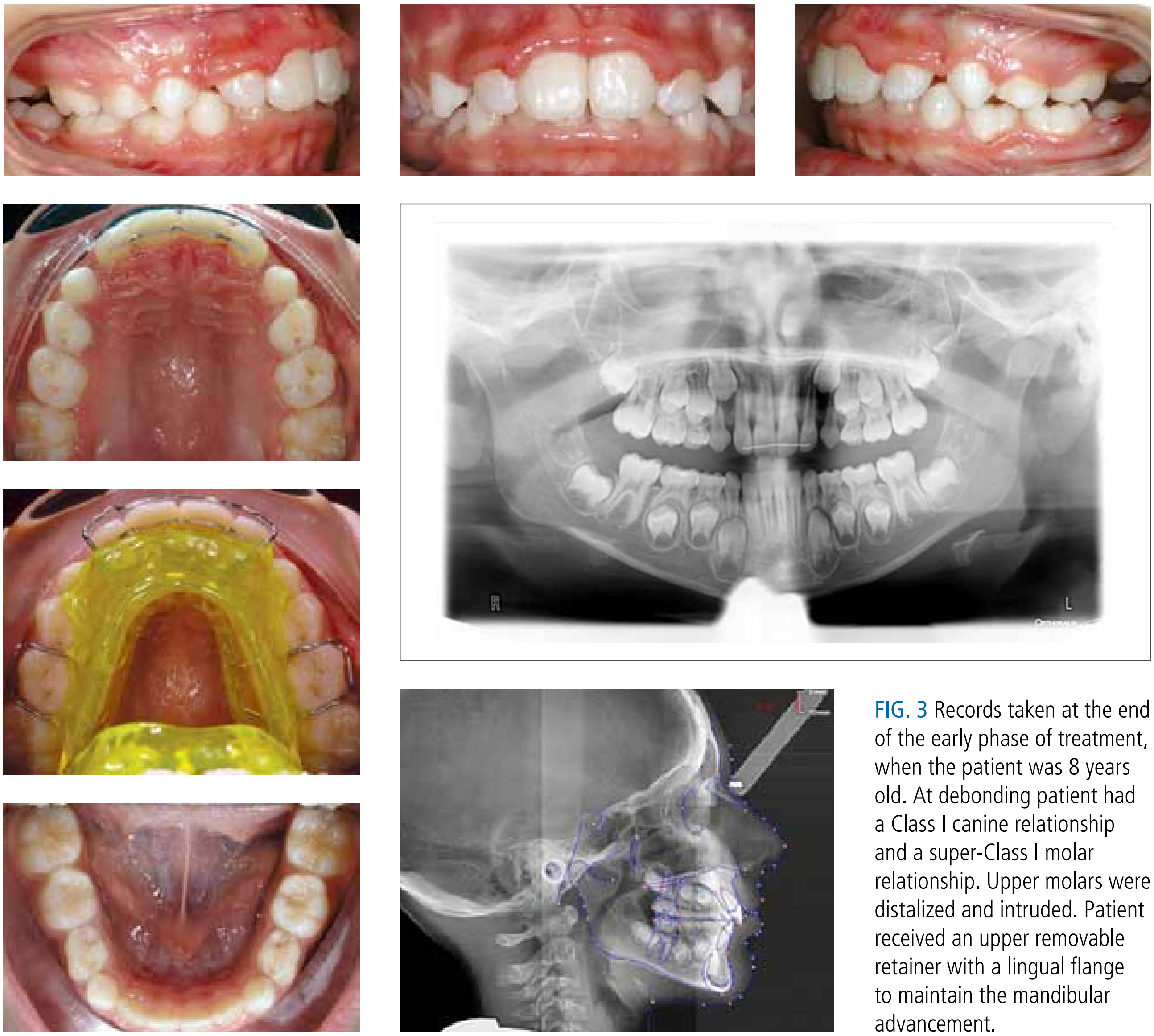


FIG. 3 Records taken at the end of the early phase of treatment, when the patient was 8 years old. At debonding patient had a Class I canine relationship and a super-Class I molar relationship. Upper molars were distalized and intruded. Patient received an upper removable retainer with a lingual flange to maintain the mandibular advancement.

the upper retainer at night and half of the day for the first 3 months. After this period, since at the follow-up visit good stability was noted, the patient was allowed to wear the retainer only at night. Such maintenance phase was planned to continue with periodic checkups all along the evolution into permanent dentition and the progressing facial growth.

The overall length of the early phase of treatment was 15 months. At debonding the patient exhibited a Class I canine relationship and a super-Class I molar relationship. The upper molars were distalised, distally rotated, and intruded (Fig. 3). At the first retainer checkup, one month after debonding, it was noted that the upper right first molar had seated onto the lower molar, while the upper left first molar was in the progress of achieving complete seating onto the antagonist (Fig. 4). The upper incisors were properly aligned, levelled and torqued. The overjet was reduced. The bite was still deeper than normal, but complete correction of the overbite was postponed to Phase II of treatment, when, with the eruption of premolars and second molars, the definite vertical dimension of the occlusion would be established. Nevertheless, the impingement of the lower incisors onto the palatal mucosa was solved. The occlusal views showed that the maxillary arch was noticeably expanded and the mesiolingual rotation of upper molars was properly corrected, while in the lower arch some improvement of incisor crowding was observed (Fig. 3). The amount of gingival display on smiling was clearly reduced. The soft tissue profile exhibited a remarkable improvement, as a result of the advancement of the soft tissue Pogonion and of a better definition of the chin-neck angle (Fig. 3). In a later follow-up visit, 12 months after fixed appliances removal, a satisfactory stability of the results of the early phase of treatment was noticed (Fig. 5).

The post-treatment panoramic radiograph showed that permanent teeth were developing regularly,

FIG. 4 First retainer check 1 month after debonding. Upper right first molar seated onto the lower molar. Upper left first molar in the progress of achieving complete seating onto the antagonist.

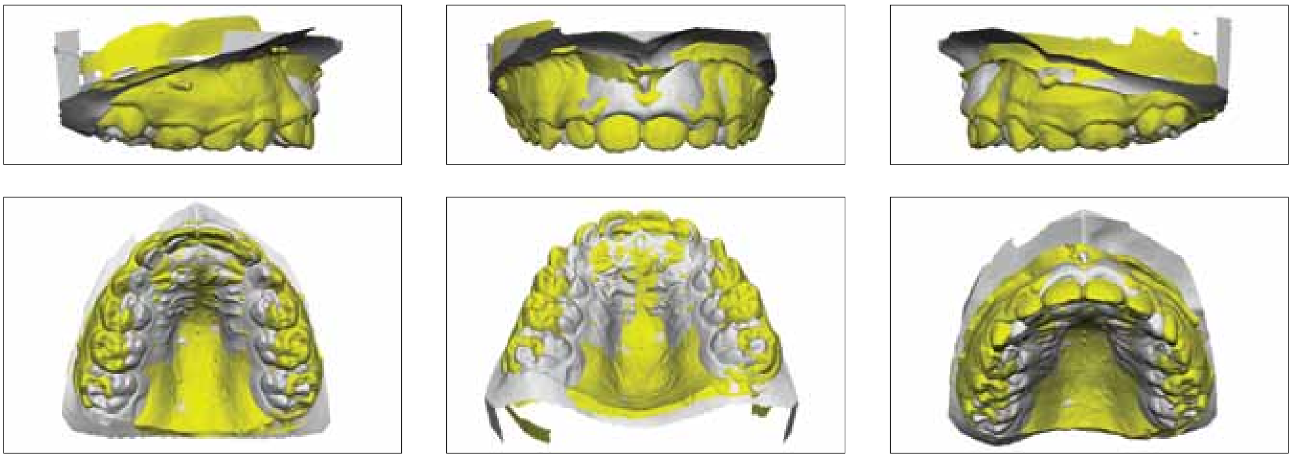
although a radiographic follow-up of the eruption of upper canines and lower third molars seemed advisable (Fig. 3). From the cephalometric analyses of pre- and post-treatment cephalograms it was evident that treatment produced a reduction of the SNA angle. Also the mandibular plane angle and the gonial angle closed slightly. Retrusion and retroclination of upper incisors were improved, while the lower incisors moved slightly forward, but their antero-posterior position remained within normal limits (Table 1).

Models' superimpositions

Pre-treatment and post-treatment plaster models were scanned by a three-dimensional scanner (D100, Imetric 3D, Courgenay, Switzerland). Superimpositions of the digital models were performed with the VAM software (Vectra 3D, Canfield Scientific, Fairfield, NJ), in order to investigate the comprehensive treatment results. Palatal rugae were used as stable structures for the superimposition of the upper casts [Ashmore et al., 2002; van der Linden, 1978], while the comparison between the pre-treatment and post-treatment lower digital models was executed by the best-fit method [Park et al., 2012]. The superimposition of pre- and post-treatment upper models confirmed the clinical observation of distalisation, derotation, and intrusion of the upper first molars. Also the expansion of the upper arch was evident (Fig. 6). In the lower arch models' superimpositions disclosed that lower molars underwent minimal to null mesialisation, while lower incisors erupted and moved slightly forward. Also,

FIG. 5

FIG. 5 Patient at 9 years of age, 1 year after the end of the early phase of treatment.



FIGG. 6 Superimposition of pre- and post-treatment digital upper models.

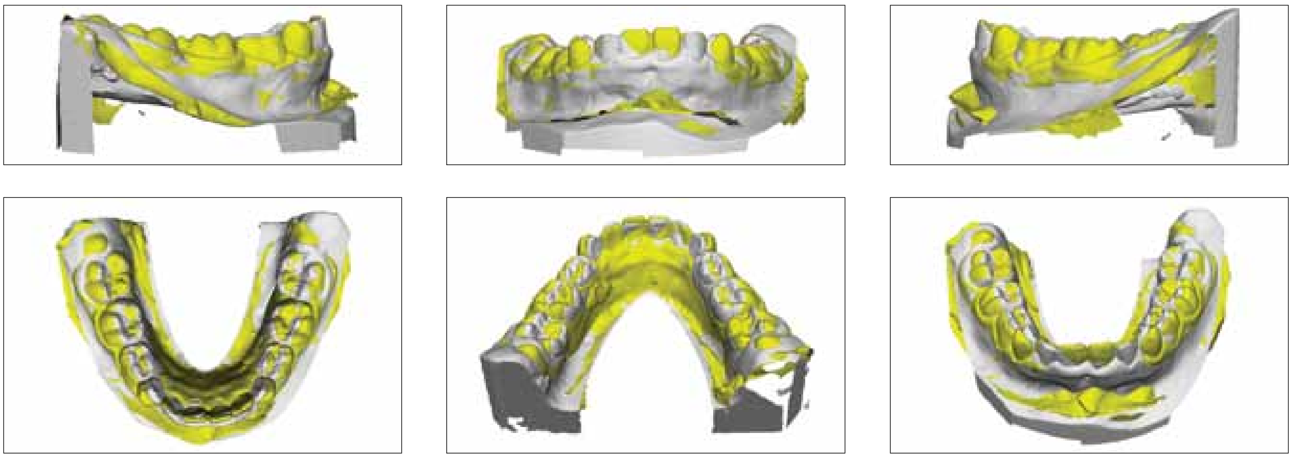


FIG. 7 Superimposition of pre- and post-treatment digital lower models.

a slight increase in the intercanine width was visible, along with some buccal uprighting of the lower molars (Fig. 7).

Cephalometric superimpositions

Pre- and post-treatment cephalometric tracings were superimposed on stable anatomical structures of the anterior cranial base, the maxilla, and the mandible (Fig. 8). Cephalometric superimposition on the anterior cranial base disclosed that the sagittal jaw relationship did not substantially change (Fig. 8a). Superimposition on the maxilla, highlighting the movement of the upper dentition relative to the maxillary bone, confirmed that upper molars had a distal and intrusive movement, while upper incisors erupted with treatment (Fig. 8b). Superimposition on the mandible, showing the changes in the lower dentition relative to lower jaw, showed the forward movement of the incisors (Fig. 8c).

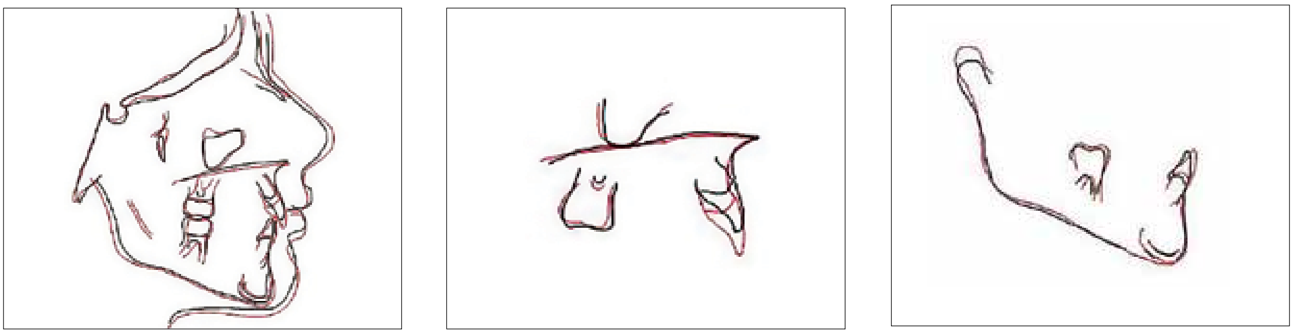


FIG. 8 Superimpositions of pre-treatment (black) and post-treatment (red) cephalometric tracings: a. superimposition on anterior cranial base; b. superimposition on maxilla; c. superimposition on mandible.

Discussion

Although it was understood that the patient was not in the ideal maturation stage for correction of a Class II malocclusion with mandibular retrognathism, i.e. the early adolescence right before the pubertal growth spurt [McNamara and Keim, 2014a; McNamara and Keim, 2014b; Sunnak et al., 2015], it was anyway decided to provide the child a first phase of treatment. The stated objectives of this early treatment were to expand the maxilla, thus encouraging a forward reposture of the mandible, and to control or hopefully revert the tendency of the mandible to rotate downward and backward with growth. Such unfavourable growth pattern had already visibly affected the aesthetics of the patient, particularly lower lip position and chin projection, as well as the definition of the chin-neck angle, at a critical age for the developing socialisation attitude of the child, in concomitance with the beginning of the primary school.

To address the issue of palatal contraction, an appliance of proven effectiveness, the rapid palatal expander [Eichenberger and Baumgartner, 2014; McNamara et al., 2015; Zhou et al., 2014], was chosen. After having increased the torque of the upper central incisors, the FRD was used for mandibular propulsion. The choice of a fixed advancer was thought to be advantageous in such a young patient, who might have offered poor compliance with a removable functional appliance. Beside the cooperation matter, also the need to manage a high angle growth pattern directed the appliance choice toward the FRD. The latter has been largely utilised in adolescents [Aras et al., 2011; Bilgiç et al., 2011; Bilgiç et al., 2015; Cacciatore et al., 2014; Franchi et al., 2011; Giuntini et al., 2015; Heinrichs et al., 2014; Jung, 2015; Servello et al., 2015; Tarvade et al., 2014] and proposed also for the treatment of young adults [Gao et al., 2014; Gunay et al., 2011; Krishna Nayak and Goyal, 2012]. Yet, the potential of FRD as a functional appliance in early treatment of children with severe Class II had not been previously explored.

In the presented early mixed dentition treatment with FRD an anchorage unit alternative to the multibracket set-up had to be conceived for the lower arch. On this regard, as both model and cephalometric superimpositions demonstrated that the buccal movement of lower incisors was confined within normal limits and lower molars moved mesially to a minimal extent (Fig. 7, 8c), it was deduced that the stainless steel ferrule provided valid anchorage to the mandibular arch. An intrusive movement of the lower incisors, commonly seen during treatment with FRD, was not observed in the present case, where indeed lower incisors slightly erupted (Fig. 7). A logical explanation for this finding was that the vertical force vectors of the coils did not directly act on the lower incisors as it happens in permanent dentition cases, where the pistons load the continuous lower archwire. Despite their slight eruption, lower incisors no longer impinged on the palatal mucosa at the end of treatment. Overjet reduction plausibly enabled this change. Conversely, the spontaneous unravelling of the lower incisors could be ascribed to the increase in the intercanine width following upper arch expansion, as well as to the incisors forward movement with FRD action (Fig. 7). Also in the upper arch it can be assumed that palatal expansion and molar distalisation contributed to the crowding relief that is noticeable on comparing pre- and post-treatment panoramic films (Fig. 1, 3). Concerning with upper molars, it should be observed that the transpalatal arch satisfactorily controlled their buccal tipping, though it was not able to prevent their excessive intrusion under the vertical force vectors of the FRD coil-piston system (Fig. 3, 6). Nevertheless, this unwanted change was quickly reverted, as the maxillary molars promptly reseated over the antagonists during retention (Fig. 4). Upper first molars moved distally, not encountering the hindrance of the second molars which were still developing higher up in the maxilla (Fig. 1).

The finding that the SNB angle did not change with treatment was quite surprising, as the improvement in the patient profile was indeed noticeable, particularly as far as chin projection was concerned (Fig. 3). It can be speculated that the soft tissue profile took the greatest advantage of the occurrence of a slight mandibular counterclockwise rotation that was testified by a reduction in the mandibular plane angle (Table 1), and was a sought-after effect of FRD treatment. An evident reduction in the amount of displayed gingiva was also obtained with treatment (Fig. 3, 5). As model superimpositions did not reveal any significant intrusion of the upper incisors (Fig. 6), it can be assumed that the improvement in the gummy smile resulted from a restrain of the downward growth of the maxilla effected by FRD. The plan to control the patient unfavourable growth pattern with FRD mechanics appeared therefore successful and the positive treatment effect was maintained over time (Fig. 5).

It should finally be mentioned that no complications occurred over the 7 months of action of the FRD, which was overall well tolerated by the young patient. As a matter of fact, in comparison with the Herbst appliance, FRD has been reported to be a less rigid appliance [Sood, 2011]. Moreover, the device used in this treatment required a less complex laboratory work than that needed for Herbst appliance, as only the double mandibular arch had to be fabricated. As indicated by the manufacturer, the coils were fitted in centric occlusion, without the need for a wax registration.

Conclusion

In conclusion, in a 7-year-old child with a severe Class II malocclusion the concern over the psychological reflections of the aesthetic impairment drove the decision to provide an early phase of treatment. The use of FRD as a non-compliance mandibular advancer after rapid palatal expansion was found to be effective at reducing the sagittal jaw discrepancy, successful at controlling the patient unfavourable growth pattern, and beneficial for the child aesthetics.

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