ORIGINAL ARTICLE

Prospective cephalometric study of the effects of maxillary protraction therapy associated with intermaxillary mechanics

Juliana de Oliveira da Luz Fontes*, Guilherme Thiesen**

Abstract

Objective: The early diagnosis and treatment of skeletal Class III (Pattern III) is still a much debated topic in orthodontic literature. Maxillary protraction associated with rapid maxillary expansion is the most popular and widely researched approach, producing the best results in the shortest period of time. This study aimed to evaluate the gradual changes that occur in the dentofacial complex in children with Pattern III growth treated with maxillary protraction associated with intermaxillary mechanics. **Methods:** The sample consisted of 10 patients with Pattern III, whose mean age was 8 years and 2 months at the beginning of treatment, consecutively treated with a modified Haas expander, modified lingual arch, intermaxillary elastics and Petit facemask for maxillary protraction during a 9-month period. Four lateral cephalograms were taken of each patient, one at the beginning of treatment and the other three at regular 3-month intervals (T1, T2, T3 and T4). Cephalometric measurements at each of the four times were compared using ANOVA variance for repeated measures and supplemented by Tukey's multiple comparisons test. **Results:** It was observed that the most significant skeletal changes occurred in the first 3 months of treatment. After that period the changes remained constant until the end of treatment. There were few dental compensations and the vertical changes which occurred showed reduced clinical significance. **Conclusions:** The therapy used in this study accomplished not only the correction of overjet but also improvements in the sagittal relationship of the basal bones and in soft tissue esthetics.

Keywords: Prognathism. Palatal expansion technique. Extraoral traction appliances. Malocclusion.

How to cite this article: Fontes JOL, Thiesen G. Prospective cephalometric study of the effects of maxillary protraction therapy associated with intermaxillary mechanics. Dental Press J Orthod. 2011 Nov-Dec;16(6):38.e1-9.

» The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

* Specialist in Orthodontics, UNISUL.
** MSc in Orthodontics and Dentofacial Orthopedics, PUC/RS. Professor of Orthodontics, UNISUL.

INTRODUCTION AND LITERATURE REVIEW

Class III malocclusion, originally defined by Angle as a mesial relationship between mandibular and maxillary molars, is actually linked to several skeletal and dental changes, which often result in a disharmonious facial appearance. Thus, Pattern III can be defined as a conspicuous anteroposterior imbalance expressed in the soft tissues of the face resulting from a sagittal skeletal discrepancy between basal bones (mandibular prognathism, maxillary deficiency, or a combination of both), accompanied or not by changes in the vertical and transverse directions. These discrepancies promote skeletal changes in the position of the teeth both inter and intra-arch.[4]

Despite its low prevalence when compared to other malocclusions,[6,21] it's prominent facial characteristics determine the need for therapy in the early development stages of individuals with this condition. However, early treatment of Pattern III can prove a major challenge to orthodontists in their clinical practice because of its complex control and difficulty in predicting the patient's morphogenetic growth pattern until adulthood.

Conversely, many professionals prefer to wait for skeletal maturity to treat this deformity through orthognathic surgery given uncertainties regarding the success and stability of early treatment. However, recent studies with long-term follow-up of patients who received early treatment with orthopedic mechanics have shown that good results can be achieved in a considerable number of patients.[26,28]

Among the early treatment modalities of Pattern III, maxillary protraction is the most popular and widely researched approach in the orthodontic literature, yielding the best results in the shortest period of time, especially in individuals who are in the late deciduous or early mixed dentition stage. Among the changes that occur during treatment, one could highlight maxillary displacement in the anterior direction, clockwise rotation of the mandibular plane, antero-superior displacement of the upper arch, lingual inclination of mandibular incisors, increased antero-inferior facial height and increased facial convexity.[1,6,10,16,18,19,23] Recently published studies report the use of different maxillary expanders, which may be associated with other intra- or intermaxillary appliances designed to enhance the skeletal effects of maxillary protraction.[3,12,14,22]

Given the undeniable importance of this topic as well as the many controversies that still surround it, this study aimed to evaluate how to maximize the effects of a proven method, i.e., maxillary protraction, through the concurrent use of this approach in combination with Petit facemask and intermaxillary mechanics with the continued use of Class III intraoral elastics. Moreover, there are no orthodontic studies in the literature assessing the gradual effects of this therapy throughout treatment, although some authors[4,7] have speculated that most skeletal effects occur during the first months of therapy.

MATERIAL AND METHODS

Sample description

To perform a prospective cephalometric study of the dental, skeletal and soft tissue changes induced during treatment, 10 patients (6 females and 4 males) were consecutively treated with a modified Haas expansion appliance, modified lingual arch and Petit facemask for maxillary protraction for a period of 9 months. Mean subject age was 8 years and 2 months at the beginning of treatment (ages ranging from 5 to 11 years). The sample was provided by the Department of Orthodontics of UNISUL – Florianópolis, Brazil.

Some selection criteria were used for inclusion of individuals in the experimental group: 1) Facial Pattern III with maxillary deficiency assessed by examining the nasolabial folds and marked deficiency in the malar region; 2) Pattern III skeletal growth, as determined by Wits≤ 0 mm; 3) deciduous dentition or mixed dentition, 4) anterior crossbite or end-to-end relationship; 5) no previous orthodontic treatment, 6) absence of congenital and/or other facial deformities.

The skeletal age of the patients was assessed using the method of cervical vertebrae maturation proposed by Bacceti, Franchi and McNamara.[2] This method consists of six stages of increasing development, but all the patients selected for this study were in the third stage, i.e., before the peak of pubertal growth spurt.

Anchorage system

Upper arch

The anchorage system used in the maxillary arch of all patients (Fig 1) was a modified fixed Haas type expansion appliance made of 1.2 mm steel wire (Dentaurum®) with buccal and lingual connecting bars. The buccal bar was extended distally in order to allow the insertion of Class III intraoral elastics. Deciduous second molars were banded whenever possible. When banding these teeth was not possible the first permanent premolars and molars were banded instead (Universal Band Kit – Morelli®). All other posterior teeth were often bonded with composite (Z100 – 3M). An 11-mm expansion screw was used (Dentaurum) and the activation protocol involved 2/4 turns per day, and the screw was opened to its maximum amplitude in all cases. During the active expansion phase (14 days after screw activation), Petit facemask for maxillary protraction was placed using an mean force of 400-600 g on each side. Patients were instructed to wear the facemask for an mean time of 12 hours per day.

Lower arch

The anchorage system used in the lower arch (Fig 2) was a modified Nance lingual arch made of 1.0-mm steel wire (Dentaurum®) with a buccal connecting bar and hooks in the canine region for the use of Class III intraoral elastics. Either the second deciduous molars or the first permanent molars were banded (universal band kit, Morelli®). The other posterior teeth were bonded with composite (Z100, 3M).

Class III elastics were extended (Fig 3) between the hooks on the posterior region of the modified Haas expander and the hooks in the anterior region of the modified Nance lingual arch. Patients were instructed to wear them 24 hours a day (removing them only for feeding and hygiene). The average force applied by the Class III intraoral elastic was 200-350 g.

All subjects in the experimental group wore the modified Haas appliance, the modified lingual arch and the facemask for a period of 9 months after which a positive overjet was attained.

FIGURE 1 - Modified fixed Haas type expansion appliance.

FIGURE 2 - Modified Nance lingual arch.

FIGURE 3 - Class III intermaxillary elastics associated with facemask extraoral elastics.

Measuring the changes

The dental, skeletal and soft tissues changes were evaluated through lateral cephalograms obtained at four different times: T1) beginning of treatment, before appliance placement; T2) after 3 months of treatment; T3) after 6 months of treatment; and T4) after 9 months of treatment, immediately before the appliance removal.

All radiographs were performed in the Radiology Department of Nivaldo Nuernberg Dental Institute (IONN, Florianópolis/SC, Brazil) using a lead protection and without charging the patients. It was always used the same X-ray machine (Siemens®, Germador-type, with a Margolis cephalostat).

The radiographs were processed by an employee of the IONN radiology department in a Al-pró Imagcorp processor (model A/T 2000M) in a dark chamber, using a total processing time of 3.5 minutes.

The cephalometric tracings were performed manually by the same previously calibrated examiner using black pencil. Comparative analysis between the two groups was conducted by measuring angular and linear profile cephalometric radiographs with scales of 0.5° and 0.5 mm, pairing up the four times in the experimental group (T1, T2, T3 and T4). No correction was made for linear magnification of the radiographic images (approximately 7% relative to the sagittal plane).

To calculate intra-examiner error, 20% of radiographs of experimental group were randomly selected and once again traced and measured with a two-week interval between the first and second evaluation. Error was calculated using Student's t-test for paired samples, comparing the values obtained in the first measurement with the values of the second measurement at a significance level of 5%. To calculate random error, Dahlberg's formula was employed.

After collecting the data, a database was structured to enable application of statistical tests using the software Statistica for Windows, version 6 (StatSoft). The cephalometric measurements were compared between the four times with ANOVA for repeated measures at a 5% significance level, since the same individual was measured at different times. To complement the analysis of variance, Tukey's multiple comparisons test was applied also at a 5% significance level, indicating when there were differences between the means (T1, T2, T3 and T4). Dental, skeletal and soft tissue changes were measured using angular (SNA, SNB, ANB, SN.Ocl, SN.PP, SN.GoMe, 1.NA, 1.NB, FMA, IMPA, 1./PP) and linear (Wits, ANS-Me, Co-A, Co-Gn, NPerp-A, NPerp-Pog, UL, LL, 1/-NA, /1-NB) cephalometric measures.

RESULTS

Calculation of intra-examiner error was performed by applying Student's t-test for paired samples at a 5% significance level. No statistically significant difference was found for any of the measures assessed. Likewise, no significant random error value was found for the angular and linear measures. The largest measurement differences were found to be 0.5° and 0.7 mm respectively.

Table 1 shows that most of the sagittal skeletal changes occurred in the maxilla in the first 3 months of therapy as revealed by the SNA, NPerpA and CoA measures. Moreover, it was confirmed that maxillary incisors underwent lingual inclination in the first three months of maxillary protraction. After that period, these teeth showed progressive proclination as treatment evolved. This initial retroclination was probably due to the substantial maxillary expansion experienced by these patients, which increased the perimeter of the maxilla.[5,27] After this initial period, labial inclination increased in the sixth and ninth months of therapy, corroborating the findings of several studies.[3,15]

Table 2 shows that measures SNB and NPerp-Pog remained virtually stable throughout treatment, exhibiting a slight reduction in the first 3 months of therapy, although not statistically significant. Effective mandibular length increased during treatment, confirming that patients' mandibles had grown during the evaluation period. However, this mandibular growth did not mean a mandibular protrusion probably due to the fact that the mandible rotated during that period.

Lower incisors showed mild retroclination during treatment as demonstrated by measures 1-NB, 1.NB and IMPA.

As shown in Table 3, treatment induced significant changes in the maxillomandibular relationship (ANB and Wits). These changes were significant in the first 3 months of treatment and remained almost stable until its end.

Table 4 allows assessment of vertical changes occurring during the treatment period. Although some mandibular rotation was noted during therapy (increases in FMA and SN.GoMe), this change was not statistically significant for any of the evaluated times. By the same reason, the palatal plane did not change significantly during treatment.

However, there were statistically significant changes in the anteroinferior facial height (ANS-Me) and in the occlusal plane (SN.Ocl). It is noteworthy that although there were changes in the occlusal plane during therapy, these changes were considered minor and clinically negligible after treatment.

Table 5 shows the measures that assess upper and lower lip protrusion relative to Steiner's S line (S-UL and S-LL). Upper lip protrusion was observed, with a significant increase in the

TABLE 1 - Means, standard deviations and variance analysis for measures used to evaluate maxillary effects.

Measure	Mean value of maxillary measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SNA	78.18 (2.85)^{A}	80.57 (3.47)^{B}	80.28 (2.60)^{B}	80.30 (3.05)^{B}	0.0001
NPerp-A	-0.51(2.79)^{A}	2.22 (2.22)^{B}	2.10 (2.39)^{B}	2.55 (2.11)^{B}	<0.0001
Co-A	83.50 (3.04)^{A}	85.56 (3.02)^{B}	86.31 (3.08)^{BC}	86.88 (3.34)^{C}	<0.0001
1.NA	4.53 (3.82)^{A}	3.47 (2.48)^{AB}	4.15 (2.93)^{AB}	5.08 (3.57)^{B}	0.0007
1/-NA	4.53 (3.82)^{A}	3.47 (2.48)^{AB}	4.15 (2.93)^{AB}	5.08 (3.57)^{B}	0.009
1.PP	115.28 (8.52)^{BC}	111.29 (9.12)^{A}	113.35 (6.80)^{AB}	116.35 (7.12)^{C}	0.0002

* Means followed by different letters differ significantly.

TABLE 2 - Means, standard deviations and variance analysis for measures used to evaluate mandibular effects.

Measure	Mean value of mandibular measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SNB	78.20 (3.09)	77.13 (2.88)	77.27 (2.85)	77.10 (3.67)	0. 082
NPerp-Pog	-1.19 (6.78)	-1.69 (6.40)	-1.64 (4.79)	-0.67 (4.97)	0.725
Co-Gn	109.79 (5.91)^{A}	110.89 (6.31)^{AB}	111.94 (7.40)^{AB}	112.95 (8.17)^{B}	0.006
1.NB	24.61 (5.87)	22.35 (4.64)	21.43 (6.04)	21.38 (6.57)	0.096
1/-NB	3.75 (2.18)	3.08 (2.14)	3.01 (2.14)	3.10 (2.40)	0.1
IMPA	89.26 (7.15)^{B}	85.50 (6.03)^{A}	85.83 (7.35)^{A}	85.10 (7.01)^{A}	0.0002

* Means followed by different letters differ significantly; where there are no letters, no significant difference was found.

TABLE 3 - Means, standard deviations and variance analysis for measures used to evaluate intermaxillary effects.

Measure	Periods				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
ANB	-0.02 (3.26)^{A}	3.34 (2.31)^{B}	3.02 (2.41)^{B}	3.20 (2.46)^{B}	<0.0001
Wits	-5.56 (3.29)^{A}	-1.78 (4.31)^{B}	0.48 (4.14)^{B}	-0.17 (3.46)^{B}	<0.0001

* Means followed by different letters differ significantly.

TABLE 4 - Means, standard deviations and variance analysis for measures used to evaluate effects in the vertical direction.

Measure	Mean value of vertical measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
SN.Ocl	19.33 (6.77)^{AB}	19.74 (6.84)^{B}	15.99 (7.34)^{A}	17.49 (8.51)^{AB}	0.031
SN.PP	8.25 (3.24)	7.62 (3.16)	7.70 (3.01)	8.26 (3.22)	0.728
SN.GoMe	37.35 (4.03)	39.32 (4.02)	38.34 (4.87)	38.35 (5.88)	0.084
FMA	26.18 (5.12)	27.59 (5.96)	26.40 (4.64)	26.85 (5.25)	0.062
ANS-Me	61.07 (5.63)^{A}	64.57 (5.38)^{B}	65.13 (5.01)^{BC}	65.84 (5.22)^{C}	<0.0001

* Means followed by different letters differ significantly; where there are no letters, no significant difference was found.

TABLE 5 - Means, standard deviations and variance analysis for measures used to evaluate soft tissues effects.

Measure	Mean value of soft tissue measurements (standard deviation)				ANOVA
	T1 (baseline)	T2 (3 months)	T3 (6 months)	T4 (9 months)	
S-UL	-0.19 (3.32)^{A}	0.15 (3.08)^{AB}	1.03 (3.18)^{B}	1.36 (2.92)^{C}	0.0003
S-LL	1.56 (3.17)^{A}	0.51 (3.27)^{AB}	0.76 (3.14)^{AB}	0.82 (3.16)^{B}	0.04

* Means followed by different letters differ significantly.

S-UL measure during treatment. Conversely, lower lip protrusion gradually decreased until the end of treatment.

DISCUSSION

Maxillary protraction in nowadays orthodontics has become the most widely used technique to correct the development of Pattern III maxillomandibular growth pattern. The popularity of maxillary protraction has increased due to awareness that maxillary deficiency plays a partial or key role in the structural etiology of Pattern III. Moreover, numerous reports have demonstrated that this appliance accomplishes a higher success rate in the long term when compared to other techniques, such as chin cups, functional appliances or camouflage therapy.[8,23,25]

Regardless of posttreatment stability, the major purpose of performing early treatment of Pattern III is to induce maximal skeletal changes with minimal dental compensation. Thus, a variety of extra and intraoral devices have been developed to enhance desirable orthopedic effects during orthopedic treatment of these patients.[12,14]

Furthermore, the results achieved by Holberg, Mahani and Rudziki[9] also should be taken into account. They reported that the forces commonly employed to promote maxillary protraction by using facemasks are apparently insufficient to significantly stimulate bone formation in circum-maxillary sutures. According to the authors, who analyzed maxillary protraction by means of the finite element method, it seems unlikely that the magnitude of the stresses induced in the sutural areas of the mid-face during therapy is sufficient to generate significant skeletal effects.

Therefore, the aim of this study was to evaluate the use of maxillary protraction associated with intermaxillary mechanics through the analysis of the gradual skeletal, dental and soft tissue effects induced by the treatment. Thus, the major goal of the therapy postulated in this study, which involves the concurrent use of intermaxillary mechanics in combination with a facemask, would be to maximize the orthopedic effect of early treatment of Pattern III.

It was noted that the mechanotherapy employed in this study proved superior—in terms of skeletal advancement of the maxilla—compared to most findings in the literature.[6,17,19,21,23,29] However, its performance was similar or inferior to others.[12,13,15,22] The same applies to the maxillomandibular relationship, which shows that the mechanotherapy applied in this study proved effective for the treatment of Pattern III, but similar to some studies that employed facemask alone.[10,11,15,22] The measures used to assess anterior mandibular protrusion exhibited a mild reduction, statistically insignificant and in line with other studies.[10,13,15,16,18,22,23]

At the end of the treatment proposed in this study, mild dentoalveolar compensations appeared in the upper arch (slight incisors buccal inclination assessed by measures 1.Na, 1-Na and 1.PP). In the lower arch, mandibular incisors experienced a slightly bigger retroclination but similar to what has been reported by other authors.[3,8,15]

Finally, these results clearly show that the simultaneous use of facemask and intermaxillary therapy, as suggested in this article, may not unreasonably potentiate the desired orthopedic effects in the interceptive treatment of Pattern III, but it neither maximize the role of the dentoalveolar component in the treatment.

Analysis of the four different assessment times revealed that most of the skeletal changes caused by therapy occurred within the first 3 months of treatment. After that period they remained almost constant until the end of treatment (as evidenced by the SNA, NPerp-A, Co-A, ANB and Wits measures presented in Tables 1 and 3).

Although most of the skeletal changes occurred in the first 3 months, it should be stressed that stopping treatment at this time could lead to relapse. Further investigation is necessary to clarify these issues.

Dental compensations were more evident in the last months of maxillary protraction (T3 and T4), and the maxillary incisors flared and mandibular incisors experienced progressive retroclination with treatment. However, the dental changes that occurred in this study can be considered minor. This leads to the conclusion that during treatment there is a tendency toward gradual dentoalveolar compensation with maintenance of the orthopedic effects achieved in the first months of maxillary protraction therapy.

The data presented in this study, which assessed maxillary protraction every 3 months, have significant clinical value as they shed light on the effects generated during treatment. Thus, the ideal time for intervention with this approach can be more accurately defined. However, some limitations of this study should be considered, including the lack of a control group, currently unfeasible for ethical reasons. Despite exhibiting normal distribution, the sample size used in this study can be considered somewhat small. In addition, longitudinal follow up is required to assess whether or not the positive effects achieved herein will be preserved until the end of the patients' growth period.

CONCLUSIONS

In observing the gradual skeletal changes that occurred during treatment one finds that virtually all significant skeletal changes took place in the first three months of treatment and remained constant until its end. From the dental point of view, there were few dental compensations. Vertical changes were also reduced and had little clinical significance. After treatment, it was found that maxillary protraction combined with intermaxillary mechanics was able to not only correct overjet but also improve sagittal relationship between basal bones and soft tissue esthetics, although these changes were not significantly enhanced when compared to others findings in the literature.

REFERENCES

1. Baccetti T, McGill JS, Franchi L, McNamara JA Jr, Tollaro I. Skeletal effects of early treatment of Class III malocclusion with maxillary expansion and face-mask therapy. Am J Orthod Dentofacial Orthop. 1998;113(3):333-43.
2. Baccetti T, Franchi L, McNamara Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod. 2005;11:119-29.
3. Battagel JM, Orton HS. A comparative study of the effects of customized facemask therapy or headgear to the lower arch on the developing Class III face. Eur J Orthod. 1995;17(6):467-82.
4. Capelozza Filho L. Diagnóstico em Ortodontia. Maringá: Dental Press; 2004.
5. Chung CH, Font B. Skeletal and dental changes in the sagittal, vertical, and transverse dimensions after rapid palatal expansion. Am J Orthod Dentofacial Orthop. 2004;126(5):569-75.
6. Gallagher RW, Miranda F, Buschang PH. Maxillary protraction: treatment and posttreatment effects. Am J Orthod Dentofacial Orthop. 1998;113(6):612-9.
7. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. Am J Orthod. 1970;57(3):219-55.
8. Hägg U, Tse A, Bendeus M, Rabie BM. Long-term follow-up of early treatment with reverse headgear. Eur J Orthod. 2003;25:95-102.
9. Holberg C, Mahaini L, Rudzki I. Analysis of sutural strain in maxillary protraction therapy. Angle Orthod. 2007;77(4):586-94.
10. Kapust AJ, Sinclair PM, Turley PK. Cephalometric effects of face mask/expansion therapy in Class III children: a comparison of three age groups. Am J Orthod Dentofacial Orthop. 1998;113(2):204-12.
11. Kim JH, Viana MA, Graber TM, Omerza FF, BeGole EA. The effectiveness of protraction face mask therapy: a meta-analysis. Am J Orthod Dentofacial Orthop. 1999;115(6):675-85.

12. Kircelli BH, Pektas ZO, Uçkan S. Orthopedic protraction with skeletal anchorage in a patient with maxillary hypoplasia and hypodontia. Angle Orthod. 2006;76(1):156-63.
13. Cha KS. Skeletal changes of maxillary protraction in patients exhibiting skeletal class III malocclusion: a comparison of three skeletal maturation groups. Angle Orthod. 2003;73(1):26-35.
14. Liou EJ, Tsai WC. A new protocol for maxillary protraction in cleft patients: repetitive weekly protocol of alternate rapid maxillary expansions and constrictions. Cleft Palate Craniofac J. 2005;42(2):121-7.
15. McDonald KE, Kapust AJ, Turley PK. Cephalometric changes after the correction of Class III malocclusion with maxillary expansion/facemask therapy. Am J Orthod Dentofacial Orthop. 1999;116(1):13-24.
16. Nartallo-Turley PE, Turley PK. Cephalometric effects of combined palatal expansion and facemask therapy on Class III malocclusion. Angle Orthod. 1998;68(3):217-24.
17. Ngan P, Yiu C, Hu A, Hägg U, Wei SH, Gunel E. Cephalometric and occlusal changes following maxillary expansion and protraction. Eur J Orthod. 1998;20(3):237-54.
18. Ngan PW, Hagg U, Yiu C, Wei SH. Treatment response and long-term dentofacial adaptations to maxillary expansion and protraction. Semin Orthod. 1997;3(4):255-64.
19. Pangrazio-Kulbersh V, Berger J, Kersten G. Effects of protraction mechanics on the midface. Am J Orthod Dentofacial Orthop. 1998;114(5):484-91.
20. Saadia M, Torres E. Sagittal changes after maxillary protraction with expansion in class III patients in the primary, mixed, and late mixed dentitions: a longitudinal retrospective study. Am J Orthod Dentofacial Orthop. 2000;117(6):669-80.
21. Silva Filho OG, Magro AC, Capelozza Filho L. Early treatment of the Class III malocclusion with rapid maxillary expansion and maxillary protraction. Am J Orthod Dentofacial Orthop. 1998;113(2):196-203.
22. Silva Filho O, Ozawa TO, Okada CH, Okada HY, Dahmen L. Anquilose intensional dos caninos decíduos como reforço de ancoragem para a tração reversa da maxila. Estudo cefalométrico prospectivo. Rev Dental Press Ortod Ortop Facial. 2006;11(6):35-44.
23. Sung SJ, Baik HS. Assessment of skeletal and dental changes by maxillary protraction. Am J Orthod Dentofacial Orthop. 1998;114(5):492-502.
24. Thiesen G, Hoffelder LB, Rego MVNN, Berthold TB, Marchioro EM. Tratamento precoce do Padrão III por meio de tração reversa da maxila. Rev Odonto Ciênc. 2004;19(45):281-6.
25. Turley PK. Orthopedic correction of Class III malocclusion with palatal expansion and custom protraction headgear. J Clin Orthod. 1988;22(5):314-25.
26. Wells AP, Sarver DM, Proffit WR. Long-term efficacy of reverse pull headgear therapy. Angle Orthod. 2006;76(6):915-22.
27. Wertz RA. Skeletal and dental changes accompanying rapid midpalatal suture opening. Am J Orthod. 1970;58(1):41-66.
28. Westwood PV, McNamara JA Jr, Baccetti T, Franchi L, Sarver DM. Long-term effects of Class III treatment with rapid maxillary expansion and facemask therapy followed by fixed appliances. Am J Orthod Dentofacial Orthop. 2003;123(3):306-20.
29. Williams MD, Sarver DM, Sadowsky PL, Bradley E. Combined rapid maxillary expansion and protraction facemask in the treatment of Class III malocclusions in growing children: a prospective long-term study. Semin Orthod. 1997;3(4):265-74.

Submitted: October 18, 2008
Revised and accepted: May 14, 2009

Contact address
Juliana de Oliveira da Luz Fontes
R. Hermínio Millis, 66 – Bom Abrigo
Zip code: 88.085-320 – Florianópolis/SC, Brazil
E-mail: juliana.fontes@gmail.com