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A retrospective comparison of functional appliance treatment of Class III malocclusions in the deciduous and mixed dentitions

Tiziano Baccetti and Isabella Tollaro
Department of Orthodontics, University of Florence, Italy

SUMMARY This retrospective study compared the effectiveness of treatment of Class III malocclusions with the removable mandibular retractor in the deciduous and mixed dentitions.

A group of 20 children with Class III malocclusions started treatment at a mean age of 5 years 1 month ± 7 months (deciduous dentition), while a group of 18 children with Class III malocclusions started treatment at a mean age of 8 years 2 months ± 9 months (mixed dentition). The mean observation period was 2 years 3 months ± 6 months for the first group, and 2 years 4 months ± 7 months for the second group. Matched control groups of children with untreated Class III malocclusions in the deciduous and in the mixed dentition (16 subjects and 15 subjects, respectively) were used. The cephalometric analysis was based on a stable basicranial reference system appropriate for longitudinal studies that begin at early developmental ages.

The results showed that treatment of Class III malocclusions in the deciduous dentition produced a more significant anterior morphogenetic rotation of the mandible, due to a more upward and forward direction of condylar growth ($P < 0.01$). This leads to significantly smaller increments in mandibular total length (Co–Pg) in children with Class III malocclusions undergoing very early treatment ($P < 0.01$). On the contrary, maxillary dento-alveolar protrusion induced by therapy was greater in Class III subjects treated in the mixed dentition ($P < 0.01$). The optimum timing to improve skeletal relationships in Class III malocclusions by means of a functional appliance appears to be in the deciduous dentition.

Introduction

Many researchers have claimed the effectiveness of early treatment of Class III malocclusions featuring either maxillary retrusion or mandibular protrusion. Nevertheless, when analysing in detail the initial age of Class III patients undergoing 'early' treatment, the starting time differs widely in the literature. A few authors report the results of studies that were initiated as early as the deciduous dentition (Thilander, 1963; Graber, 1977; Ritucci and Nanda, 1986; Stensland *et al.*, 1988; Tollaro *et al.*, 1995, 1996), while others describe craniofacial changes induced by treatment in the mixed dentition (Irie and Nakamura, 1975; Ishii *et al.*, 1987; Rygh and Ask, 1992; Allen *et al.*, 1993; Hanada *et al.*, 1994; Ülgen and Firatli, 1994; Battagel and Orton, 1995; McNamara and McGill, 1995).

The results of early treatment of Class III malocclusions in relation to the beginning of therapy are available for samples of subjects that were treated with a chincap (Sakamoto, 1981), with chincap combined with FR3 (Mutschisch and Droschl, 1994), and with chincap combined with maxillary protraction headgear (Takada *et al.*, 1993). In particular, Sakamoto (1981) noted a greater improvement of skeletal sagittal relationships in Japanese children with Class III malocclusions treated with a chincap from the age of 3–5 years compared with children treated at later ages. By investigating relatively small groups of patients (nine subjects in the deciduous dentition and 11 subjects in the mixed dentition) Mutschisch and

Droschl (1994) found that very early treatment of Class III malocclusions offered the best chance to achieve normal skeletal relationships.

Previous studies (Tollaro *et al.*, 1995, 1996) demonstrated that treatment of Class III malocclusion in the deciduous dentition by means of a functional appliance (Removable Mandibular Retractor, RMR) produced significant effects on the direction of condylar growth and, consequently, on mandibular size and shape.

The aim of this study was to compare craniofacial changes induced by treatment of Class III malocclusions with the RMR in the deciduous and mixed dentitions, in order to establish optimum timing for this type of therapy.

Subjects and methods

Subjects

Four groups of subjects with Class III malocclusion were selected from the files of the Department of Orthodontics of the University of Florence.

The first group (group 1) consisted of 20 children (14 males, nine females), mean age at the first observation (immediately before the beginning of treatment) 5 years 1 month ± 7 months, mean age at the second observation (after treatment) 6 years 11 months ± 8 months. The second group (group 2) consisted of 16 children (nine males, seven females), mean age at the first observation 5 years 2 months ± 8 months, mean age at the second observation 7 years 2 months ± 9 months. This group had not undergone any treatment and was used as control for group 1 (treatment of Class III malocclusion in the deciduous dentition). At the time of first observation all the subjects both in groups 1 and 2 showed full deciduous dentition with anterior crossbite, a Class III deciduous canine relationship, and mesial step deciduous molar relationship.

The third group (group 3) comprised 18 subjects (11 males, seven females), mean age at the first observation (immediately before treatment) 8 years 2 months ± 9 months, mean age at the second observation (after treatment) 9 years 11 months ± 1 year. The fourth group (group 4) comprised 15 subjects (nine males, six females), mean age at the first observation 8 years 1 month ± 7 months, mean age at the second observation 10 years 1 month ± 9 months. Group 4 was an untreated group which was used as control for group 3 (treatment of Class III malocclusion in the mixed dentition). At the time of the first observation all the subjects in groups 3 and 4 were in the mixed dentition and exhibited anterior crossbite, a Class III deciduous canine relationship, and a Class III permanent molar relationship.

Additional criteria for case selection were that all groups were white, with no missing or supernumerary teeth, and an absence of cleft lip or palate, or other craniofacial malformations.

Functional analysis of mandibular protrusion (Graber *et al.*, 1985) revealed a postural rest position of the mandible anterior to the occlusal position in all the patients.

The second observation was performed in both treated groups (1 and 3) when a full correction of anterior crossbite had been achieved. The mean observation period was 2 years 3 months ± 6 months in group 1, 2 years 2 months ± 8 months in group 2, 2 years 4 months ± 7 months in group 3, and 2 years ± 9 months in group 4.

The availability of subjects with untreated Class III malocclusions (groups 2 and 4) was due to the fact that several patients with Class III malocclusions refused treatment at the time of the first observation and started treatment at later ages.

Appliance

Treatment was accomplished in groups 1 and 3 by means of RMR throughout the observation period (Figure 1). As described in previous articles (Tollaro *et al.*, 1995, 1996), RMR is constructed to work as a true functional appliance. The appliance consists of a resin plate which is attached to the upper jaw by Adams' clasps and which bears a labial arch extending to the cervical margin of the mandibular incisors. The labial arch is activated so as to be placed 2 mm in front of these teeth when the mandible is forced into maximum retrusion. Therefore, the arch is intended to work as a stop for sagittal movement of the mandible. Expansion screws and springs for the proclination of upper incisors were added to RMR in all treated subjects.

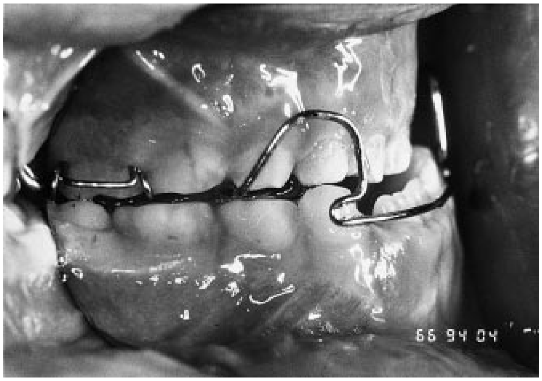

Figure 1 Removable Mandibular Retractor.

The children of both treated groups wore the appliance at least 14 hours a day (night-time included) until the first evidence of a corrected anterior crossbite. Thereafter, the patients wore the same appliance night-time only until completion of the observation period. Co-operation to treatment was good in both treated groups.

Cephalometric analysis

Lateral cephalograms of the 69 children with Class III malocclusions were taken at the first and second observations. The same X-ray device was used for the 138 radiograms, which were carried out by a single technician. Focus-median plane distance was 152 cm and film-median plane distance was 10 cm with an enlargement of approximately 7 per cent. No correction was made for this radiographic enlargement, as it affected all the cephalograms of all the four groups in the same way.

Cephalometric analysis comprised a reference system traced through craniofacial stable structures and represented by the two following lines (Tollaro *et al.*, 1995, 1996):

1. Stable basicranial line (SBL): this line is traced through the most superior point of the anterior wall of the sella turcica at the junction with tuberculum sellae (point T, Viazis, 1991) and it is tangent to lamina cribrosa of the ethmoid. These basicranial structures do not undergo remodelling from the age of 4–5 years (Melsen, 1974).
2. Vertical T (VertT): line perpendicular to SBL and passing through point T.

The following landmarks were also used for the analysis: point A (A), point B (B), prosthion (Pr), infradentale (Id), pogonion (Pg), menton (Me), gonion intersection (Go), articulare (Ar), condylion (Co), centre of the condyle (Cs), i.e. a point equidistant from the anterior, posterior, and superior borders of the condylar head, basion (Ba), anterior nasal spine (ANS), posterior nasal spine (PNS). The definitions of all these landmarks correspond to those given by Björk (1947), Ødegaard (1970), and Riolo *et al.* (1974).

Linear measurements for the assessment of sagittal relationships (Figure 2): A–VertT, B–VertT, Pr–VertT, Id–VertT.

Linear measurements for the assessment of mandibular dimensions (Figure 2): Co–Pg, Co–Go, Go–Pg.

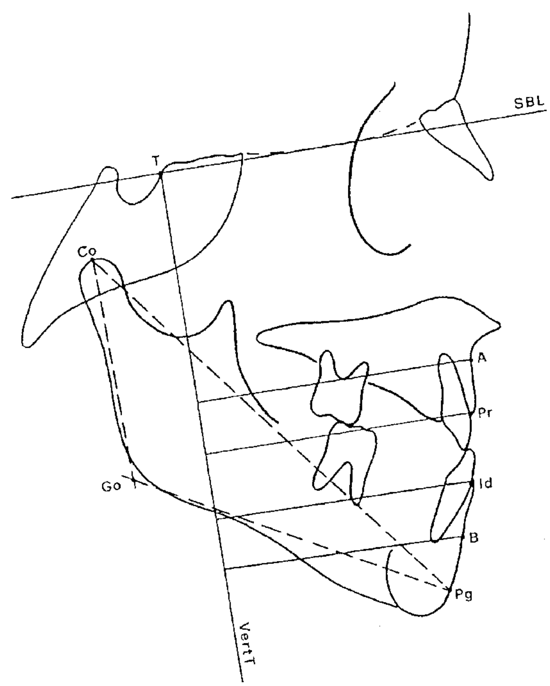

Figure 2 Linear measurements for assessment of sagittal relationships (continuous lines) and of mandibular dimensions (dotted lines).

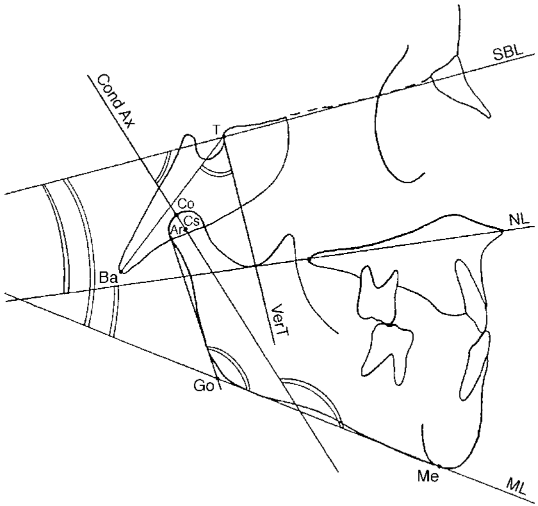

Figure 3 Angular measurements for assessment of cranial base angulation, vertical relationships, and mandibular ramus and condyle inclinations.

Angular measurement for the assessment of cranial base angulation (Figure 3): Ba–T–VertT.

Angular measurements for the assessment of vertical relationships (Figure 3): mandibular line (ML)–SBL, nasal line (NL)–SBL, nasal line-mandibular line (NL–ML).

Angular measurements for the assessment of mandibular ramus and condyle inclinations (Figure 3): gonial angle (Ar–Go–Me), condylar axis (CondAx)–SBL, CondAx–ML. Condylar axis is a line passing through point condylion and point Cs.

Method error

All the radiographs were traced by one investigator and then retraced by the other investigator. Average values for landmark locations were used. Method error was calculated for all the measurements by means of Dahlberg's formula (Dahlberg, 1940) on the total number of observations. The error ranged between 0.12 and 0.75 mm for the linear measurements, and between 0.18 and 0.88 degrees for the angular measurements. Houston's coefficient of reliability (Houston, 1983) was greater than 90 per cent for all the measurements.

Data analysis

The values for all the cephalometric measurements at the time of first observation in groups 1 and 2, and in groups 3 and 4 were compared by means of a non-parametric test (Mann–Whitney *U*-test) for independent samples ($P < 0.05$; Glantz, 1987; Statgraphics®, 1987). No statistically significant differences for any measurement were found (Table 1).

The homogeneity between groups 1 and 2, and between groups 3 and 4, as to type of malocclusion, sex, observation period, craniofacial sagittal and vertical relationships, cranial base angulation, and condyle and ramus inclinations at the first observation allowed a comparison of groups 1 and 2, and of groups 3 and 4 on the differences between the values at the second and at the first observation for all the cephalometric variables (Mann–Whitney *U*-test). The method error for these differences was also calculated as their values could be affected by tracing errors both at the first and at the second observation (Dahlberg, 1940). The error ranged between 0.24 and 0.97 mm for linear measurements and between 0.21 and 0.92 degrees for angular measurements.

While for angular measurements the differences between the values at the second and at the first observation were considered, for linear measurements the comparison was made on the percentage changes (increments or decreases) shown by the value at the second observation in relation to the value at the first observation. Percentage increments or decreases were used in order to minimize the effects of dimensional differences of starting forms, due to the different initial ages of the two groups (Wendell and Nanda, 1985).

Furthermore, a comparison between untreated groups in the deciduous and mixed dentitions (groups 2 and 4), and between treated groups in the deciduous and mixed dentitions (groups 1 and 3) on the changes from the first to the second observation was performed by means of Mann–Whitney *U*-test.

The level of significance for all these comparisons was $P < 0.01$, due to the multiple comparisons.

Table 1 Descriptive statistics and statistical comparison of starting forms.

Cephalometric measurements	Group 1 (treated group in the deciduous dentition) $n = 20$				Group 2 (untreated group in the deciduous dentition) $n = 16$				Mann–Whitney *U*-test ($P < 0.05$)	Group 3 (treated group in the mixed dentition) $n = 18$				Group 4 (untreated group in the mixed dentition) $n = 15$				Mann–Whitney *U*-test ($P < 0.05$)
	Median	Max	Min	Range	Median	Max	Min	Range		Median	Max	Min	Range	Median	Max	Min	Range	
A–VertT (mm)	55	65.5	44	21.5	55.75	66	42.5	23.5	*ns*	57.5	67.5	48.5	19	57.5	69	46	23	*ns*
B–VertT (mm)	53.5	64	36	28	52.5	63	36	27	*ns*	57	67	46.5	20.5	57.5	69	43.5	25.5	*ns*
Pr–VerT (mm)	54.75	62.5	42	20.5	55.5	66	40	26	*ns*	58	76	48	28	57.25	72.5	51	21.5	*ns*
Id–VertT (mm)	55.75	64.5	39	25.5	54.75	66	38.5	27.5	*ns*	58.25	73	44	29	58	69.5	44	25.5	*ns*
Co–Pg (mm)	97	108	88.5	19.5	98	107.5	87	20.5	*ns*	106.5	122	92	30	105.75	120	99	21	*ns*
Co–Go (mm)	44	50	39.5	10.5	45	49	40.5	8.5	*ns*	49.75	65	44	21	50.25	57	43	14	*ns*
Go–Pg (mm)	66.5	73.5	58	15.5	65.5	73.5	57	16.5	*ns*	68.5	83	63	20	69.5	80	63	17	*ns*
Ba–T–VertT (°)	41	47	29	18	40	49	29	20	*ns*	40	47	28	19	40.5	45	34.5	10.5	*ns*
ML–SBL (°)	30	55	21.5	33.5	30	54	23	31	*ns*	29.5	42.5	14	28.5	30.5	42	19	23	*ns*
NL–SBL (°)	3.5	16	–0.5	16.5	4.5	16	–1.5	17.5	*ns*	3.25	11	–5.5	16.5	3.75	9	–3	12	*ns*
NL–ML (°)	27	33.5	14.5	19	25	41	19.5	21.5	*ns*	27.5	40	18	22	27	33.5	14.5	19	*ns*
Ar–Go–Me (°)	128.25	138	117.5	20.5	129	144	121	23	*ns*	128	139.5	114	25.5	128.25	138	117.5	20.5	*ns*
CondAx–SBL (°)	70.5	87	64	23	66.5	74	58.5	15.5	*ns*	71.5	88	67	21	70.5	87	64	23	*ns*
CondAx–ML (°)	139	146	124	22	142	155.5	123	32.5	*ns*	140.5	153	126	27	139	146	124	22	*ns*

ns = not significant

Results

Table 2 reports the descriptive statistics and the results of the non-parametric statistical comparison on the differences or on the percentage increments/decreases between the second and the first observation for the cephalometric measurements in all the four groups.

Comparison between treated and untreated groups in the deciduous dentition (groups 1 and 2)

The treated group in the deciduous dentition (group 1) showed significantly larger percentage increments for A–VertT and Pr–VertT. However, there were significantly smaller percentage increments for B–VertT, Id–VertT, and Co–Pg, and significantly smaller increments of the gonial angle and in the inclination of the condyle to the mandibular line. Smaller decreases were also found in the inclination of the condyle to the cranial base, when compared with the controls (group 2). No other significant treatment effects were detected in the deciduous dentition.

Comparison between treated and untreated groups in the mixed dentition (groups 3 and 4)

The only significant differences between group 3 and group 4 were significantly larger percentage increments for Pr–VertT, and smaller percentage increments for Id–VertT.

Comparison between untreated groups in the deciduous and mixed dentitions (groups 2 and 4)

The changes between the first and the second observation did not show any significant differences in the Class III untreated group in the deciduous dentition (group 2) when compared with the Class III untreated group in the mixed dentition (group 3).

Comparison between treated groups in the deciduous and mixed dentitions (groups 1 and 3)

When compared with the group treated in the deciduous dentition (group 1), the group treated in the mixed dentition (group 3) exhibited significantly smaller percentage decreases for B–VertT and larger percentage increments for Pr–VertT and Co–Pg, significantly smaller decreases for Ar–Go–Me and CondAx–ML, and significantly smaller increments for CondAx–SBL.

Discussion

Although a large number of clinical studies have demonstrated short- and long-term results of orthodontic/orthopaedic treatment on growing mandibles, little is known about different skeletal treatment effects of Class III malocclusion in the deciduous and mixed dentitions. The present cephalometric study was carried out retrospectively to compare the effectiveness of the removable mandibular retractor for the correction of mandibular protrusion in these two phases of development.

The cephalometric analysis applied was suitable for longitudinal investigations starting from the earliest ages, as it was based on a reference system drawn through stable basicranial structures (Melsen, 1974). The results of previous studies on early treatment of Class III malocclusion suggested the use of angular measurements of skeletal change in mandibular ramus and condylar growth in addition to sagittal and vertical parameters

The use of matched control groups consisting of untreated Class III subjects allowed a comparison directly on the changes between the first and the second observation for both the developmental phases.

The group treated in the deciduous dentition (group 1) showed more significant skeletal modifications than the group treated in the mixed dentition (group 3), when compared with controls (groups 2 and 4, respectively):

(1) Decreases in mandibular protrusion. The distance between VertT line and point B became significantly reduced along with treatment in the deciduous dentition, while the same did not occur for the group in the mixed dentition. Changes in maxillary protrusion (A–VertT) did not show significant differences between the two treated groups, even when the changes in A–VertT were significant in children treated in

Table 2 Descriptive statistics and statistical comparisons for the differences between the second and the first observation.

Cephalometric measurements	Differences second — first observations																Mann–Whitney *U* test ($P < 0.01$)			
	Group 1 (treated group in the deciduous dentition) $n = 20$				Group 2 (untreated group in the deciduous dentition) $n = 16$				Group 3 (treated group in the mixed dentition) $n = 18$				Group 4 (untreated group in the mixed dentition) $n = 15$				Group 1 versus Group 2	Group 3 versus Group 4	Group 2 versus Group 4	Group 1 versus Group 3
	Median	Max	Min	Range	Median	Max	Min	Range	Median	Max	Min	Range	Median	Max	Min	Range				
A–VertT†	5.27	12.5	–3.84	16.34	2.24	10.8	–3.12	13.92	3.8	8.51	–1.56	10.07	2.65	9.46	0.28	9.18	*	*ns*	*ns*	*ns*
B–VertT†	–0.47	5.18	–10.38	15.56	7.61	12.24	0.16	12.08	5.45	8.69	–7.11	15.8	8.1	11.42	1.12	10.3	*	*ns*	*ns*	*
Pr–VerT†	7.76	15.04	–1	16.04	2.25	11.41	–2.7	14.11	13.1	22.56	7.14	15.42	3.62	12.8	–1.9	14.7	*	*	*ns*	*
Id–VertT†	0.45	6.26	–10.36	16.62	6.84	11.38	1.25	12.63	1.77	7.89	–5.76	13.65	6.69	13.49	–2	15.49	*	*	*ns*	*ns*
Co–Pg†	5.2	11.34	0	11.34	8.67	16.78	3.26	13.52	7.98	15.78	4.16	11.62	8.27	14.84	3.21	11.63	*	*ns*	*ns*	*
Co–Go†	11.36	18.22	1.14	17.08	11.11	19.5	2.81	16.69	10.1	19.41	4	15.41	10.9	18.6	3.34	15.26	*ns*	*ns*	*ns*	*ns*
Go–Pg†	8.27	18.38	2.28	16.1	7.63	17.83	3.44	14.39	8.38	14.47	2.5	11.97	8.63	16.71	4.27	12.44	*ns*	*ns*	*ns*	*ns*
Ba–T–VertT (°)	–1.5	5	–5.5	10.5	–1	4.5	–6.5	11	–1.5	1.5	–3.5	5	–1	3.5	–2.5	6	*ns*	*ns*	*ns*	*ns*
ML–SBL (°)	–2	5	–4.5	9.5	–1	4	–5	9	1	3	–3.5	6.5	0	4.5	–3	7.5	*ns*	*ns*	*ns*	*ns*
NL–SBL (°)	0	2.5	–7	9.5	–0.5	3	–8	11	0.5	4	–3	7	0.5	3.5	–3	6.5	*ns*	*ns*	*ns*	*ns*
NL–ML (°)	0.5	3.5	–5	8.5	0.25	4	–3.5	7.5	0.25	4.5	–4	8.5	–0.75	3	–3.5	6.5	*ns*	*ns*	*ns*	*ns*
Ar–Go–Me (°)	–4.5	0	–13.5	13.5	0.5	3.5	–5.5	9	–2	2	–4.5	6.5	0.25	4.5	–6.5	11	*	*ns*	*ns*	*
CondAx–SBL (°)	8.5	15.5	1	14.5	–1.5	4.5	–7	11.5	3.5	6	–5.5	11.5	1	6.5	–4	10.5	*	*ns*	*ns*	*
CondAx–ML (°)	–7.5	–0.5	–19	18.5	1	6.5	–6.5	13	–3.25	6.5	–7.5	14	–0.5	3	–10.5	13.5	*	*ns*	*ns*	*

† = percentage changes relative to the first observation
* = significant
ns = not significant

the deciduous dentition. They were not significant in the children treated in the mixed dentition, when compared with untreated controls.

(2) Increments in maxillary dento-alveolar protrusion were greater in the group treated in the mixed dentition, whereas no statistically significant differences were found between the two treated groups for changes in mandibular dento-alveolar protrusion.

(3) Modifications in the inclination of mandibular ramus and of condylar axis were larger in the group treated in the deciduous dentition. In subjects undergoing very early treatment the condyle showed a more upward and forward direction of growth, and decreases in the gonial angle were significantly more evident. As an ultimate consequence of such skeletal change, increments in the total length of the mandible (Co–Pg) were significantly smaller in the group treated in the deciduous dentition.

No significant differences between very early and early treatment of Class III malocclusion were found for cranial base angulation or for skeletal vertical relationships.

Skeletal and dento-alveolar changes in the two groups with untreated Class III malocclusions did not differ significantly. Therefore, the comparisons between the two age groups undergoing treatment were not related to normally occurring differences in the facial growth between the two age groups with untreated Class III malocclusion.

As stated in previous contributions (Tollaro *et al.*, 1995, 1996), major skeletal changes induced by early functional therapy in Class III children involve primarily mandibular shape. Anterior morphogenetic rotation of the mandible takes place in treated children as a result of upward and forward direction of condylar growth and of a reduction of gonial angle. These phenomena represent a biological mechanism which is able to 'dissipate' excess of mandibular growth relative to the maxilla and, consequently, to reduce total length of the mandible (Lavergne and Gasson, 1977a,b, 1978). The present study demonstrated that all these processes are significantly more effective in those children with Class III malocclusion who are treated in the deciduous dentition.

Minor skeletal modifications can be induced by treatment starting from more advanced dentition phases. On the other hand, increments in maxillary dento-alveolar protrusion were greater in the group that underwent treatment in the mixed dentition. More proclination of the upper incisors is then necessary to achieve a normalized occlusion in the mixed dentition, compensating for weaker skeletal adaptations.

The findings of this study agree with previous evidence on smaller groups of Japanese subjects (Sakamoto, 1981) and of European subjects (Mutschisch and Droschl, 1994) treated with a chin cap. Therefore, optimum timing for treatment of Class III malocclusion either with orthopaedic devices or with functional appliances appears to be during the deciduous dentition. Further studies analysing the differential long-term stability of the results achieved by treatment of Class III malocclusions either in the primary dentition or at later developmental phases are obviously needed to confirm these results.

Conclusions

The results of the present longitudinal cephalometric study on craniofacial skeletal modifications induced by early functional treatment of Class III malocclusion with the Removable Mandibular Retractor in the deciduous dentition compared with the same type of treatment during later developmental phases (mixed dentition) may be summarized as follows:

1. Treatment of Class III malocclusion in the deciduous dentition is able to produce a more significant anterior morphogenetic rotation of the mandible due to an upward-forward direction of condylar growth, leading to reduced mandibular protrusion and total length;
2. Maxillary dento-alveolar protrusion induced by treatment is greater in subjects treated at later ages, whereas skeletal changes are significantly more evident in children treated in the deciduous dentition.

Address for correspondence

Dr Tiziano Baccetti
Istituto di Odonto-Gnato-Stomatologia
Università degli Studi di Firenze
Via del Ponte di Mezzo, 46–48
50127 Firenze
Italy

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