Original Article

Early Treatment to Correct Class III Relations with or without Face Masks

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ABSTRACT

Objective: To determine what therapeutic effects can be expected in the case of early treatment of Class III relations with removable appliances with or without face masks.

Materials and Methods: Records available at the university clinic of Tübingen for 41 patients who had undergone early treatment because of prognathic abnormalities were retrospectively evaluated. Lateral cephalograms taken and casts obtained at baseline and at the end of early treatment were included in the analysis. Two treatment strategies were compared. The first group included removable functional orthopedic appliances only (FOA group), while the second group was treated with removable appliances and with face masks mounted on a cemented maxillary expansion appliance (face mask group).

Results: Positive changes were achieved in both groups for overjet (FOA group: +1.3 mm; face mask group: +2.2 mm) and Wits values (FOA group: +0.4 mm; face mask group: 1.7 mm). Moreover, a change in mean ANB values was achieved in the face mask group (+0.9°). The FOA group exhibited a reduction in mandibular angles. Changes in maxillary inclination with reduced inclination angles led to increases in overjet and overbite. The face mask group showed dorsal rotation of the mandible with reduced SNB values (−0.8°).

Conclusion: Early treatment of prognathism is a meaningful option, as demonstrated by the dentoskeletal (and hence functional) improvements observed in the present study.

KEY WORDS: Prognathism; Class III; Early treatment; Face mask; Prognathism activator

INTRODUCTION

Considering the protracted treatment schedules in prognathism, any information that would shed light on the effectiveness of early treatment in the deciduous dentition or in the early phase of the mixed dentition is relevant. One important question is whether the changes induced to skeletal or dental relations by early treatment will be permanent.

The success of early treatment has been confirmed by investigations of maxillary protraction using Delaire face masks with various modifications. Takada et al[1] reported on treatment with maxillary protraction headgears in three different age groups. The prepubertal and midpubertal groups revealed a significantly greater effect on maxillary growth and more pronounced enlargement of the SNA angles than the postpubertal group. Baccetti et al[2] and Kim et al[3] reported that treatment with face masks to ventralize maxillary growth was more effective in early than in late mixed dentitions. Similarly, Suda et al[4] observed that face masks combined with maxillary expansion appliances were more effective in early than in late phases of skeletal maturation.

Similar results were obtained with functional orthopedic appliances (FOAs). Baccetti and Tollaro[5] reported that treatment with a mandibular retractor influenced mandibular rotation and condylar development more effectively in children with deciduous than mixed dentition. Wilhelm-Nold and Droschl[6] achieved better treatment outcomes in deciduous than in permanent dentitions using chin caps with or without simultaneous application of Fränkel's function regulator type III.

Essential requirements for early treatment of Class III relations include optimal timing but also selecting the most appropriate orthodontic appliance. Removable plates, functional orthopedic appliances, and face masks (frequently mounted on a cemented maxillary expansion appliance) are known to be clinically effec-

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Table 1. Treatment Groups Including Number of Patients, Treatment Duration, and Gender Distribution

	No. of Patients	Female	Male	Mean Age at Baseline, y	Mean Duration of Treatment, mo
Maxillary expansion appliance + face mask	17	11	6	6.98	29.47
Functional orthopedic appliances only + plate	24	13	11	7.12	31.29

tive in this connection. Frequently, the therapy does not remain confined to a specific type of appliance but may instead include various appliances in combination, depending on the treatment progress.

The objective of the present study was to investigate the effects of treatment with strictly removable appliances compared to treatment with removable appliances in combination with face masks.

MATERIALS AND METHODS

The records of 41 patients who had undergone early treatment because of prognathic abnormalities were used for retrospective analysis. Only patients with negative Wits values[7] or negative differences between individual and measured ANB values[8] were included. None of the patients had reached the late phase of mixed dentition. Patients with syndromes were excluded from the study.

Patients who had been treated exclusively with removable appliances (plates, functional orthopedic appliances) were assigned to the FOA group. Patients who alternated between removable appliances and a face mask mounted on a maxillary expansion appliance were assigned to the face mask group. The orientation of tensile forces was ventrocaudal, starting at palatally mounted hooks. Table 1 shows number of patients, gender distributions, mean ages at baseline, and treatment periods.

Treatment was carried out for a mean of 31.3 months in the FOA group and for a mean of 29.5 months in the face mask group. Casts were fabricated, and standardized lateral cephalograms were taken and analyzed both at baseline and after early treatment was completed. The casts were used to evaluate overjet and overbite; the cephalometric parameters are illustrated in Figure 1.

Lateral cephalograms were analyzed by a single investigator using fr-win software (Computer Konkret AG, Falkenstein, Germany). Another 10 cephalograms obtained at least 2 months later were arbitrarily picked for analysis. In accordance with Dahlberg,[9] the combined systematic error was calculated as $\sqrt{\Sigma\ d^2/2n}$, where d is the difference between two measurements and n is the number of measurements performed in duplicate. The systematic error in this study was found to be 0.76° (range, 0.46° to 1.23°) for angular measurements and 0.80 mm (range, 0.41 to 1.16 mm) for linear measurements.

As a normal distribution could not be assumed given the small number of cases, the *t*-test could not be applied reliably, and the statistical comparison of the result for the two groups was done using the two-sided Wilcoxon test with JMP[10] statistic software.

Table 2 shows the average baseline values for the situations in both groups. Larger differences were seen only for the sagittal values for SNB, ANB, Wits, and overjet, although only the ANB and overjet values were statistically significant.

The treatment provider used his or her own discretion in determining which appliances were to be used during the course of treatment. The values demonstrate, however, that—in addition to removable therapy—face masks mounted on a cemented maxillary expansion appliance (face mask group) were used in the more pronounced skeletal Class III cases. A removable treatment only (FOA group) was performed for the less pronounced Class III cases.

RESULTS

An overview of the results is provided in Table 3. The effect of early treatment on maxillary position was

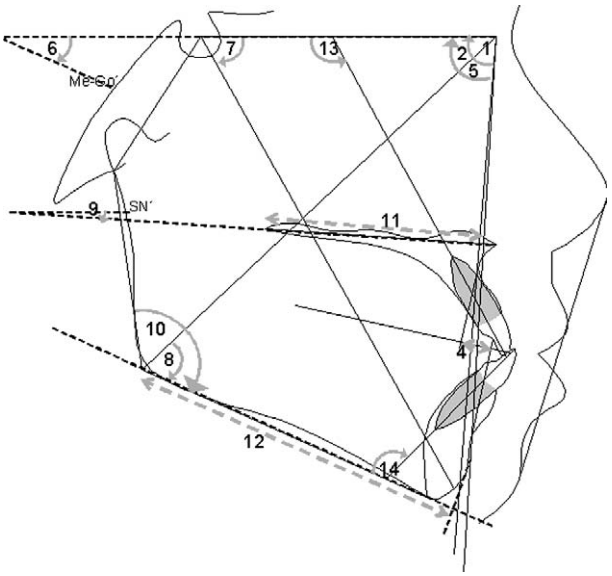

Figure 1. Illustration of angles and distances measured in cephalograms. 1: SNA; 2: SNB; 3: ANB (not shown); 4: Wits value; 5: SNPog; 6: SN-MeGo; 7: y-axis (SNGn); 8: Go2 angle (NGoMe); 9: SN-SpP (maxillary inclination); 10: mandibular angle (ArGoMe); 11: length of maxilla; 12: length of mandible; 13: angulation of upper first incisor; and 14: angulation of lower first incisor.

Table 2. Baseline Values for Both Groups[a]

Variable	FOA Group	Face Mask Group	*P* Value
SNA, °	80.72 (79.56, 81.90)	80.84 (79.45, 82.23)	.989
SNB, °	77.83 (76.40, 79.25)	79.68 (77.98, 81.37)	.149
ANB, °	2.90 (2.01, 3.79)	1.36 (0.30, 2.42)	.027
Wits, mm	−2.43 (−3.28, −1.57)	−3.74 (−4.76, −2.72)	.086
SN-Pog, °	78.03 (76.53, 79.52)	79.23 (77.46, 81.00)	.466
SN-MeGo, °	36.42 (34.20, 38.63)	36.42 (33.78, 39.05)	.781
y-axis, °	66.93 (65.45, 68.42)	66.95 (65.19, 68.72)	.905
Go2 (NGoMe), °	74.99 (73.44, 76.54)	75.48 (73.64, 77.33)	.516
NS-SpP, °	6.30 (5.08, 7.52)	6.34 (4.89, 7.78)	.791
Mandibular angle (ArGoMe), °	129.77 (127.18, 132.35)	130.08 (127.01, 133.16)	.822
Length of maxilla, mm	43.87 (42.75, 44.98)	42.79 (41.47, 44.11)	.216
Length of mandible, mm	66.56 (64.94, 68.18)	66.89 (64.97, 68.82)	.791
Angulation of upper first incisors, °	98.11 (94.05, 102.17)	97.83 (92.97, 102.70)	.842
Angulation of lower first incisors, °	88.55 (84.83, 92.28)	86.84 (82.37, 91.31)	.797
Overjet, mm	0.58 (−0.12, 1.29)	−0.82 (−1.66, 0.01)	.026
Overbite, mm	0.30 (−0.48, 1.08)	0.12 (−0.82, 1.07)	.895

[a] FOA indicates that patients were exclusively treated with plates and functional orthopedic appliances; face mask, that a face mask was used in addition. Data include 95% confidence intervals and *P* values derived from intergroup comparisons of mean values using the Wilcoxon test.

small in both groups. SNA values increased by 0.40° in the FOA group treated exclusively with removable appliances, as compared to 0.29° in the face mask group treated additionally with a maxillary expansion appliance and face mask (Figure 1). The SNB values increased by 1.08° in the FOA group but decreased by 0.81° in the face mask group. The difference between both groups was statistically significant.

Changes in chin position were +1.38° in the FOA group and −0.01° in the face mask group. This intergroup difference was not statistically significant. ANB and Wits values changed in accordance with SNA and SNB values. The ANB values decreased by 0.47° in the FOA group but increased by 0.88° in the face mask group. Wits values increased in both groups (FOA group: +0.38 mm; face mask group: +1.67 mm). The skeletal effect in reducing Class III relations was more pronounced in the face mask group than in the FOA group, and it was more pronounced in the mandible than in the maxilla.

Intergroup differences in SN-MeGo values were highly significant ($P = .001$), as those angles decreased by 1° in the FOA group while they increased by 1.12° in the face mask group. Statistical significance was also reached for intergroup changes in y-axis values over the course of treatment, although the significance level was only $P = .05$. These angles increased by 0.15° in the FOA group and by 1.4° in the face mask group. Go2 angles (NGoMe) decreased by 0.37° in the FOA group and increased by 1.49° in the face mask group. This difference was again significant at the .01 level.

Table 3. Differences Between Findings in Cephalograms and on Casts at the Beginning and End of Treatment[a]

Variable	FOA Group	Face Mask Group	*P* Value
SNA, °	0.40 (−0.73, 1.53)	0.29 (−1.05, 1.64)	.958
SNB, °	1.08 (0.29, 1.87)	−0.81 (−1.74, 0.13)	.006
ANB, °	−0.47 (−1.29, 0.35)	0.88 (−0.10, 1.85)	.121
Wits, mm	0.38 (−0.55, 1.31)	1.67 (0.57, 2.78)	.276
SN-Pog, °	1.38 (0.47, 2.28)	−0.01 (−1.08, 1.07)	.092
SN-MeGo, °	−1.00 (−1.80, −0.20)	1.12 (0.17, 2.07)	.001
y-axis, °	0.15 (−0.55, 0.85)	1.40 (0.57, 2.23)	.043
Go2 (NGoMe), °	−0.37 (−1.10, 0.36)	1.49 (0.62, 2.37)	.004
NS-SpP, °	0.85 (−0.68, 2.37)	−0.15 (−1.96, 1.66)	.779
Mandibular angle (ArGoMe), °	−2.97 (−4.37, −1.21)	−0.32 (−2.42, 1.78)	.04
Length of maxilla, mm	1.51 (0.28, 2.74)	1.94 (0.48, 3.41)	.623
Length of mandible, mm	3.56 (2.23, 4.90)	3.63 (2.04, 5.12)	.811
Angulation of upper first incisors, °	6.18 (2.70, 9.66)	4.27 (0.10, 8.44)	.648
Angulation of lower first incisors, °	3.84 (1.17, 6.52)	0.59 (−2.62, 3.80)	.13
Overjet, mm	1.33 (0.76, 1.91)	2.15 (1.46, 2.84)	.075
Overbite, mm	1.50 (0.77, 2.23)	0.50 (−0.38, 1.38)	.11

[a] FOA indicates that patients were exclusively treated with plates and functional orthopedic appliances.

Maxillary inclinations toward the cranial base (NS-SpP) increased by 0.85° in the FOA group, whereas they decreased by 0.15° in the face mask group. The mandibular angles (ArGoMe) decreased by 2.97° in the FOA group and by 0.32° in the face mask group. The difference in the decrease was statistically significant ($P = .05$).

Maxillary elongation was 1.51 mm in the FOA group and 1.94 mm in the face mask group over the course of treatment. This intergroup difference was not statistically significant. Mandibular elongation was minor in both groups (FOA group: 3.56 mm; face mask group: 3.62 mm).

Angulations of the upper first incisors increased by 6.18° in the FOA group and by 4.27° in the face mask group relative to the cranial base. Angulations of the lower incisors changed by 3.84° in the FOA group and by 0.59° in the face mask group relative to the mandibular plane. Overjet increased by 1.33 mm in the FOA group and by 2.15 mm in the face mask group. At the same time, bite deepening occurred. Overbite increased by 1.5 mm in the FOA group, compared to only 0.5 mm in the face mask group.

DISCUSSION

The present study was designed to investigate the effects of early treatment to correct Class III abnormalities. The devices used for treatment included removable appliances such as prognathism activators and maxillary plates alone or in combination with a face mask mounted on a maxillary expansion appliance. The effects that were achieved over the course of early treatment are illustrated by the findings of the study.

As no separate control group was available, the results were compared with groups of untreated Class III cases in the literature. The group described by Chong et al[12] spanned an age range of 6.36 to 8.02 years, while the group described by Macdonald et al[11] spanned an age range of 8.7 to 11.3 years. The basis for age comparison is better with Chong et al,[12] while the basis for observation time comparison is better with Macdonald et al.[11]

SNA angles decreased by 0.3° in the FOA group and 0.4° in the face mask group over 2.5 years, which indicates that skeletal Class III relations were reduced, although these reductions fell short of the changes reported in the literature. Macdonald et al[11] and Takada et al[1] achieved mean changes ranging between 1.5° and 2.3° with the use of protraction headgears within 1 to 1.1 years. Chong et al[12] reported changes of 0.9° over an observation period of 2 years. Jäger et al[13] and Kim et al[3] published results of meta-analyses comprising 12 and 14 publications dealing with maxillary protraction. Covering observation periods between 6 and 24 months, the SNA values in these studies increased by 1.4° and 1.7°, respectively.

SNA angles in untreated control groups changed by values ranging from −0.3° to +0.2° within a given observation period.[11,12] Similar values have been reported for other sagittal parameters (SNB, ANB, and Wits).

Treatment with protraction headgears has shown a greater effect than in the present study concerning the reduction of skeletal Class III relations in terms of enlarged ANB angles. Macdonald et al[11] and Takada et al[1] achieved increases of 3.4° and 3.6° within 1 year, respectively; Chong et al[12] observed a mean enlargement of 2° within 2 years. The corresponding value in the present study was 0.8° (face mask group). Wits values in the face mask group increased by 1.7 mm, which is similar to the finding of 1.9 mm reported by Chong et al.[12] However, Macdonald et al[11] found that some of the sagittal effects achieved with face masks were lost in the follow-up period when no treatment was performed. While the effects achieved are smaller with exclusively removable appliances, findings obtained in control groups[11,12] have clearly demonstrated that they are able to induce minor improvements and to counteract the progression of Class III abnormalities.

Similarly, the overjet changes recorded in the present study (+1.3 and +2.1 mm) were smaller than those reported by Macdonald et al[11] and Chong et al[12] after continuous treatment with protraction headgears (+5.0 and +4.8 mm) but larger than those observed in a control group (−0.4 mm).[11] The increases in overjet we recorded during additional treatment with face masks compared to treatment with removable appliances only fell short of statistical significance but were nevertheless relevant from a clinical viewpoint.

The results for maxillary elongation in both groups were in keeping with values ranging from 1.8 to 2.2 mm reported by Chong et al[12] and Takada et al.[1] The results for mandibular elongation, by contrast, were clearly more pronounced than those given by the above study groups (3.6 mm vs 1.9 mm[12] or 2.6 mm[1]). In fact, they were close to the +4.4 mm on record for an untreated control group.[12] Possible reasons include the longer observation period (30 months vs 24 or 12 months) and the switching of appliances. Sagittal relations (ANB, Wits, and overjet) could be improved despite the fact that mandibles were distinctly elongated during treatment compared to the length of maxillae, the mean difference being roughly 2 mm. The changes observed in vertical parameters might explain this phenomenon: SN-MeGo, Go2, and mandibular angle were reduced in the FOA group. The mandible shifts to a more distal position in the alveolar region. The chin region, by contrast, will move slightly in a ventral di-

rection (SN-Pog: +1.4°). The anterior maxilla swivels in a caudal direction, resulting in bite deepening (overbite: +1.5 mm).

In the literature, face masks with buccally mounted hooks used to secure the rubber elastics have been described to cause anterior rotation of the maxilla, with changes in NL-NSL values ranging between −0.25° and −1.4°.[1,12–16] The patient sample analyzed in the present study revealed only a small degree of maxillary rotation. Possible reasons may be found in the specific configuration we used, including a ventrocaudally oriented force vector, palatally mounted hooks to hang in the rubber elastics, and intermittent treatment with FOA appliances.

Our finding of posterior rotation of the mandible is in keeping with similar results obtained in numerous previous studies investigating various modified versions of the facemask.[14–19] The results of a meta-analysis by Jäger et al[13] and Kim et al[3] revealed that SN-MeGo angles became enlarged by 0.9° and 1.8° during treatment with face masks. Jäger et al[13] believed that the main reason for the documented reductions of SNB values by 0.9° was posterior rotation of the mandible.

The present study also confirmed that chin positions were more dorsal after treatment with an additional face mask than with FOA appliances only (SN-Pog: 0° vs 1.4°). Posterior rotation of the mandible will counteract bite deepening. Yüksel et al[20] observed a 1.9-mm reduction in overbite during exclusive treatment with face masks over 7 months in the early phase of mixed dentition. This is in contrast to Chong et al,[12] who reported increases in overbite of 0.8 mm following exclusive treatment with face masks. In our patient sample, face masks in combination with removable appliances would also be associated with overbite increases of 0.5 mm. As a possible explanation for this discrepancy, Naumann et al[21] indicated that the degree of overbite is not directly related to any vertical parameters in the lateral cephalograms.

Different effects of face masks and functional orthopedic appliances on vertical parameters were also reported by Cozza et al[17] in a study dealing with patients who wore a face mask in the first treatment phase, followed by a functional orthopedic appliance in the second phase. SN-MeGo and base angles increased in the first phase, and one again decreased in the second phase. Macdonald et al[11] also observed an enlargement of the FMA angle during 8 months of treatment with face masks, which again was followed by a reduction over the next 2 years, during which no treatment was performed.

The proclination of maxillary anterior segments (angulation of the central incisors) in our group treated exclusively with removable appliances can be ascribed to the impact of sagittally acting elements such as Bertoni screws or Y plates. The skeletal effects observed in the face mask group gave rise to greater increases of ANB values than in the FOA group. This difference was statistically significant.

Surprisingly, some proclination of the mandibular anterior segment (angulation of the central incisors) was present both in the FOA group and in the face mask group. A plausible explanation for this phenomenon would be that the observation period coincided with the transition phase to permanent dentition in about 30% of patients. The permanent anterior teeth will erupt at a lingual position to the deciduous teeth and will be prompted by lingual pressure to move in a labial direction, thereby resulting in proclination of the mandibular anterior segment.[22]

CONCLUSIONS

- While improvements in sagittal relations (ANB, Wits, and overjet) can be achieved with both therapeutic approaches, the effect is more pronounced when the face mask is used.
- Exclusive treatment with plates and functional orthopedic appliances induces a reduction of the mandibular angle, causing the mandible to shift dorsally. The anterior maxilla will move in a caudal direction as the overbite stabilizes, thereby causing bite deepening.
- Treatment with a face mask will increase the degree of overjet, notably by dorsal rotation of the mandible. However, the effect of the mask is mitigated by additional treatment with FOA appliances.
- The changes revealed by the present study in overjet and cephalometric sagittal parameters demonstrate that early treatment is clinically indicated.

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