# CRITICAL FACTORS INFLUENCING STABILITY OF CLASS III TREATMENT IN GROWING CHILDREN

Toru INAMI

Reprinted from Aichi-Gakuin DENTAL SCIENCE
Vol.22, No. 1 , 2009

ORIGINAL

Aichi-Gakuin Dent Sci 22 : 11 – 17, 2009

# CRITICAL FACTORS INFLUENCING STABILITY OF CLASS III TREATMENT IN GROWING CHILDREN

TORU INAMI
*Department of Orthodontics, School of Dentistry, Aichi-Gakuin University*

## SYNOPSIS

**This study was designed to identify predictors of response to early treatment in mixed-dentition cases with anterior crossbite, a major indication for orthodontic treatment in growing children, treated with an acrylic splint-type rapid maxillary expansion (ASRME) and maxillary protraction (facemask) appliances. 18 months after crossbite correction, 27 patients were divided into groups with and without relapse of anterior crossbite for comparison of cephalometric parameters. This study indicated useful parameters for determining if patients have a skeletal mandibular prognathisms and if skeletal Class III problem in the early mixed dentition is likely to respond to early treatment (occlusal guidance). These parameters appear to serve a useful purpose by helping to identify children who are likely to benefit from early treatment of anterior crossbite, thereby reducing the amount of treatment needed in later life, particularly once the children have passed the peak of their growth and development.**

Key words: crossbite, growing children, stability

## INTRODUCTION

Children undergo active skeletal growth and neuromuscular development from the time of primary tooth eruption to the completion of the permanent dentition, which is also a period of growth and development often associated with the manifestation of malocclusions. It has been shown that there is a greater chance for normal development of not only occlusal function but of temporomandibular morphology if a good balance between form and function is maintained during the period of occlusal development, highlighting the importance of treatment concepts and systems that facilitate early correction of occlusal problems and restoration of occlusal harmony.

Objectives for early treatment of anterior crossbite during the period of growth and development include the normalization of the anterior overbite and overjet, as well as the improvement of alveolar status, function, and skeletal maxillo-mandibular relationship. However, it is difficult to fully correct anterior crossbite in some cases even if treatment is started early. There are patients who, after successful correction in the primary dentition, experience relapse in the mixed dentition. In other cases, orthognathic surgery may be required due to excessive mandibular growth in the permanent dentition. Clinicians also witness spontaneous correction of anterior crossbite during the primary dentition or early mixed dentition[1].

Before the start of treatment, or even early in the course of treatment, it is extremely difficult to predict how each case will progress. This study was therefore designed to identify predictors of response to early treatment in mixed-dentition cases with anterior crossbite, a major indication for orthodontic treatment in growing children, treated with an acrylic splint-type rapid maxillary expansion (ASRME) and maxillary protraction (facemask) appliances. 18 months after crossbite correction, 27 patients were divided into groups with and without relapse of anterior crossbite for comparison of cephalometric parameters.

## STUDY MATERIALS

The study included 27 boys and girls with early

Received for publication August 26, 2009
Accepted for publication October 21, 2009

mixed dentition who were treated by the same orthodontist from 1989. Their orthodontic records were used with permission from the patients and their parents or guardians. Selection criteria for the study subjects were as follows; initial orthodontic records (T1) were taken before treatment.

After 20-24 days of ASRME appliance active wear, approximately 6 months of protractor wear immediately following ASRME, then removing these appliances and a second sets of records (T2) were taken.

The third sets of records (T3) were taken an average of 1.5 years after removal of ASRME and protraction appliances, respectively.

The model and cephalometric analysis data collected at these three time points were used as study materials. The subjects were divided into two groups by the amount of overjet at T3 (Table 1). Of 27 subjects, 19 maintained normal overjet (Group N), while 8 showed negative overjet due to a relapse of anterior crossbite (Group R).

## METHODS

The two groups were compared at T1, T2 and T3 for the following items based on the collected data:

1. Status of appliance wear
2. Results of model analysis
3. Cephalometric measurements
   The statistical software Stat View 5.0 (Abacus Concepts, Piscataway, NJ USA) was used for statistical analysis, and Student's t-test was performed to test the level of significance between the two independent groups. The level of significance was set at 0.05% ($p<0.0005$) for this study.

The orthodontic treatment appliances and protocol used with the study subjects were as follows:

The expansion appliance was ASRME with a bite plane effect covering the entire crowns of the teeth in the buccal segments in the early mixed dentition period (Fig. 1A, 1B). Immediately following expansion, the expansion screw was immobilized with brass wire or acrylic resin before starting maxillary protraction. The facemask used with every subject in this study was a Face Crib, commercially available from Rocky Mountain Morita (Tokyo, Japan) (Fig. 2). Forward and downward traction force of approximately 250 g per side was applied with a rub-

Table 1 Sample number and initial age of subjects

| | Group N (Normal Overjet at T3) | Group R (Reverse Overjet at T3) |
|---|---|---|
| Sample Number | 19 | 8 |
| Minimum Age | 6y7m | 6y11m |
| Maximum Age | 10y2m | 10y11m |
| Average Age | 7y11m±11m | 9y0m±1y4m |

(mean±SD)


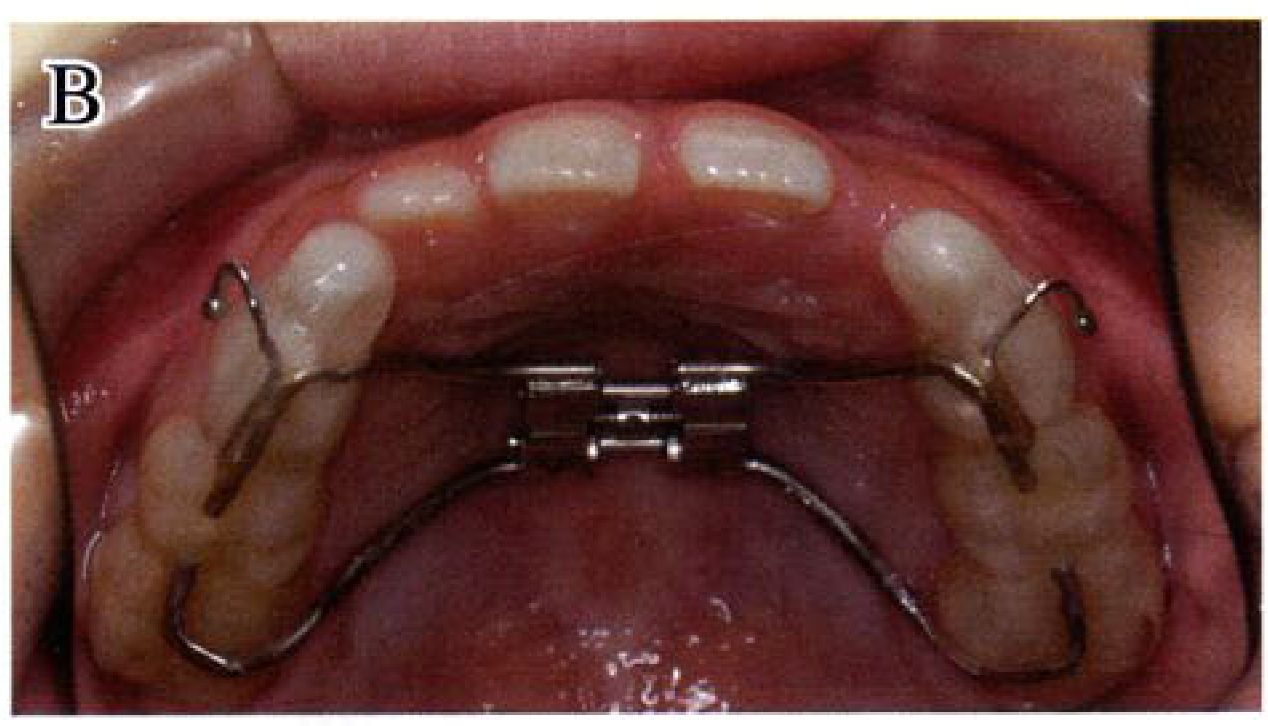


Fig. 1A, 1B ASRME appliance

ber band. A Fränkel functional appliance (Type III) was used as a retainer from the time of appliance removal to the end of the observation period, during which time each case was followed periodically at an interval of one to two months (Fig. 3).

## Results

1. There was no significant difference in the initial age between Group N and Group R. (Table 1).
2. Duration of appliance use and model analysis
   1) The average duration of the facemask use was 5.7 months.
   2) The average time of facemask use per day was 10.5 hours.
   3) Model analysis showed an average lateral expansion of 3.1 mm achieved with the appliance during a period of 20-24 days.

None of the time of the appliance use and model analysis showed a significant difference between Group N and Group R at all of the time points (Table 2).

3. Cephalometric comparisons between the groups at 3 time points
   1) Linear measurements

None of the linear cephalometric measurements showed a significant difference between Group N and Group R at T1 or T2, while there were significant differences in Wits and overjet measurements between the groups at T3 (Table 3).

   2) Angular measurements

Significant differences were found in FMIA, IMPA, Gonial angle, AB to Mandibular. and L1 to NB between the groups at T1. FMIA, IMPA and L1 to NB were not significantly different between the groups at T2. While ANB, Convexity and AB plane showed significant differences only at T3, Gonial angle and AB to Mand. significantly differed between the groups at all three time points (Table 4A, B, C)

   3) Comparison of indices between the groups at 3 time points

There was a significant difference in APDI at T3. ODI shows significant differences at all time points (Table 4D).

## Discussion

Anterior crossbite accounts for a large portion of malocclusions in Japanese patients. Maxillary underdevelopment, constriction and retrusion are reported to be frequent causes of anterior crossbite[2]. ASRME appliances have been shown to split not only the midpalatal suture but also the zygomaxillary

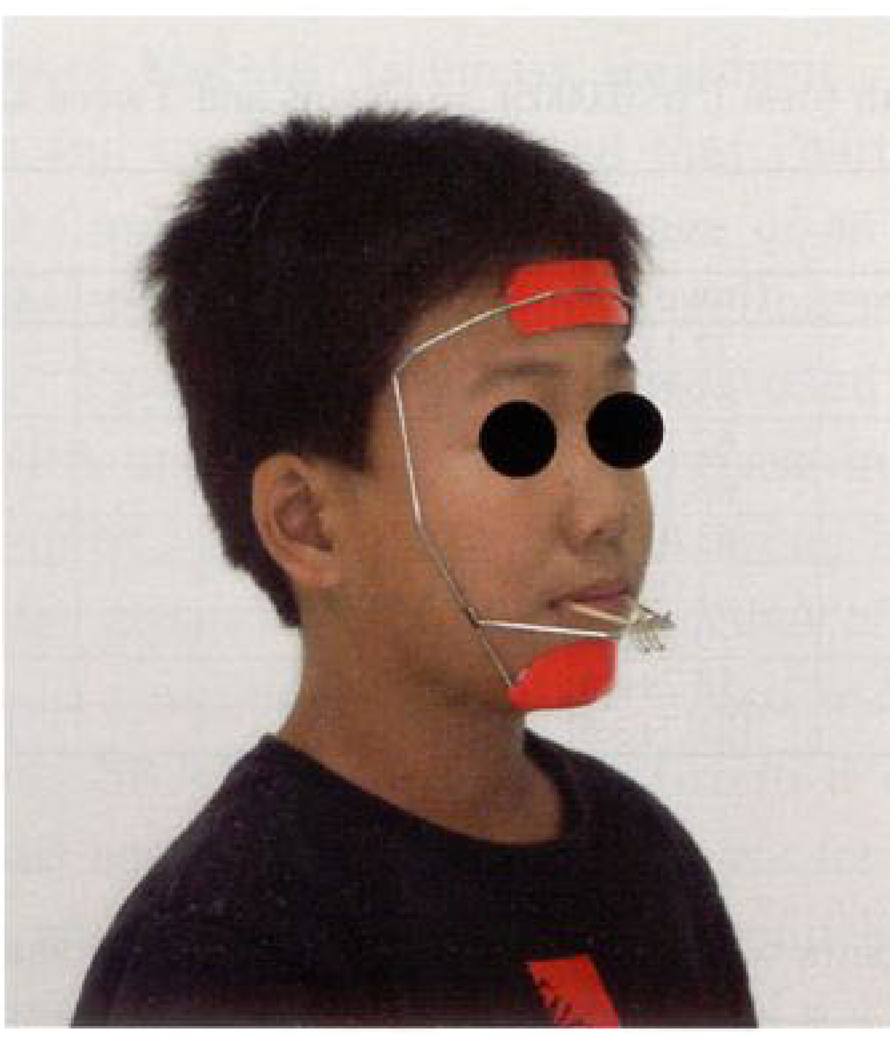

Fig. 2 Facemask

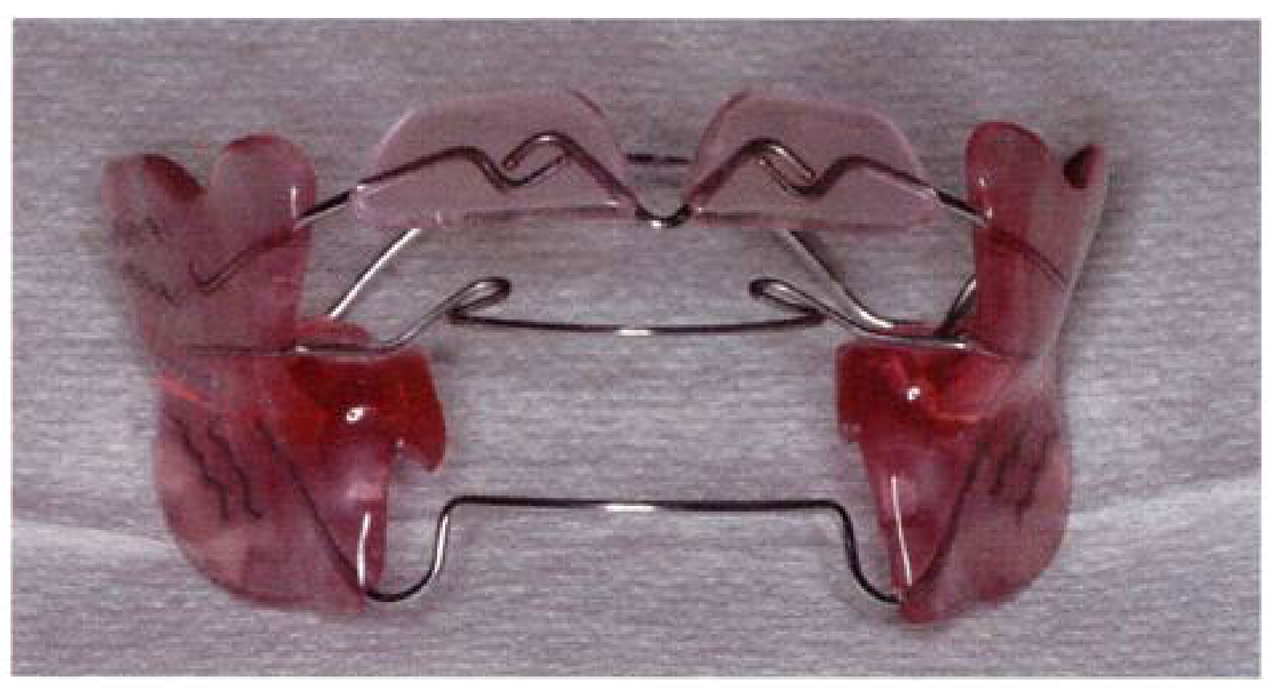

Fig. 3 Type III Fränkel appliance

Table 2 Duratioin of facemask use and model analysis of expansion

| | Average duration of facemask use (month) | Average daily time of facemask use (hour) | Average amount of lateral expansion with ASRME (mm) |
|---|---|---|---|
| Group N (19) | 5.5±1.5 | 10.4±1.9 | 3.2±0.3 |
| Group R (8) | 6.4±1.4 | 10.9±0.4 | 3.0±0.2 |
| Total | 5.7±1.6 | 10.5±1.7 | 3.1±0.3 |

(mean±SD)

Table 3 Inter-group comparison of linear measurements at 3 time points with t-test (* p<0.0005)

| | T1 | | | T2 | | | T3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurements (mm) | Group N | Significant difference | Group R | Group N | Significant difference | Group R | Group N | Significant difference | Group R |
| N-Me | 111.1±4.2 | | 113.1±2.5 | 116.2±4.8 | | 117.5±2.5 | 119.8±6.8 | | 123.5±3.2 |
| N-ANS | 50.2±2.2 | | 51.4±1.6 | 51.5±2.4 | | 52.5±1.2 | 54.1±3.4 | | 56.1±1.5 |
| ANS-Me | 61.9±3.4 | | 62.6±1.4 | 66.3±3.9 | | 66.2±1.6 | 67.1±4.8 | | 68.1±2.6 |
| N-S | 65.5±2.3 | | 65.3±2.5 | 66.0±2.2 | | 66.0±2.3 | 67.2±2.3 | | 67.6±2.8 |
| ANS-Ptm' | 47.5±2.1 | | 46.8±2.4 | 48.7±3.4 | | 48.1±2.6 | 50.3±3.3 | | 49.6±2.7 |
| A'-Ptm' | 43.8±2.1 | | 42.4±2.6 | 45.5±3.2 | | 44.2±2.8 | 46.8±2.9 | | 45.7±2.6 |
| S'-Ptm' | 20.1±2.2 | | 19.5±1.7 | 19.8±1.9 | | 19.1±1.3 | 20.0±2.1 | | 19.6±1.6 |
| Gn-Cd | 104.2±3.6 | | 105.9±4.5 | 107.1±5.2 | | 109.5±4.6 | 112.0±6.1 | | 118.8±6.2 |
| Cd-Go | 49.8±2.8 | | 49.3±4.1 | 51.0±3.3 | | 51.2±4.3 | 54.2±4.0 | | 57.2±4.9 |
| Pog-Go | 70.0±3.1 | | 69.7±3.8 | 72.2±3.6 | | 72.2±3.6 | 75.0±3.5 | | 76.6±4.8 |
| Over jet | -2.3±0.9 | | -2.1±0.7 | 3.1±1.1 | | 0.7±2.4 | 3.1±0.9 | * | -2.3±1.8 |
| Over bite | 2.2±2.3 | | 2.3±1.9 | 0.6±1.4 | | 0.8±1.8 | 1.4±1.2 | | 1.8±2.4 |
| WITS | -6.1±2.2 | | -9.2±2.6 | -3.6±2.6 | | -6.7±3.3 | -3.9±2.1 | * | -9.2±2.8 |
| U1 to NA | 2.5±2.3 | | 4.2±1.9 | 4.9±1.8 | | 4.7±1.2 | 5.6±1.1 | | 5.0±1.8 |
| L1 to NB | 5.8±1.1 | | 4.4±0.8 | 5.2±1.4 | | 4.2±1.1 | 5.3±1.8 | | 5.3±1.5 |

(mean±SD)

Table 4A Inter-group comparison of angular measurements at 3 time points with t-test (*p<0.0005) — Steiner analysis —

| | T1 | | | T2 | | | T3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurements (°) | Group N | Significant difference | Group R | Group N | Significant difference | Group R | Group N | Significant difference | Group R |
| SNA | 79.3±3.2 | | 77.7±2.3 | 80.5±2.9 | | 78.6±2.0 | 80.7±3.2 | | 79.1±2.9 |
| SNB | 78.8±2.3 | | 79.3±2.4 | 78.0±2.5 | | 78.6±2.1 | 79.1±2.5 | | 80.7±2.5 |
| ANB | 0.5±1.8 | | -1.7±1.6 | 2.4±1.7 | | 0.0±1.7 | 1.8±1.1 | * | -1.6±2.3 |
| U1 to NA | 22.5±6.7 | | 26.2±6.7 | 26.2±5.2 | | 26.5±4.4 | 27.8±3.4 | | 26.7±4.1 |
| L1 to NB | 28.6±2.9 | * | 23.9±2.4 | 25.4±3.9 | | 24.1±4.1 | 24.8±4.5 | | 24.5±3.9 |
| U1 to L1 | 128.3±7.1 | | 131.5±7.6 | 125.9±5.5 | | 129.4±5.4 | 125.6±6.1 | | 130.4±3.8 |
| Occl to S | 20.9±3.5 | | 21.3±6.1 | 21.2±5.2 | | 20.7±4.2 | 18.8±3.2 | | 19.2±3.3 |
| GoGn to S | 34.8±3.6 | | 37.0±4.0 | 36.8±3.6 | | 38.6±4.4 | 35.4±4.1 | | 36.6±4.5 |

(mean±SD)

Table 4B Inter-group comparison of angular measurements at 3 time points with t-test (*p<0.0005) — Downs and Tweed analysis —

| | T1 | | | T2 | | | T3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurements (°) | Group N | Significant difference | Group R | Group N | Significant difference | Group R | Group N | Significant difference | Group R |
| FMA | 29.6±3.4 | | 31.3±4.1 | 31.7±3.6 | | 32.1±4.7 | 30.1±41 | | 30.7±5.2 |
| IMPA | 94.0±4.3 | * | 86.1±4.4 | 89.5±5.4 | | 85.8±6.1 | 89.3±6.1 | | 85.5±6.4 |
| FMIA | 56.3±3.2 | * | 62.6±2.5 | 58.8±3.7 | | 62.1±3.0 | 60.5±4.2 | | 63.8±3.6 |
| Facial A | 84.2±1.9 | | 85.8±2.6 | 83.7±2.0 | | 85.7±2.3 | 84.9±1.7 | | 87.9±2.7 |
| Y-Axis | 62.9±2.7 | | 62.1±2.8 | 64.6±2.5 | | 63.2±2.9 | 63.8±2.7 | | 62.0±2.9 |
| Conv. | 2.6±4.3 | | -2.2±3.7 | 6.1±3.7 | | 1.0±3.4 | 4.6±2.6 | * | -2.6±5.5 |
| A-B plane | 0.0±2.4 | | -3.1±2.5 | 2.7±2.2 | | -0.5±2.7 | 2.1±1.5 | * | -2.9±3.1 |
| Occl A | 14.7±3.4 | | 14.2±5.9 | 14.0±2.6 | | 13.2±4.5 | 12.5±3.1 | | 11.6±3.7 |
| Gonial | 126.2±3.5 | * | 133.4±3.3 | 125.9±3.3 | * | 131.7±3.6 | 125.1±4.0 | * | 132.1±4.6 |

(mean±SD)

Table 4C Inter-group comparison of angular measurements at 3 time points with t-test (*p<0.0005) — Other analysis —

| | T1 | | | T2 | | | T3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurements (°) | Group N | Significant difference | Group R | Group N | Significant difference | Group R | Group N | Significant difference | Group R |
| U1-NF | 112.0±6.1 | | 113.8±7.8 | 116.6±5.4 | | 114.7±5.2 | 118.4±3.8 | | 115.5±4.1 |
| U1-SN | 101.8±6.5 | | 103.9±6.9 | 106.7±4.9 | | 105.0±4.6 | 108.7±4.0 | | 105.9±3.2 |
| A-B to Mand. | 66.1±2.9 | * | 59.7±2.6 | 67.3±3.2 | * | 61.8±2.8 | 67.1±3.6 | * | 58.6±4.2 |
| FH.NF | 4.0±2.3 | | 2.7±1.2 | 3.7±2.3 | | 2.1±1.2 | 3.4±2.4 | | 2.1±1.1 |
| C.F. | 158.4±3.2 | | 154.2±5.6 | 155.7±5.1 | | 152.2±5.3 | 156.6±4.6 | | 153.4±6.9 |

(mean±SD)

Table 4D Inter-group comparison of indices at 3 time points with t-test (*p<0.0005)

| | T1 | | | T2 | | | T3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Indices | Group N | Significant difference | Group R | Group N | Significant difference | Group R | Group N | Significant difference | Group R |
| ODI | 70.1±2.8 | * | 62.0±3.1 | 71.0±2.6 | * | 63.9±3.5 | 70.5±3.3 | * | 60.6±4.5 |
| APDI | 88.2±3.4 | | 91.7±5.1 | 84.7±4.6 | | 88.3±4.3 | 86.2±2.9 | * | 92.8±6.0 |

(mean±SD)

and zygotemporalis sutures. Facemasks have been shown to exert their action on the maxillary complex around the maxillary sutures[3-6]. Some authors have suggested that a combined use of ASRME and facemask appliances are effective in treating skeletal mandibular prognathism in growing children through growth stimulation at these sutures, while others have failed to show the effectiveness of the combination therapy[7, 8]. There has been a lack of consensus to date.

In the present study, some patients experienced relapse of anterior crossbite following overjet normalization with the combination therapy. The subjects were therefore divided into a group with stable results and a group with relapse. The present study thus aimed to analyze differences between the groups and identify predictors of treatment outcome.

1) Effect of ASRME/facemask treatment

Ngan and coworkers reported that Point A came forward 2mm with 6 months usage of an ASRME appliance and a maxillary protraction appliance (MPA). Takahashi and associates used a horn-type MPA and experienced a decrease in SNA of 0.6° despite 14.4 months of MPA wear in a non-responder group and an increase in SNA of 1.1° in 8 months in a responder group[9-13]. Also, in the present study SNA increased 0.9° in Group R despite a combined use of ASRME and facemask for an average duration of 5.7 months, while Group N showed stable results with an SNA increase of 1.4°, indicating that this increase in SNA contributed to the ANB improvement observed long after treatment in Group N.

SNB, on the other hand, decreased only 0.8° in Group N and as much as 0.7° in Group R. However, Group R showed a marked increase in SNB of 2.1° during the follow-up period. These findings are in agreement with the changes in Point B reported by Takahashi and associates. These changes seem to have contributed to the significant differences in ANB, AB plane, Wits index, AB to Mand., APDI and ODI observed during the long follow-up period. In other words, the patients who had small changes in Point A and large changes in Point B during ASRME/facemask treatment may have been more prone to relapse. While no differences were found in horizontal parameters such as Point A and Point B at T1, the two groups showed large differences in horizontal parameters at T3. None of the parameters thus seemed to reliably predict stability of outcome in the treatment of mandibular protrusion.

2) Predictability of ASRME/facemask treatment effect

The present study showed significant differences in the three dental measurements, L1 to NB, IMPA and FMIA at T1, indicating that patients with retroclined lower anterior teeth before treatment are more likely to experience relapse after ASRME/facemask treatment. In contrast, ANB, Conv., Wits, and APDI showed significant differences in the follow-up period, though no differences were noted before treatment. These measurements represent horizontal discrepancies between the maxilla and mandible and are extremely useful as parameters of the severity of anterior crossbite[14, 15]. It is no surprise that both groups shared similar values for these measurements before correction of anterior crossbite and that Group R, which experienced the relapse of anterior crossbite, showed significantly larger values post-treatment. These measurements thus would not qualify as useful predictors of treatment outcome. In contrast, Gonial angle, AB to Mand., and ODI significantly differed between the two groups at all three time points. These measurements are vertical parameters of the facial skeleton[16]. Although anterior crossbite is by definition a malocclusion with a horizontal jaw discrepancy, the results indicate that the vertical parameters have a greater bearing on the stability of anterior crossbite treatment than horizontal parameters. That is, anterior crossbite cases with a larger Gonial angle, and smaller AB to Mand. and ODI values before treatment may be more prone to relapse of anterior crossbite long after treatment and obtain stable results may be more challenging.

3) Significance of early treatment in anterior crossbite cases

The importance of occlusal guidance during growth and development has been emphasized. McNamara has stated that the objective of early treatment is to create an oral environment conducive to sound jaw growth by correcting any skeletal, dental and muscular disharmonies that may exist prior to the completion of the permanent dentition[17]. Particularly in anterior crossbite cases, it seems more desirable to initiate treatment early in order to encourage the maxilla to grow forward to its full potential by moving the anterior teeth out of crossbite. Thus, the goals for early treatment of anterior crossbite are twofold; firstly, improvement in overjet relationship of the permanent anterior teeth through dentoalveolar movements, which is aimed at correcting tooth alignment, muscle function, chewing cycle and oral habits; preventing anterior crossbite from worsening; promoting development of good oral function. Secondly, improving skeletal jaw relationship by stimulating maxillary development while controlling mandibular growth. Early treatment also provides support for patients suffering from any functional impairment, psychological stress or social handicap.

Early treatment has the following advantages: (1) Normal skeletal growth can be expected and skeletal improvement can be facilitated; (2) Treatment can be simplified; (3) The maxilla can be expanded laterally; (4) Early normalization of oral function can lead to early functional improvement; (5) Worsening of anterior crossbite can be avoided; and (6) Early resolution of chief complaints can offer reassurance to parents and improve compliance in young children.

The disadvantages of early treatment include the following: (1) Treatment time is often prolonged because patient management until the end of growth is needed (although this may be solved with proper treatment timing and a combination of regular follow-ups and check-ups); (2) Early treatment would be futile in the event of relapse (however, it might at least eliminate growth disturbances caused by persistent malocclusion); (3) The patient and the family may burn out, making patient and practice management less efficient. It is important to fully consider all the pros and cons when performing early treatment.

## Conclusion

This study has indicated the usefulness of the aforementioned parameters in determining if the patient has a skeletal mandibular prognathism and if the skeletal Class Ⅲ problem in the early mixed dentition is likely to respond to early treatment (occlusal guidance). These parameters (Gonial angle, AB to Mandibular and ODI) serve a useful purpose as they help to identify children who are likely to benefit from early treatment of anterior crossbite by reducing the amount of treatment needed in later life past the peak of growth and development.

## Acknowledgement

I deeply thank Professor Shigemi Goto and Associate Professor Ken Miyazawa for assistance in this work.

## References

1. Miyahara, H.: A morphological study of the deciduous reversed bite-A longitudinal observation till the Hellman's Ⅲ A stage-(in Japanese). J. Jpn. Orthod. Soc., **43**: 1-15, 1984.
2. Susami, R., Asai, Y., Hirose, K., Hosoi, T., Hayashi, I., Takimoto, T., Okada, H., Kitamura, T., Sakai, T., Sawamura, M., Do, A., Nomura, E., Hayashi, I., Fukazawa, F., Mimura, C.: The prevalence of malocclu-

sion in Japanese school children-part 2. Age distribution of prevalence rate-(in Japanese). J. Jpn. Orthod. Soc., **30**: 230-239, 1971.

3. Roberts, C.A., Subtelny, J.D.: Use of the face mask in the treatment of maxillary skeletal retrusion. Am. J. Orthod. Dentofacial Orthop., **93** (5): 388-394, 1988.
4. Ishii, H.: Experimental study on the effect of the orthopedic appliance to skeletal classⅢ cases with underdeveloped nasomaxillary complex (in Japanese). J. Jpn. Orthod. Soc., **38**: 187-209, 1979.
5. Baccetti, T., Franchi, L.: Shape-coordinate and tensor analysis of skeletal changes in children with treated ClassⅢ malocclusions. Am. J. Orthod. Dentofacial Orthop., **112**(6): 622-633, 1997.
6. Yamaguchi, H., Suzuki, T., Takagi, S., Kawate, T.: The improved frontal pull apparatus to the maxilla and results of its use (in Japanese). J. Jpn. Orthod. Soc., **37**(1): 69-82, 1978.
7. Turley, P. K.: Orthopedic correction of ClassⅢ malocclusion with palatal expansion and custom protraction headgear. J. Clin. Orthod., **22**(5): 314-325, 1988.
8. Baccetti, T., Franchi, L., McNamara, J. A. Jr.: Thin-plate spline analysis of treatment effects of rapid maxillary expansion and face mask therapy in early ClassⅢ malocclusions. Eur. J. Orthod., **21**: 275-281, 1999.
9. Ngan, P., Wei, S. H., Hagg, U., Yiu, C. K., Merwin, D., Stickel, B.: Effect of protraction headgear on classⅢ malocclusion. Quintessence Int., **23**(3): 197-207, 1992.
10. Major, P. W., elBadrawy, H. E.: Maxillary protraction for early orthopedic correction of skeletal ClassⅢ malocclusion. Pediatr. Dent., **15**(3): 203-207, 1993.
11. Ngan , P., Hagg, U., Yiu, C., Merwin, D., Wei, S. H.: Treatment response to maxillary expansion and protraction. Eur. J. Orthod., **18**: 151-168, 1996.
12. Takahashi, N., Morioka, T., Satoh, K., Seino, Y., Miura, H.: Clinical evaluation of a maxillary protractive appliance combined with rapid palatal expansion-Characteristics of patients with no positive results - (in Japanese). J. Tohoku Orthod. Soc., **9**(1): 30-38, 2001.
13. Amano, K., Kaida, K., Isono, H., Hirashita, A., Kuwahara, Y.: Long-term post-treatment evaluation of rapid palatal expansion and maxillary protraction in skeletal classⅢ cases. Orthod. Waves., **59**(6): 407-412, 2000.
14. Oktay, H.: A comparison of ANB, WITS, AF-BF, and APDI measurements. Am. J. Orthod. Dentofacial Orthop., **99**, 122-128, 1991.
15. Kim, Y. H., Vietas, J. J.: Anteroposterior dysplasia indicator: An adjunct to cephalometric differential diagnosis. Am. J. Orthod., **73**(6): 619-633, 1978.
16. Kim, Y. H.: Overbite depth indicator with particular reference to anterior open-bite. Am. J. Orthod.: **65**(6): 586-611, 1974.
17. McNamara, J.A. Jr., Brudon, W.L.: Orthodontic and orthopedic treatment in the mixed dentition. Ann Arbor, Mich., Needham Press, pp. 1-12, 1993.