Changes in occlusal contact area and average bite pressure during treatment of anterior crossbite in primary dentition

Yasutaka Yawaka* / Syouji Hironaka** / Akemi Akiyama*** / Ikuko Matzuduka**** / Chihiro Takasaki***** / Haruhisa Oguchi******

The purpose of this study was to examine changes in functional parameters of patients with anterior crossbite in primary dentition during orthodontic treatment. Occlusal contact area (OCA), average bite pressure (ABP) and integrated occlusal load (IOL) were measured. Data obtained before the start of treatment (period A), data obtained when crossbite had improved (period B) and data obtained when the appliance had been removed (period C) were compared. OCA showed the lowest value in period B, and then gradually increased. ABP increased until period B and then declined or became constant. OCA and IOL showed significant differences in periods A and B and periods B and C ($p<0.05$). The results suggest that about 6 months is required for stability of the occlusion and acquisition of function in the new occlusion after improvement of crossbite.
J Clin Pediatr Dent 28(1): 75-80, 2003

INTRODUCTION

There are many reports on early orthodontic treatment of anterior crossbite in primary dentition.[1-7] Early treatment is considered to be important to recover original growth and development by elimination of etiological factors as soon as possible. However, the changes in the relationship between the maxilla and mandible and changes in functional factors during by early treatment of anterior crossbite in primary dentition have not been elucidated. Determination of the changes in functional factors is important to assess the usefulness of early treatment.

Pressure-sensitive devices for measurement of the occlusal contact area and occlusal load have been developed, and Photocclusion and T-Scan system have been developed for measurement of occlusal contact and occlusal load.[8,9] Photocclusion records the color patterns of a thin photoelastic sheet at occlusal contact points, and the occlusal pressure is measured by a color calibration chart and a conversion scale. However, quantitative measurement of the color patterns is difficult, and the sheet is relatively inflexible. The T-Scan system is a system for measurement of occlusal contact and occlusal load based on change in the electrical resistance at occlusal contact points. However, this system has some problems, such as narrow measuring range, unstable measured values and shift of the mandible due to the inflexible sensor.

Recently, a new system for measurements called the Dental Prescale-Occluzer® system (Fuji Film, Tokyo, Japan) has become available (Figure 1). This system enables accurate measurements of occlusal contact area (OCA), average bite pressure (ABP), integrated occlusal load (IOL) and balancing point of occlusal load (BOL) by a color-developing chemical reaction in a thin pressure-sensitive sheet. This computerized system simultaneously provides quantitative data on all occlusal points in the dental arch.[10-12] Evaluation of occlusal function using the Dental Prescale-Occluzer®

* Yasutaka Yawaka, DDS, PhD, Instructor, Department of Oral Functional Science (Pediatric Dentistry), Hokkaido University, Graduate School of Dental Medicine, Japan.
** Syouji Hironaka, DDS, PhD, Instructor, Department of Hygiene and Oral Health, Showa University, School of Dentistry , Japan.
*** Akemi Akiyama, DDS, dentisit in private practice, Japan.
**** Ikuko Matzuduka, DDS, dentisit in private practice, Japan.
***** Chihiro Takasaki, DDS, Graduate school student, Department of Oral Functional Science (Pediatric Dentistry), Hokkaido University, Graduate School of Dental Medicine, Japan.
****** Haruhisa Oguchi, DDS, PhD, Professor and Chairman, Department of Oral Functional Science (Pediatric Dentistry), Hokkaido University, Graduate School of Dental Medicine, Japan.

All correspondence should be addressed to Yasutaka Yawaka, DDS, PhD, Department of Oral Functional Science (Pediatric Dentistry), Hokkaido University, Graduate School of Dental Medicine, Kita-13, Nishi-7, Kita-ku, Sapporo 060-8586, Japan.

Voice: +81-11-706-4293
Fax: +81-11-706-4307
E-mail: yawaka@den.hokudai.ac.jp

Figure 1. a: A photograph showing the pressure-sensitive sheets (Dental Prescale® 50H type-R), before (left side) and after (right side) examination. **b:** A photograph showing the analyzing scanner (Occluzer®; right side) and the personal computer (left side) which is used data calculation and preservation.

system is a relatively simple procedure since the sensor sheet is thin and very flexible and there are four sizes of sheets. This system is therefore particularly suitable for children. Various parameters such as OCA, ABP and IOL in Japanese children with normal occlusion in primary dentition have been measured using this system, and mean values have been reported.[13]

The purpose of this study was to compare OCA, ABP and IOL in anterior crossbite patients with primary dentition measured before and during orthodontic treatment with those in subjects with normal occlusion.

MATERIALS AND METHODS

Six Japanese patients (four boys and two girls) with anterior crossbite in primary dentition participated were enrolled in this study (Figure 2a). All patients had treated dental caries and had no full crowns or missing teeth. Anterior crossbite was treated by the use of a lingual arch appliance and a chin cap. The mean age of the subjects at the start of the orthodontic treatment was 4.9 years (range of ages: 4.1 to 6.2 years). Prior to the treatment, the purpose of the study and procedures to be used were fully explained to the patients and the parents, and informed consent for use of the data in this study was obtained.

Figure 2. Oral photographs showing changes in occlusion in a subject in this study. **a:** A photograph showing anterior crossbite in primary dentition before the start of orthodontic treatment (period A). **b:** A photograph showing improvement in crossbite (period B). **c:** A photograph taken in period C, after removal of the lingual arch appliance. In comparison with period B (Figure 2b), there is close occlusion in anterior teeth, and there are some differences in occlusal contact area (OCA), average bite pressure (ABP) and integrated occlusal load (IOL) between Figures 2b and 2c. The data are shown in Figures 3 and 4.

Each subject was seated in a relaxed upright position. A pressure-sensitive sheet (Dental Prescale®) was placed between upper and lower dental arches, and the subjects were instructed to bite as forcefully as possible for 3 seconds. Recording of OCA, ABP and IOL was longitudinally performed before setting a lingual arch appliance (T0) and after setting the appliance at each visit for the treatment period with about 1-month intervals between visits (T1, T2, T3, T4, T5, T6 and T7). Two 50H type-R sheets were used in each treatment session. The sheets

Table. Comparison of the Mean Values of Parameters in the Anterior Crossbite and Normal Occlusion Groups.

	Occlusal contact area (mm^2) mean±SD	Average bite pressure (Mpa) mean±SD	Integrated occlusal load (N) mean±SD
Subject[a]	7.7±4.3[c]	44.8±4.7[d]	326.8±148.0[e]
Normal[b]	9.2±7.3[c]	45.7±8.2[d]	391.8±258.3[e]

[a] Patients with anterior cross bite in primaty dentition (n = 6)
[b] Japanese children with normal occlusion in primary dentition (n = 145).[13]
[c-e] Not significant difference by one sample t-test.

were scanned and digitized by a scanner (Occluzer®) with the analyzing system. OCA (mm^2), ABP (MPa) and IOL (N) were automatically calculated twice at each visit, and the mean values were used for analysis.

The values of the three parameters in the subjects were compared with those in Japanese children with normal occlusion in primary dentition. Data obtained before the start of treatment (period A; Figure 2a), data obtained when crossbite had improved (period B; Figure 2b) and data obtained when the lingual arch appliance had been removed (period C; Figure 2c) were examined in detail.

In statistical analysis, one sample t-test was used for comparison of the parameters in the subjects with crossbite and in children with normal occlusion. Wilcoxon's signed-rank test was used to test for significance in differences between values of parameters in periods A, B and C.

RESULTS

OCA, ABP and IOL in the subjects were slightly lower than the mean values in Japanese children with normal occlusion in primary dentition (Table). However, there were no significant differences between the parameters in the subjects and those in the children with normal occlusion as determined by one sample t-test.

Changes in OCA, ABP and IOL are shown in Figure 3. Period B is indicated by T1 for subjects a, c, d and f and by T3 and T2 for subjects b and e, respectively. Period C is indicated by T5 for subjects b and e and by T6 for subjects c, d and f. Period C for subject a is indicated by T4. OCA decreased remarkably in all subjects after setting of the lingual arch appliance, showing the lowest value in period B, and then gradually increased to the pretreatment level. ABP increased until period B and then gradually declined or became constant. The change in IOL was similar to that in OCA. Four subjects who could be measured after 6 months from period B got the pretreatment level of functional parameters.

Both OCA and IOL showed significant differences in periods A and B and in periods B and C, respectively (both $p<0.05$) (Figures 4a and 4c). ABP showed significant differences in periods A and B and in periods A and C (both $p<0.05$) (Figure 4b).

DISCUSSION

Studies using Dental Prescale-Occluzer® system have recently been done on the characteristics of this system,[14,15] effectiveness of a stabilization splint,[16] conditions of disorder in the temporomandibular joint,[17] effectiveness of denture form,[18] and changes after oral surgery.[19] However, all of the subjects in those studies were adults. There have been few studies using child subjects, and there have been no reports on changes in primary dentition. Thus, the results of the present study on changes in occlusion in child patients with primary dentition, who had received orthodontic treatment should contribute to elucidation of functional factors in primary dentition.

Preparation of the patients was required for application of this system to children with primary dentition. The subjects in this study practiced biting a Dental Prescale® sheet in order to be able to reproduce intercusping when biting without the sheet. Most of the subjects were able to reproduce the occlusion in biting the sheet after practicing once or twice. Therefore, it seems that this system can be easily used for children.

There were no significant differences between OCA, ABP and IOL in the subjects with anterior crossbite and the Japanese children with normal occlusion in primary dentition. For a period of about 4 years prior to the start of orthodontic treatment, the patient had been using anterior crossbite as occlusion. Therefore, it was thought that functional development proceeded with anterior crossbite in the patients to a level similar to that of normal occlusion.

The remarkable decrease in OCA in period B resulted from temporary premature contact in the primary anterior teeth due to a change in the mandibular position and movement of maxillary anterior teeth during the period of orthodontic treatment. ABP increased significantly up to period B because there was no fundamental change in maximum bite force and OCA decreased in period B. There was a statistically significant difference between ABP in period A and that in period C (Figure 4b). It seemed that the function was improved by orthodontic treatment, since OCA showed a tendency to recover to the pretreatment level and ABP in period C was higher than the pretreatment level. In this study, there were some variations in IOL (Figure 3c). It was thought that IOL was affected by OCA and ABP because IOL in this system was calculated as the product of OCA and ABP.

It has been reported that the bite force of prognathic patients steadily increased after surgery and approached normal values within 2 to 3 years using various methods with a custom bite force gauge consisting of four strain gauges mounted on two

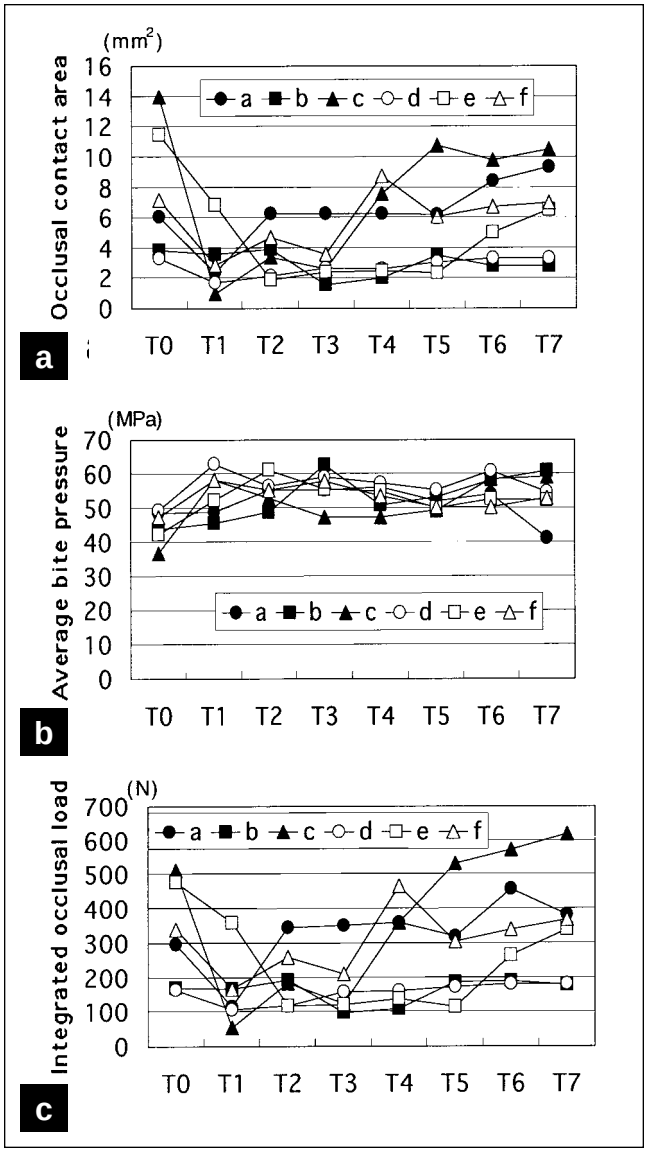

Figure 3. a: Changes in the occlusal contact area (OCA). OCA decreased in all subjects after placement of the appliance, showing the lowest value in period B, and then gradually increased. **b:** Changes in the average bite pressure (ABP). ABP increased until period B and then gradually declined or became constant. **c:** Changes in the integrated occlusal load (IOL). The change in IOL was similar to that in OCA. Period A for all subjects is indicated by T0. Period B is indicated by T1 for subjects a, c, d and f and by T3 and T2 for subjects b and e, respectively. Period C is indicated by T5 for subjects b and e and by T6 for subjects c, d and f. Period C for subject a is indicated by T4.

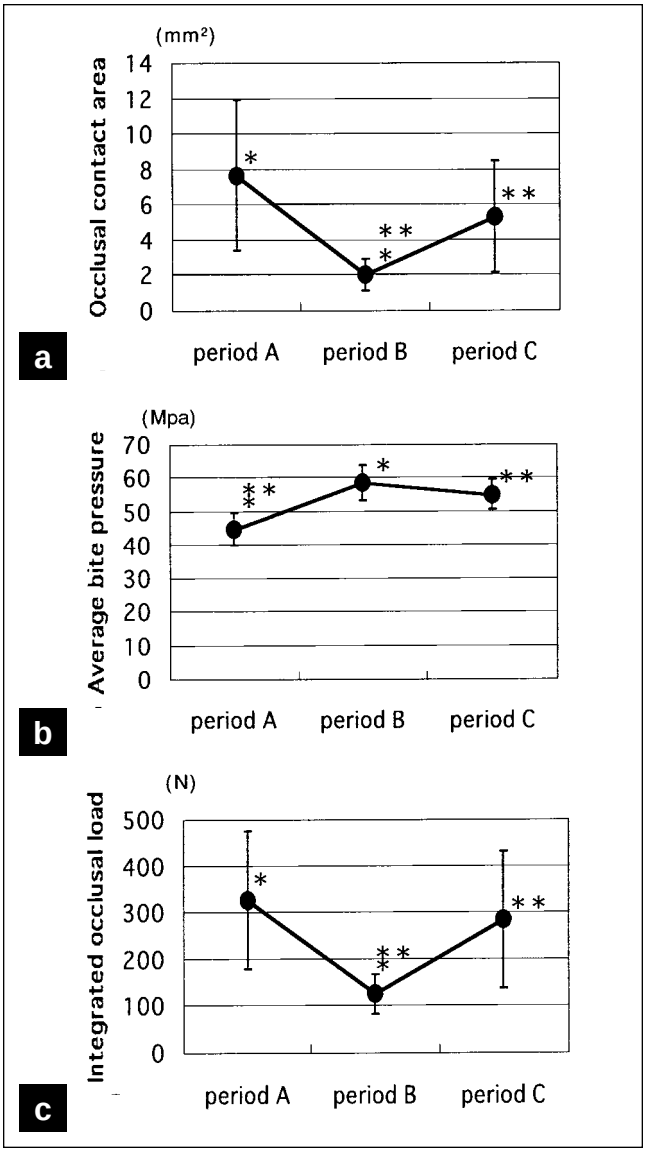

Figure 4. a: Changes in occlusal contact area (OCA) during orthodontic treatment. There were significant differences between the values of OCA in periods A and B and in periods B and C (both $p<0.05$). **b:** Changes in average bite pressure (ABP) during orthodontic treatment. There were significant differences between the values of ABP in periods A and B and in periods A and C (both $p<0.05$). **c:** Changes in integrated occlusal load (IOL) during orthodontic treatment. There were significant differences between the values of IOL in periods A and B and in periods B and C (both $p<0.05$).

stainless-steel bars.[20] In a previous study, bite forces and occlusal contact areas of prognathic patients were measured using a Dental Prescale-Occluzer® system before and after surgery, and it was found that they exceeded preoperative levels at 6 months after surgery but that the postoperative levels were still only about half or less than the levels of healthy subjects.[19] These findings suggest that a relatively long time after improvement of occlusion by surgical therapy is required for recovery of function. The results of the present study showed that a relatively long time was required for recovery of function after improvement in crossbite in many patients. It was thought that the patients gradually acquired new function with the new occlusion by using the improved occlusion. Therefore, the results of this study suggest that there is a time lag in about 6 months between improvement in crossbite and recovery of function.

Although improvement in crossbite is the main goal of early treatment of anterior crossbite, stability of the

new occlusion with acquisition of occulusal function is very important for the patient. Therefore, appropriate observation and management of the oral condition until the new occlusion has become stable are important. Measurements of three parameters seemed to provide useful information on the occlusal condition of the patients.

The Dental Pescale-Occluzer® system used in this study is very easy to use and is a simple means for evaluating OCA, ABP and IOL in child patients. This system also enables calculation of occlusal balance. In this study, however, occlusal balance was not calculated because of the difficulty in determining the relationship between oral condition and the data. Although further investigation using this system is needed, data obtained using this system seem to be good indicators of change in correction of anterior crossbite due to orthodontic treatment.

REFERENCES

1. Valentaine F, Howitt JW. Implications of early anterior crossbite correction. J Dent Child 37: 420-427, 1970.
2. Campbell PM. The dilemma of Class III treatment. Early or late? Angle Orthod 53: 175-191, 1983.
3. Vadiakas G, Viazis AD. Anterior crossbite correction in early deciduous dentition. Am J Orthod Dentofac Orthop 102: 160-162, 1992.
4. Ngan P, Hu A, Fields HWJr. Treatment of Class III problems begins with differential diagnosis of anterior crossbite. Pediatr Dent 19: 386-395, 1997.
5. Kocadereli I. Early treatment of posterior and anterior crossbite in a child with bilaterally constricted maxilla: Report of case. J Dent Child 65: 41-46, 1998.
6. Trankmann J, Lisson JA, Treutlein C. Different orthodontic treatment effects in Angle Class III patients. J Orofac Orthop 62: 327-336, 2001.
7. Murakami T, Hamano Y, Hagg U. A maxillary protracting bow appliance for Class III treatment in the primary dentition. Int J Paediatr Dent 11: 78-83, 2001.
8. Amsterdam M, Purdum LC, Purdum KL. The occlusalgraph: a graphic representation of photocclusion data. J Prosthet Dent 57: 94-98, 1986.
9. Maness WL, Benjamin M, Podoloff R, Bobbick A, Golden RF. Computerized occlusal analysis: a new technology. Quintessence Int 18: 287- 292, 1987.
10. Hattori Y, Okugawa H, Watanabe M. Occlusal force measurement using dental prescale. J Jpn Prosthod Soc 38: 835-841, 1994.
11. Suzuki T, Watanabe S, Yoshitomi N, Ishinabe S, Kumagai H, Uchida T, *et al.* Evaluation of a new measuring system for occlusal force with pressure sensitive sheet. J Jpn Prosthod Soc 38: 966-973, 1994.
12. Matsui Y, Ohno K, Michi K, Suzuki Y, Yamagata K. A computerized method of evaluating balance of occlusal load. J Oral Rehabilitation 23: 530-535, 1996.
13. Tamura H, Morikawa T, Nishino M, Kohri Y, Igarashi S, Oguchi H, *et al*. Studies on the function of occlusion and the masticatory function in children. Jpn J Ped Dent 36: 111-122, 1998.
14. Hidaka O, Iwasaki M, Morimoto T. Influence of clenching intensity on bite force balance, occlusal contact area, and average bite pressure. J Dent Res 78: 1336-1344, 1999.
15. Shinogaya T, Bakke M, Thomsen CE, Vilmann A, Sodeyama A, Matsumoto M. Effects of ethnicity, gender and age on clenching force and load distribution. Clin Oral Invest 5: 63-68, 2001.
16. Kurita H, Ikeda K, Kurashina K. Evaluation of the effect of a stabilization splint on occlusal force in patients with masticatory muscle disorders. J Oral Rehabilitation 27: 79-82, 2000.
17. Sato S, Ohta M, Sawatari M, Kawamura H, Motegi K. Occlusal contact area, occlusal pressure, bite force, and masticatory efficiency in patients with anterior disc displacement of the temporomandibular joint. J Oral Rehabilitation 26: 906-911, 1999.
18. Miyaura K, Morita M, Matsuka Y, Yamashita A, Watanabe T. Rehabilitation of biting abilities in patients with different types of dental prostheses. J Oral Rehabilitation 27: 1073-1076, 2000.
19. Harada K, Watanabe M, Ohkura K, Enomoto S. Measure of bite force and occlusal contact area before and after bilateral sagittal split ramus osteotomy of the mandible using a new pressure-sensitive device: A preliminary report. J Oral Maxilofac Surg 58: 370-373, 2000.
20. Ellis E III, Throckmorton GS, Sinn DP. Bite force before and after surgical correction of mandibular prognathism. J Oral Maxillofac Surg 54: 176-181, 1996.