Clinical Report

APPLICATION OF “PRESCALE” AS AN AID TO CLINICAL DIAGNOSIS IN ORTHODONTICS

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Received 7 February, 2003/Accepted for Publication 18 June, 2004

Abstract

We examined the feasibility of applying the Dental Prescale Occluzer System™ to the evaluation of occlusion in orthodontic patients. The patients were classified according to the type of malocclusion or facial pattern. The values of occlusal contact area and occlusal force obtained from these individuals differed depending on the type of occlusion or facial pattern. These values were higher in individuals with normal occlusion than in patients with malocclusion and higher in patients with the Brachyo facial pattern than in those with the Dolico facial pattern. Because this system can very easily analyze the occlusal contact area, the mean pressure on each occlusal contact point, and the occlusal force during the process of orthodontic treatments, it can be useful as an aid for the initial diagnosis of occlusal problems, the observation of the changes in occlusion during treatment, and the establishment of the final goal of orthodontic treatments.

Key words: Occlusal pattern—Occlusal pressure—Occlusal contact—Occlusal force—Pressure-sensitive sheet

INTRODUCTION

One of the purposes of orthodontic treatment is establishing effective masticatory function by improving functional occlusion. Normal structure of the stomatognathic system is indispensable for proper physiological function. Previous studies^{8,20)} have shown that malocclusion patients have masticatory function that is inferior to the function in subjects with normal occlusion. This inferiority can be improved by orthodontic treatment. However, an easy and rapid method applicable in a general clinic that evaluates masticatory function has not been developed until recently.

The Dental Prescale Occluzer System™ developed by Fuji Photo Film Co., Ltd. has recently allowed for easy measurements of occlusal contact areas and pressures in occlusion. This system is now being used in various fields of dental research, particularly by Japanese researchers^{2-18,22-33)}. These studies have suggested that this system might help evaluating masticatory function and could be applicable to general dental clinical work. Therefore, I used this system to analyze the occlusal status of patients with malocclusion as well as patients with different facial patterns to evaluate its usefulness in general orthodontic treatment.

Table 1 Distribution of the numbers and ages of the subjects with malocclusion and controls with normal occlusion

Occlusion type	Number of subjects	Average age*
Normal occlusion	10	14.10 $\pm$ 4.27
Crowding	21	12.73 $\pm$ 7.12
Mandibular protrusion	19	10.96 $\pm$ 4.27
Maxillary protrusion (ov) ¹	18	12.79 $\pm$ 5.52
Maxillary protrusion (un) ²	10	14.21 $\pm$ 7.63
Lateral crossbite	5	13.20 $\pm$ 7.10
Open bite	20	12.51 $\pm$ 5.25
Total	103	12.93 $\pm$ 7.30

* Values are mean age $\pm$ SD.¹ subjects with overbites beyond 5 mm² subjects with overbites below 5 mm

Table 2 Cephalometric analysis of the subjects with various occlusal types listed in Table 1

	Facial axis	Facial depth	Mandibular plane	Lower facial height	Mandibular arc	Total facial height
Normal occlusion	86.52 $\pm$ 2.98	84.30 $\pm$ 3.43	29.64 $\pm$ 3.62	46.44 $\pm$ 1.50	31.82 $\pm$ 4.81	58.50 $\pm$ 2.11
Crowding	84.46 $\pm$ 4.25	84.41 $\pm$ 3.05	32.39 $\pm$ 4.66	48.22 $\pm$ 4.17	33.30 $\pm$ 4.18	61.14 $\pm$ 4.56
Mandibular protrusion	89.24 $\pm$ 3.23	87.60 $\pm$ 4.27	28.39 $\pm$ 5.99	44.67 $\pm$ 4.08	33.80 $\pm$ 6.96	57.32 $\pm$ 4.58
Maxillary protrusion (ov) ¹	83.84 $\pm$ 2.54	83.46 $\pm$ 2.55	31.43 $\pm$ 3.10	46.30 $\pm$ 3.32	34.88 $\pm$ 2.64	58.72 $\pm$ 3.49
Maxillary protrusion (un) ²	85.34 $\pm$ 3.75	85.28 $\pm$ 2.20	31.66 $\pm$ 4.55	45.03 $\pm$ 3.80	31.53 $\pm$ 4.98	59.93 $\pm$ 4.23
Lateral crossbite	83.12 $\pm$ 5.49	85.46 $\pm$ 2.74	34.54 $\pm$ 4.41	49.68 $\pm$ 5.06	29.18 $\pm$ 6.63	65.20 $\pm$ 4.85
Open bite	83.26 $\pm$ 5.55	85.45 $\pm$ 3.26	33.70 $\pm$ 5.87	51.47 $\pm$ 5.88	31.00 $\pm$ 4.58	64.09 $\pm$ 6.04

Values show mean degree $\pm$ SD.¹ maxillary protrusion with over 5 mm of overbite.² maxillary protrusion with under 5 mm of overbite.

MATERIALS AND METHODS

1. Subjects

The subjects were 93 patients with malocclusion and 124 patients with different facial patterns²¹⁾ who came to my office. In the analyses of the subjects with malocclusion, 10 individuals from our office staff and their friends were selected as a control group. These subjects had no missing, decayed, or restored teeth. They displayed no crowding or displacement teeth. They had 28 permanent teeth and had clinically normal occlusion with frontal overjet and overbite at 2–3 mm in the centric occlusal position.

Visually, no skeletally unbalanced relationships between the maxilla and mandible were observed. These subjects were regarded as individuals with normal occlusion in this study.

The distribution of the numbers and ages of the 93 subjects with malocclusion and normal occlusion are shown in Table 1. I classified the malocclusion patients into six groups; crowding type, mandibular protrusion type, two types with maxillary protrusion, lateral crossbite type, and open bite type. The maxillary protrusion subjects were classified into two types: maxillary protrusion ov. and maxillary protrusion un. The former type

Fig. 1 Cephalometric measurements

FX: Facial axis angle, FD: Facial depth angle, MP: Mandibular plane angle, LFH: Lower facial height angle, MA: Mandibular arc angle and TFH: Total facial height angle

Table 3 Distribution of the numbers and ages of the subjects with different facial patterns

Facial pattern	Number of subjects	Average age*
Severe Dolico pattern	17	13.23 $\pm$ 2.77
Dolico pattern	19	12.25 $\pm$ 3.70
Mesio tendency to Dolico	17	13.37 $\pm$ 8.23
Mesio pattern	19	11.38 $\pm$ 6.51
Mesio tendency to Brachyo	22	11.33 $\pm$ 4.74
Brachyo pattern	13	12.45 $\pm$ 6.99
Severe Brachyo pattern	17	12.44 $\pm$ 4.81
Total	124	12.35 $\pm$ 5.39

* Values are mean age $\pm$ SD.

includes a subject with overbites beyond 5 mm and the latter includes that below 5 mm. Crowding subjects were selected under the criterion that the subject had more than four dislocated teeth on each maxillary and mandibular arch. Open bite subjects were selected under the criterion that the subject had over -3 mm overbite at centric occlusion.

Cephalometric analyses of these subjects are shown in Table 2, and the items measured for the analysis are shown in Fig. 1. Cephalo-

metric analysis of malocclusion and normal occlusion subjects did not show any remarkable characteristics in the comparison between the analyzed data of different occlusal types, which suggested that the differences in the skeletal patterns of these subjects were not significant.

The distributions of the numbers and ages of the 124 subjects with different facial patterns are shown in Table 3. The subjects were classified accordingly to the method of

Table 4 Cephalometric analysis of subjects with the different facial patterns listed in Table 3

Facial pattern	Facial axis	Facial depth	Mandibular plane angle	Lower facial height	Mandibular arc	Total facial height
Severe Dolico pattern	82.64 ± 5.74	84.17 ± 3.03	35.40 ± 5.98	50.60 ± 6.72	30.86 ± 5.47	63.97 ± 7.09
Dolico pattern	84.91 ± 3.70	84.09 ± 2.79	33.11 ± 4.54	48.46 ± 4.31	31.41 ± 4.10	60.69 ± 4.31
Mesio tendency to Dolico	83.22 ± 4.08	83.74 ± 2.82	34.52 ± 4.25	49.08 ± 3.19	31.57 ± 4.80	62.79 ± 4.74
Mesio pattern	83.66 ± 3.22	83.64 ± 2.45	32.88 ± 2.94	47.87 ± 3.93	29.86 ± 4.86	62.64 ± 3.50
Mesio tendency to Brachyo	87.45 ± 2.88	87.26 ± 3.74	29.79 ± 2.99	46.20 ± 1.99	32.11 ± 4.30	59.33 ± 2.78
Brachyo pattern	86.47 ± 2.96	85.58 ± 2.64	29.09 ± 3.13	45.73 ± 3.23	34.37 ± 3.24	58.37 ± 3.11
Severe Brachyo pattern	90.72 ± 3.30	88.67 ± 3.06	24.95 ± 3.49	41.05 ± 2.33	38.74 ± 3.48	53.73 ± 2.38

Values are mean degree ± SD.

Fig. 2 Prescale sheets (A), and an example of the display on the analyzing computer, Occluzer FPD 703 (B)

Ricketts *et al.*²¹⁾. The cephalometric analyses of these subjects are shown in Table 4. In this method, when more than three of the items of the cephalometric analysis shown in Fig. 1 fell under the standard values for individual facial pattern, the subject was classified into the corresponding type. Thus, the individual average values showed the tendencies as expected in that the values for the Dolico pattern were lower in facial axis, facial depth, and mandibular arc and were higher in mandibular plane, lower facial height, and total facial height than were those for the Brachyo facial pattern.

2. Analysis of occlusion using the Dental Prescale Occluzer System™

After practicing biting 2–3 times, the subjects were instructed to bite the Prescale sheet

once and to keep biting for five seconds. There are two types of the Prescale; Type R and Type W. In this study, the pressure sensitive sheets 50H, Type R, were used. The Prescale sheet used was scanned and subjected to analysis by the Occluzer FPD703 (Fuji Film Co.). It contains software, the Occluzergraph-M Version 1.0 (Fuji Film Co.), which works on a Macintosh Power Book 5300cs and Power Mac G4 (Apple Co. Inc.). Values for occlusal contact areas, mean pressure on each occlusal contact area, and the occlusal forces are calculated automatically by the Occluzer and are visualized on the monitor together with the pattern of occlusal contact area on the Prescale sheet (Fig. 2B).

3. Data analysis

The data obtained were classified by each

Table 5 Average values for occlusal contact area, occlusal force, and occlusal pressure per unit area in the different occlusion groups

	Contact area (mm ²)		Occlusal pressure per unit area (MPa)		Occlusal force (N)	
	Average	S.D.	Average	S.D.	Average	S.D.
Normal occlusion	8.48	2.67	51.09	7.71	423.27	113.92
Mandibular protrusion	7.60	3.80	46.13	6.79	348.91	172.02
Crowding	7.49	3.58	46.95	5.39	346.10	154.16
Maxillary protrusion (un) ¹	6.04	3.12	47.22	5.32	281.46	141.22
Lateral crossbite	4.80	1.80	51.12	10.28	245.62	104.22
Maxillary protrusion (ov) ²	4.70	3.25	50.14	8.80	222.37	146.79
Open bite	3.33	1.36	52.16	6.02	170.92	68.74

¹ subjects with overbites below 5 mm² subjects with overbites beyond 5 mm

group, and statistics were arranged using Microsoft Excel 8.0 (Microsoft Co.) and tested by Stat-View J 5.0. One-way factorial ANOVA, multiple comparison tests, and the Scheffe method as Post-Hoc tests were used to determine significant differences between the groups.

ANALYZED RESULTS

1. Analyses of occlusal patterns in the subjects with malocclusion and normal occlusion using a dental prescale system

Table 5 showed the average values of occlusal contact areas (abbreviated word "Area"), occlusal force (abbreviated word "Force"), and values of occlusal pressure per unit area (Force/Area abbreviated word "Pre"), among six groups of malocclusion including a group with normal occlusion. The value for Area was the widest at 8.48 mm² and that for Force was the highest at 423.27N in the group of normal occlusion. The lowest average values for Area and Force were obtained in the open bite group. The values for both Area and Force declined in the following order: normal occlusion, mandibular protrusion, crowding, maxillary protrusion un., lateral crossbite, maxillary protrusion ov., and open bite groups. However, this order

was not reflected to the values for Pre. When the value for Area or Force was compared between each group, statistically significant differences were observed with the same tendency; normal occlusion *vs.* open bite, crowding *vs.* open bite, and mandibular protrusion *vs.* open bite groups (Table 6). In the comparison of occlusal force, an additional significant difference was observed for mandibular protrusion *vs.* open bite group. No significant difference was observed in the comparison of Pre.

2. Analyses of occlusal patterns in the subjects with different facial patterns using a dental prescale system

Table 7 shows the average values of Area, Pre, and Force among groups with different facial patterns. The value for Area was the widest at 9.8mm² in the group with the Brachyo pattern and that for Force was the highest at 457.28N in the group with the severe Brachyo pattern. The values for Area and Force were the lowest in this group with the severe Dolico pattern. The values for Force declined in this order: severe Brachyo, Brachyo, Mesio tendency to Brachyo, Mesio, Mesio tendency to Dolico, Dolico, and severe Dolico patterns. The values for Area declined in the same order as those for Force other than those for severe Brachyo and Brachyo;

Table 6 Results of ANOVA and Scheffe methods for analyzing malocclusion and normal occlusion

Contact area

	Normal occlusion	Crowding	Mand. pro.	Max. pro. ov.	Max. pro. un.	Lat. crossbite	Open bite
Normal occlusion		0.9944	0.9967	0.1527	0.7239	0.5801	0.008
Crowding			>.9999	0.271	0.9354	0.8041	0.0093
Mand. pro.				0.1811	0.8926	0.7554	0.0036
Max. pro. ov.					0.9594	>.9999	0.9307
Max. pro. un.						0.9963	0.3942
Lat. crossbite							0.9886
Open bite	**	**	**				

Average pressure

	Normal occlusion	Crowding	Mand. pro.	Max. pro. ov.	Max. pro. un.	Lat. crossbite	Open bite
Normal occlusion		0.8777	0.7227	>.9999	0.9328	>.9999	>.9999
Crowding			>.9999	0.9152	>.9999	0.961	0.4643
Mand. pro.				0.7444	0.9998	0.9018	0.2264
Max. pro. ov.					0.964	>.9999	0.9916
Max. pro. un.						0.9773	0.6491
Lat. crossbite							>.9999
Open bite							

Force

	Normal occlusion	Crowding	Mand. pro.	Max. pro. ov.	Max. pro. un.	Lat. crossbite	Open bite
Normal occlusion		0.9123	0.9159	0.045	0.4212	0.4921	0.0024
Crowding			>.9999	0.2863	0.9371	0.9093	0.0197
Mand. pro.				0.2133	0.9101	0.8896	0.0099
Max. pro. ov.	*				0.9633	>.9999	0.9708
Max. pro. un.						0.9997	0.5206
Lat. crossbite							0.9783
Open bite	**	*	**				

** 1% level significant difference

* 5% level significant difference

the value for Brachyo was higher than that for severe Brachyo. These orders were not reflected to the values for Pre. When the value for Area, Pre or Force was compared between each group (Table 8), significant differences were observed with the similar tendency in

the comparisons of Area and Force. Both values of severe Dolico differed significantly from those for severe Brachyo, Brachyo, Mesio-Brachyo or Mesio. Both values for Dolico differed from those for severe Dolico, Brachyo, Mesio-Brachyo, or Mesio, and both

Table 7 Average values for contact area, occlusal pressure per unit area, and occlusal force in different facial patterns

	Contact area (mm ²)		Occlusal pressure per unit area (MPa)		Occlusal force (N)	
	Average	S.D.	Average	S.D.	Average	S.D.
Severe Dolico pattern	1.99	1.06	49.26	10.90	94.53	45.70
Dolico pattern	2.92	1.01	56.08	8.25	159.23	50.38
Mesio tendency to Dolico	4.92	2.03	49.19	5.70	243.29	106.29
Mesio pattern	6.83	2.47	46.28	7.30	314.57	108.65
Mesio tendency to Brachyo	7.76	2.71	47.16	7.45	355.91	114.19
Brachyo pattern	9.80	5.14	45.58	6.93	423.34	161.74
Severe Brachyo pattern	9.69	3.69	47.57	5.81	457.28	169.04

values for Mesio-Dolico differed from those for severe Brachyo or Brachyo. In the values for Force, those for severe Dolico *vs.* Mesio-Dolico and Mesio *vs.* severe Brachyo were also significantly different. In the comparison of Pre, only the value for Dolico was significantly different from that for Brachyo, Mesio-Brachyo, or Mesio.

DISCUSSION

The Dental Prescale Occluzer System™ has an advantage of being able to evaluate occlusion at nearly physiological conditions because the thickness of the prescale sheet is very thin and the use of this sheet does not interfere ordinary occlusion at centric position. Although this system is now widely used in general dental clinics in Japan, there are only a few papers concerning the clinical use of this system in orthodontics^{1,7,8,34)}.

Therefore, I analyzed the occlusal status of a large number of patients with malocclusion or different facial patterns using the Dental Prescale System to obtain better insight in the clinical use of this system.

In the present study, the subjects with normal occlusion had the highest values in contact areas and occlusal force compared with patients with different types of malocclusion. The results suggested that these values would

increase in the process of improving malocclusion during orthodontic treatment. Therefore, if we continue to measure contact areas and occlusal force in the same individuals during the course of treatment, it will help to follow the course of improvement of occlusion. In addition, if we increase the number of subjects with normal occlusion and establish the range of these values or find correlations between the values before and after treatment in every type of malocclusion, these values might be used to survey the final status of orthodontic treatment.

Proffit *et al.*²⁰⁾ reported that long-faced individuals have less occlusal force than individuals with normal vertical facial dimensions. Park¹⁹⁾ reported that the main frequency of electromyography of Dolico-facial type subjects was lower than that of Brachyo or Mesio facial type subjects. Inaba⁶⁾ examined the occlusal force in 64 subjects with normal occlusion using the prescale and concluded that Brachyo-facial-type subjects had the largest values for contact area, occlusal force, and mean biting force per unit area, followed by the Mesio facial-type and Dolico facial-type subjects in that order. In the present comparison of contact area and occlusal force among individuals with different facial patterns, the values for Area and Force were significantly higher in the individuals with Brachyo facial pattern than in those with Dolico facial

Table 8 Results of ANOVA and Scheffe methods for analyzing different facial patterns

Occlusal contact

	Sev. Brachyo	Brachyo	Mesio-Brachyo	Mesio	Mesio-Dolico	Dolico	Sev. Dolico
Sev. Brachyo		>.9999	0.599	0.1598	0.0008	<.0001	<.0001
Brachyo			0.5997	0.1743	0.0013	<.0001	<.0001
Mesio-Brachyo				0.9789	0.1353	<.0001	<.0001
Mesio					0.6475	0.0068	0.0002
Mesio-Dolico	**	**				0.5882	0.1359
Dolico	**	**	**	**			0.983
Sev. Dolico	**	**	**	**			

Average pressure

	Sev. Brachyo	Brachyo	Mesio-Brachyo	Mesio	Mesio-Dolico	Dolico	Sev. Dolico
Sev. Brachyo		0.9976	>.9999	0.9997	0.999	0.1028	0.9985
Brachyo			0.9991	>.9999	0.946	0.0271	0.9334
Mesio-Brachyo				>.9999	0.9952	0.0423	0.9931
Mesio					0.9728	0.0238	0.9644
Mesio-Dolico						0.318	>.9999
Dolico		*	*	*			0.296
Sev. Dolico							

Force

	Sev. Brachyo	Brachyo	Mesio-Brachyo	Mesio	Mesio-Dolico	Dolico	Sev. Dolico
Sev. Brachyo		0.9946	0.2747	0.0343	0.0001	<.0001	<.0001
Brachyo			0.8053	0.2946	0.0058	<.0001	<.0001
Mesio-Brachyo				0.9679	0.1611	0.0001	<.0001
Mesio	*				0.7358	0.0099	<.0001
Mesio-Dolico	**	**				0.5571	0.0225
Dolico	**	**	**	**			0.7968
Sev. Dolico	**	**	**	**	*		

** 1% level significant difference

* 5% level significant difference

pattern. However, the values for Pre did not show the same tendency. Because the subjects in this paper consisted of patients with malocclusion, the difference in the results of Pre from the results by Inaba⁶⁾ might be caused partly by the quality of occlusion in the sub-

jects. Further studies may be necessary to clarify the cause of this discrepancy.

In conclusion, although it will not be possible to apply the values obtained in this study directly to the comparison in all type of patients with malocclusion and facial

patterns, application of the Dental Prescale System to observing changes in the occlusion of orthodontic patients may help in evaluating the condition of occlusion in first examinations and in follow-up. I also recommend considering the differences in facial patterns when applying Dental Prescale Systems to clinical diagnosis in orthodontics.

ACKNOWLEDGEMENT

The author would like to express his appreciation to Dr. Ram S. Nanda of the University of Oklahoma for his valuable advice and support of this study.

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