**A Study on Changes in the Facial Soft and Hard Tissues
Associated with the Treatment of Anterior Crossbite
—With Reference to the Application of Moiré Topography—**

by

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Introduction

In recent years, a new measuring technique using moiré topography has been introduced into the field of dentistry and various measurements have since been made of the face, the palate, the alveolar ridge and the like. This particular technique is advantageous over other measuring techniques, including contour cartography, in that it is simple to manipulate, it makes measurement possible without touching variable portions and it also permits qualitative as well as quantitative analysis. Especially in the field of orthodontics, studies have been made on the facial characteristics of malocclusal patients and of the facial changes before and after treatment.

Studies on facial soft tissue have hitherto been conducted mainly in two dimensions using lateral cephalometric radiographs and facial photographs.

In this study the author employed moiré topography and, from a standpoint of quantitative analysis, made observations of the morphological changes in the facial soft tissues of anterior crossbite patients after bite improvement by means of an FKO apparatus. The author also studied how the sectional areas were interrelated. Another purpose of this study was to learn about the relationships between the morphological changes in the soft tissue in the upper lip region and the changes in measurement values obtained from lateral cephalometric radiographs.

Materials and Methods

1. Materials

Of the anterior crossbite patients treated in the Department of Orthodontics, Nihon University Dental Hospital, a selective use was made of 39 patients (17 males and 22 females) whose bites had been improved using an FKO apparatus. In this study the frontal moiré photographs and the lateral cephalometric radiographs before and after treatment were used.

The mean age of the above-mentioned 39 subjects when treatment started was 9 years and 5 months. Fifteen belonged to III A, 21 to III B and 3 to III C according to Helman's classification of dental ages. The treatment periods ranged from 39 to 209 days. The mean period was 92 days. The crossbite conditions and the presence of maxillary cuspids were studied using Angle's models.

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2. Methods

In moiré photography the author followed KAMONJI's method. After the point of the left-eye socket was marked on each subject, he was instructed to repeat articulation at centric occlusion without constricting the lips. Right and left ear-rods were then inserted in the auricular orifices. The eye-point indicator, designed to be horizontal to the floor, was placed in position as so to be in agreement with the point of the left-eye socket to prevent horizontal as well as vertical movements. Frontal photographs were then taken.

The photographic apparatus was a Fujinon Moiré Camera FM-3011, a product of the Fuji Film Company. The intervals between the isobars were set at 2 mm, the shutter speed at 1/8 sec. and the lens opening at F8 or F16.

1. Spn	8. Sn
2. Basic moiré contours	9. Sto
3. FHP	10. Ch
4. Median line	UL Upper lip region
5. SnP	UB Buccal region
6. StoP	U Upper jaw
7. Outermost part of upper lip	L Lower jaw

Fig. 1 Landmarks for moiré photography

The exposed film was developed and positive pictures (Fujifilm WP-4) half as large as life were prepared. Frontal moiré photographs were thus obtained.

The measurement landmarks (the base points, the base planes and the base moiré stripes) are shown in Fig. 1.

The base points

- Spn: The lowest point of the root of the nose; the median point between the inner canthi of both eyes
- Sn: The apex of the angle formed by the lower edge of the membranous part of the nasal septum and the dermal surface of the upper lip
- Sto: The point of junction of the oral fissure and the median line with the mouth lightly closed
- Ch: The points in the angles of the mouth where the vermillion labial margins meet at both lateral ends

The base planes

FHP: The line that passes the center of the indicator designed to indicate the point of the left-eye socket

Facial median line: The line that vertically crosses FHP through Spn

1. SN to mand.	5. Facial angle
2. SNA	6. FH to $\perp$
3. SNB	7. $\perp$ to $\bar{T}$
4. SN-Pog.	8. Mand to $\bar{T}$

Fig. 2 Measurement landmarks for angles

Fig. 3 Measurement landmarks for distance items

The base moiré contours

In accordance with KAMONJI's method, the fifteenth line (counting both black and white contours) going downward externally from SnP was used as the base.

The method for measuring frontal moiré photographs

As shown in Fig. 1, a line that passes Sn and runs parallel to FHP was drawn and designated as SnP. The line that links Ch, Sto and Ch' was further extended outward from Ch and Ch', parallel to FHP, and was designated as StoP. The upper jaw (U) is a section formed by SnP, the base moiré contour and StoP. The lower jaw (L) is a section formed by StoP and the base moiré contour. The upper jaw was divided into two sections: the upper lip region (UL), an area surrounded by the outermost contours extending from the wings of the nose to the oral fissure and the upper buccal region (UB), an area extending outward from the next contour to the base moiré contour.

Measurements were made of the surface area and volume of each section using a summagraphic apparatus (FORM 16, manufactured by Summagraphics).

Measurement of the upper lip region

The width, height and depth of the upper lip region were measured. The width was the maximum width of the upper lip region and the height was the distance from Sn on the facial median line to Sto. 1/20 mm vernier calipers were used for measurement. As for the depth, the mean number of contours from the outermost

Table 1 Samples in the present study

case	sex	age	dental age Helman	treatment period(days)	case	sex	age	dental age Helman	treatment period(days)
1	F.	7y. 7m.	III A	43	21	M.	9y. 4m.	III B	74
2	M.	7y. 8m.	III B	90	22	F.	9y. 5m.	III A	76
3	M.	7y. 9m.	III A	92	23	F.	9y. 6m.	III B	98
4	F.	7y.10m.	III A	42	24	F.	9y. 6m.	III B	85
5	M.	7y.10m.	III A	78	25	F.	9y. 6m.	III B	122
6	M.	7y.11m.	III B	147	26	M.	9y. 9m.	III A	95
7	F.	7y.11m.	III B	209	27	M.	10y. 0m.	III B	39
8	F.	8y. 0m.	III B	114	28	M.	10y. 2m.	III B	197
9	M.	8y. 2m.	III A	58	29	F.	10y. 2m.	III B	120
10	M.	8y. 2m.	III A	75	30	M.	10y. 7m.	III B	71
11	F.	8y. 3m.	III A	57	31	F.	10y. 8m.	III B	54
12	F.	8y. 4m.	III B	52	32	F.	10y. 8m.	III B	42
13	M.	8y. 5m.	III A	76	33	F.	10y. 8m.	III B	77
14	F.	8y. 6m.	III A	61	34	F.	10y. 9m.	III B	53
15	M.	8y. 9m.	III A	156	35	M.	10y.10m.	III B	45
16	F.	8y.10m.	III B	149	36	M.	10y.11m.	III A	42
17	F.	8y.11m.	III A	132	37	M.	11y. 2m.	III C	104
18	F.	8y.11m.	III B	126	38	F.	11y. 5m.	III C	121
19	M.	9y. 3m.	III B	141	39	F.	12y. 7m.	III C	134
20	F.	9y. 3m.	III A	58	mean		9y. 5m.		92

moiré contour to the highest moiré contour in the upper lip region, on both the left and right sides, was evaluated.

Analysis of the lateral cephalometric radiographs

IZUKA ET AL.'s method was used for measuring the lateral cephalometric radiographs. For angle measurements 8 items (Fig. 2), expected to show changes resulting from the use of the FKO technique, and 2 items (Fig. 3) for measuring distances were selected from the series of criteria of both Down's and North-western's analysis.

Results

1. The rates of change in the surface area and volume of each section before and after the improvement of bite observed on the frontal moiré photographs are shown in Table 1. In computing the rates of change the formula:

$$\frac{\text{post-op.} - \text{pre-op.}}{\text{pre-op.}} \times 100(\%)$$

Table 2 Change in the surface of each region

case	UL	UB	U	L	case	UL	UB	U	L
1	+ 6.36	+ 5.07	+ 5.62	-10.56	21	+17.11	- 2.36	+ 5.80	+11.10
2	- 3.45	- 2.42	- 2.81	-21.97	22	+ 2.03	+ 7.83	+ 5.66	-20.12
3	- 9.03	-21.93	-18.69	+ 0.67	23	+ 1.66	+ 5.65	+ 4.36	-11.12
4	+11.95	- 9.05	- 1.51	- 0.94	24	+17.98	-24.84	-10.77	-56.86
5	+ 3.19	-14.26	- 5.64	-21.18	25	+ 6.57	- 6.28	- 0.41	+ 0.12
6	- 0.97	+ 9.57	+ 4.33	+ 2.73	26	+20.39	- 1.38	+ 8.15	-15.90
7	- 0.72	+23.68	+13.42	- 5.72	27	-10.32	+ 4.31	- 2.48	-28.07
8	-25.97	- 3.29	-13.64	-24.75	28	+ 4.15	- 0.96	+ 0.99	-18.36
9	- 0.92	- 8.87	- 5.37	-33.46	29	- 1.17	-26.05	-16.86	-11.27
10	- 1.24	- 6.81	- 4.61	- 8.08	30	+ 2.77	- 1.02	+ 0.71	- 4.54
11	+ 3.49	- 1.99	- 0.06	+ 1.42	31	- 2.72	- 6.98	- 5.49	- 5.29
12	+14.89	-13.92	- 3.45	- 1.50	32	- 2.55	-14.07	- 8.05	- 5.74
13	+ 2.83	+12.27	+ 7.75	-22.48	33	- 9.23	+12.53	+ 1.86	- 3.12
14	- 4.05	- 4.31	- 4.19	-11.70	34	+ 0.89	+ 3.18	+ 2.41	- 0.44
15	+ 1.19	+ 9.51	+ 5.49	- 7.13	35	- 6.43	+ 5.92	+ 1.04	- 4.96
16	- 3.87	-12.90	- 9.77	-24.01	36	+11.55	- 6.08	+ 0.92	-28.99
17	- 5.33	-10.66	- 8.56	-21.86	37	+ 2.49	-19.28	- 8.71	-30.96
18	+ 9.09	+ 5.26	+ 6.98	+14.29	38	+ 8.88	- 6.31	- 0.81	- 7.33
19	- 2.27	+ 2.65	+ 0.43	-29.40	39	-18.58	+14.01	- 2.54	-31.77
20	+11.22	- 0.25	+ 4.22	-15.80	mean	+ 1.46	- 2.69	- 1.39	-13.21

(%)

was used. In the tabulation, the positive sign (+) indicates an increase and the negative sign (-) means a decrease after treatment.

The rates of change in the surface area and volume are shown in Tables 2 and 3.

Table 4 shows the mean values and differences in the width, height and depth of the upper lip region before and after treatment.

2. The analytical values of the lateral cephalometric radiographs and the mean values of their differences before and after treatment are shown in Table 5.

3. The models of the oral cavity showed that there were 24 cases of anterior crossbite involving deciduous or permanent cuspids on both sides of the mandible (61.5%) and 28 cases with deciduous or permanent cuspids on both sides of the maxilla (71.8%).

4. Table 6 shows the measurement values for the 6 items believed to be mainly responsible for changes in the hard tissues as observed on the lateral cephalometric radiographs. It also shows the rates of change in the surface area and volume of the soft tissue of each section as well as correlations between the width, height and depth. A single asterisk * shows the correlation at a significant level of 5% and a double asterisk **, the correlation at a significant level of 1%.

Table 3 Change in the volume of each region

case	UL	UB	U	L	case	UL	UB	U	L
1	+ 1.96	- 1.83	+ 0.50	-24.15	21	+29.60	+ 1.37	+18.75	+20.91
2	- 6.20	-12.74	- 9.09	-32.50	22	- 0.46	+ 4.93	+ 2.01	-35.09
3	- 0.99	-20.20	-13.15	-10.80	23	- 4.48	+ 0.77	- 1.69	-27.80
4	+15.93	-11.05	+ 2.78	+ 2.77	24	+ 0.45	-54.83	-26.63	-64.30
5	- 3.10	-28.02	-13.48	-43.04	25	+15.50	- 2.36	+ 9.44	+ 1.57
6	+ 7.51	+27.62	+13.37	-12.75	26	+24.88	+ 1.16	+16.21	-23.11
7	- 4.48	+28.17	+ 8.44	-31.21	27	-21.14	- 3.24	-15.07	-45.81
8	+ 4.19	-16.16	- 1.82	-35.12	28	- 4.08	-12.07	- 7.61	-41.01
9	- 4.70	-21.05	-10.59	-42.84	29	- 2.83	-24.37	-11.81	-17.92
10	- 2.38	-12.12	- 6.64	-21.93	30	- 1.82	- 1.93	- 1.86	-25.53
11	+ 2.53	- 7.44	- 2.37	- 8.25	31	- 5.70	- 9.91	- 7.78	-19.23
12	+15.15	-20.76	- 1.44	- 8.50	32	- 4.01	-16.28	- 7.07	-13.84
13	- 4.29	+ 7.64	- 0.58	-40.05	33	- 8.41	+10.81	- 2.46	-19.31
14	- 6.43	- 8.40	- 7.11	-17.53	34	- 1.43	+ 2.44	+ 1.96	- 8.36
15	+ 5.34	+15.57	+ 8.41	-12.18	35	- 8.89	+ 5.50	- 2.57	-18.20
16	-12.86	-23.30	-18.12	-47.59	36	+ 8.16	-18.63	- 4.06	-42.14
17	-17.49	-23.64	-20.04	-38.04	37	- 3.07	-34.44	-12.60	-41.61
18	+21.80	+15.80	+19.74	+26.16	38	+ 1.77	-14.22	- 5.74	-23.04
19	- 2.97	+ 1.10	- 1.58	-40.13	39	-22.44	+11.35	-12.68	-49.12
20	+ 1.07	- 8.47	- 3.07	-29.41	mean	+ 0.03	- 7.01	- 3.26	-24.62

(%)

Table 4 Means of width, height and depth in upper lip region

	Width (mm)	Height (mm)	Depth (mm)
Before	43.9 (5.7)	18.7 (2.0)	9.4 (1.5)
After	42.0 (4.8)	19.2 (2.0)	9.8 (1.3)
Deff.	- 1.9	+ 0.5	+ 0.4

():SD

Table 5 Means of radio cephalometric analysis before and after treatment

measure- ment	SN to Mand.	SNA	SNB	SNPog	Facial Angle	FHto $\perp$	$\perp$ to $\overline{\text{T}}$	Mand. to $\overline{\text{T}}$	over jet (mm)	over bite (mm)
Before	36.8	79.0	79.1	78.7	85.9	107.0	134.7	88.6	- 3.6	4.1
After	38.8	79.0	77.6	77.2	84.1	113.8	129.2	84.8	2.0	1.5
Diff.	+ 2.0	0.0	-1.5 *	-1.5 *	-1.8 *	+6.8 **	- 5.4**	-3.8*	+ 5.6**	-2.5**

unit : degree

* : significant at 5% level

** : significant at 1% level

Table 6 Correlation coefficient value between hard tissue and soft tissue

	S group				V group				UL		
	UL	UB	U	L	UL	UB	U	L	Width	Height	Depth
SN to mand	-0.089	0.143	0.100	0.017	-0.130	0.130	0.023	-0.187	-0.347*	0.290	-0.261
FH to $\perp$	0.164	-0.154	-0.033	0.071	0.229	-0.088	0.104	0.102	0.054	0.101	-0.056
mand to $\overline{\text{T}}$	-0.098	0.136	0.031	-0.099	-0.144	0.049	-0.099	-0.164	-0.279	0.063	-0.140
$\perp$ to $\overline{\text{T}}$	0.001	0.013	0.004	0.108	-0.050	0.065	0.002	0.160	0.190	-0.237	0.073
over jet	-0.120	0.253	0.177	0.038	-0.157	0.276	0.087	-0.076	-0.293	0.067	-0.129
over bite	-0.001	-0.297	-0.261	0.032	0.028	-0.286	-0.171	0.156	0.280	-0.254	0.081
S group	UL	-0.214	0.376*	0.127	0.678**	-0.165	0.324*	0.252	0.564**	0.168	0.439**
	UB		0.814**	0.222	-0.087	0.901**	0.537**	0.075	-0.443**	0.241	-0.266
	U			0.314	0.320*	0.760**	0.723**	0.244	-0.069	0.318*	0.016
	L				0.478**	0.528**	0.674**	0.917**	0.309	-0.282	0.175
V group	UL					0.116	0.741**	0.665**	0.689**	-0.029	0.454**
	UB						0.734**	0.396*	-0.280	0.077	-0.180
	U							0.713**	0.297	0.028	0.198
	L								0.482**	-0.295	0.278

* : Significant at 5% level

** : Significant at 1% level

Discussion

Based on the analytical values of the lateral cephalometric radiographs, the healing process for anterior crossbite patients, using an FKO apparatus, went through a rotation of the mandibular body, a lingual inclination of the mandibular anteriors and a labial inclination of the maxillary anteriors. This was in agreement with previous reports.

Relationships between the hard and soft tissues deserve no special mention. It is believed that changes brought about in the hard tissue using an FKO apparatus do not directly affect the surface area and volume of the soft tissue.

In the region of the soft tissue, changes in the UL are considered significant.

Table 7 Changes in upper lip region (surface)

measurement group case		Hard tissue			Soft tissue		
		SN to mand.	FH to $\perp$	Mand. to $\overline{1}$	Width (mm)	Height (mm)	Depth (mm)
S(+)	12	+ 1.4	+ 7.7	- 3.9	+ 1.6	+ 0.5	+ 1.1
S($\pm$)	20	+ 2.4	+ 6.6	- 4.0	- 3.0	+ 0.4	+ 0.2
S(-)	7	+ 2.1	+ 6.1	- 3.2	- 5.0	+ 0.4	0

unit : degree

Table 8 Changes in upper lip region (volume)

measure- ment group case		Hard tissue			Soft tissue		
		SN to Mand.	FH to $\perp$	Mand. to $\overline{1}$	Width (mm)	Height (mm)	Depth (mm)
V(+)	9	+1.5	+7.3	-4.2	+1.2	+0.9	+1.0
V($\pm$)	21	+2.4	+7.5	-3.7	-1.9	+0.6	+0.2
V(-)	9	+1.6	+5.4	-3.4	-4.2	+0.2	+0.1

unit : degree

They occur irrespective of changes that take place in the hard tissue of the UB. Thus, the author was led to believe that conditions of the mandibular and maxillary anteriors are responsible for changes in the UL. The rate of presence of the deciduous or permanent cuspids on both sides of the maxilla and the rate of anterior crossbite involving deciduous or permanent cuspids on both sides of the mandible were studied. Changes in the surface area and volume of the UL were also examined (Tables 7, 8, 9 and 10).

It is considered that the higher the rate of presence of the deciduous or permanent cuspids on both sides of the maxilla, the greater the recovery of fullness in the UL due to maxillary deciduous or permanent cuspids. Also, the higher the rate of anterior crossbite involving deciduous or permanent cuspids on both sides of the mandible, the greater is the upward push of the upper lip. After treatment much of this upward push will disappear.

Table 9

C|C or 3|3 existence and C|C or 3|3 cross bite in each of S groups

	Case	<u>C C or 3 3</u> Existence	<u>C C or 3 3</u> Cross bite
S(+)	12	8 (66.7)	6 (50.0)
S(±)	20	16 (80.0)	14 (65.0)
S(-)	7	4 (57.1)	5 (71.4)

() : %

Table 10

C|C or 3|3 existence and C|C or 3|3 cross bite in each of V group

	Case	<u>C C or 3 3</u> Existence	<u>C C or 3 3</u> Crossbite
V(+)	9	7 (77.8)	5 (55.6)
V(±)	21	14 (66.7)	12 (57.1)
V(-)	9	7 (77.8)	7 (77.8)

() : %

In the S(+) and V(+) groups the recovery of fullness is far greater than the disappearance of the upward push, whereas in the S(±) and V(±) groups the disappearance of the upward push and the recovery of fullness are well balanced. In the S(-) and V(-) groups the disappearance of the upward push of the mandibular anteriors is far greater than the recovery of fullness in the UL.

For the reasons given above, the frontal moiré photographs of the facial soft tissue before and after improvement of anterior crossbites by means of an FKO apparatus did not show the subtle changes in the soft tissue as they did in the hard tissue.

The surface area and volume of the UL are correlated with its width and depth and the upward push of the upper lip by the mandibular anteriors is considered to be a factor responsible for changes in the width and depth. As anterior bite improves the upward push disappears and the upper lip loses its support and recedes. The smaller the degree of upward push, the smaller the degree of recession of the upper lip when the upward push disappears. At the same time, in the presence of the deciduous or permanent cuspids on both sides of the maxilla, the upper lip, which has been deprived of the support of the mandibular anteriors, takes on a certain degree of fullness along its surface because of the cuspids that are present. On the contrary, in the absence of the deciduous or permanent cuspids, the recovery of fullness is not sufficient. In similar cases of bite improvement, using an FKO apparatus, a variety of changes occur in the UL depending upon the conditions of the anterior crossbite and the maxillary cuspids. Therefore, in some cases the profile of the patient does not improve after treatment.

Conclusion

Thirty-nine subjects suffering from anterior crossbite were treated using an FKO apparatus for improvement of bite. On the basis of their frontal moiré photographs and lateral cephalometric radiographs before and after treatment, studies were made on the changes in the facial soft tissue in each section and also on the relationships between the sections, especially those between the soft and hard tissues in the upper lip region. As a result, the author reached the following conclusions.

1. In the analytical values of the lateral cephalometric radiographs a correlation did not exist between the changes in the hard tissue and those in the surface area and volume of the soft tissue.
2. A significant correlation was noted between the rates of change in the surface area and volume in each section.
3. A correlation existed in the rates of change between the surface area and volume and the width and depth of the upper lip region.
4. The changes in the surface area and volume of the upper lip region after an improvement of the bite suggest that they bear some relationship to the conditions of anterior crossbite and the presence of maxillary cuspids.
5. From the above findings, it was confirmed that by using moiré photographs taken before and after orthodontic treatment, it is possible to make an effective qualitative and quantitative analysis of the changes in the facial soft tissue brought about by orthodontic treatment. It is also possible to learn about the relationships between morphological changes in the soft tissue and changes in measurement values. The author, therefore, believes that moiré photography is an extremely simple and useful tool in making a diagnosis before orthodontic treatment and for studying the changes in the regions in and around the jaws.

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