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An Approach to Determine the Necessity of Orthognathic Osteotomy or Orthodontic Treatment in a Cleft Individual

-comparison of craniomaxillo-facial structures in borderline cases by roentogenocephalometrics-

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Summary: At an early stage of growth, it seems nearly impossible to predict the treatment result which the malocclusion of a cleft patient could be corrected by surgical or orthodontic treatment. This study was done to get any clue to confirm the way which the treatment should be finished one or another of both plans for so called a "borderline case" by using a method of data analysis gained from roentgenocephalograms longitudinally. The subjects were unilateral cleft lip & palate patients, who were divided into two groups. One was the OPE group which are corrected by orthodontic treatment with orthognathic osteotomy, the other was the Non-OPE group which are corrected by orthodontics only. These cephalograms were used to evaluate some characteristics of maxillofacial structures. The results showed a possibility to identify the difference of the two groups by utilizing some parameters at an early stage of growth.

1. Introduction

Cleft patients have severe dental problems related to their abnormal facial structures, disturbed facial growth patterns and tooth anomalies, therefore their habilitation is needed from childhood to adulthood. Early orthodontic treatment is often indicated in order to change unfavorable growth pattern and to correct abnormal oral functions such as speech, mastication and swallowing. A majority of treatment objectives in some cases can be achieved through orthodontic treatment alone, while surgical treatment must be applied in the long run for others. At the adulthood, the combined approach between orthodontics and surgery such as the orthognathic osteotomy would be the best way for the one with severe maxillo-mandibular three dimensional disharmony which could not be treated by orthodontic treatment alone. However, the selection of orthodontic or surgical orthodontic treatment remains subjective in nature, which often result in forced long continuous orthodontic treatment on surgical case in the borderline cases. Besides, the decision for the surgery or not are multifactorial things which are related not only maxillo-mandibular relationship but also occlusion, soft tissue profile and the consent of the patient for the surgery. If we could judge the treatment plan for the surgical case earlier before the patient reaches maturity, we could avoid to force long term treatment of growth control which must be finally useless at the time of surgery. The earlier, the better.

This study was designed to investigate cephalometrically, on a longitudinal basis, the possibility of growth prediction for surgical-orthodontic treatment in the cleft patients as early grwth stage as possible with the aid of the cephalometric analysis (Fig. 1).

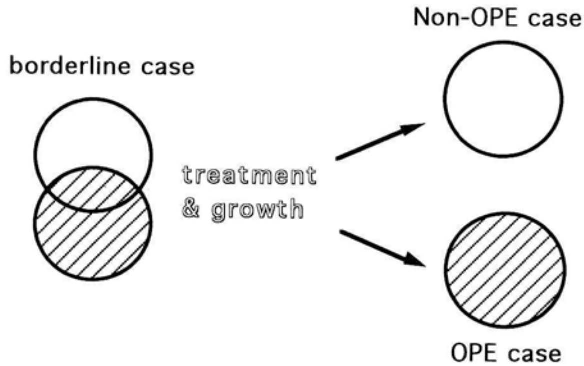

Fig. 1. Concept of the study
How to predict the orthognathic surgical case in its early growth stage?
What is some parameter to detect the surgical case?

2. Materials and methods

2.1 Subjects

The subjects were 67 Japanese unilateral cleft lip and palate (UCLP) patients (37 males and 30 females) at the Department of Orthodontics, Showa University Dental Hospital. Two orthodontic doctors who have the clinical experience in the treatment of the CLP patients over ten years have judged the 67 subjects to be **borderline cases** by the condition of malocclusion using dental cast model. Criteria of selection for the borderline cases were based on the severity of the maloccluion or treatment which all cases had light anterior crossbite before treatment at early mixed dentition. The cases which could be obviously made a diagnosis for surgical in the term of severe maxillo-mandibular relationship and would be favorable not to need the surgery in the future were omitted. Finally 33 of the patients had orthodontic treatment with osteotomy (**OPE group**) and 34 had only orthodontic treatment (**Non-OPE group**).

The lateral radiographic cephalograms, dental casts and hand-wrist radiograph were longitudinally assessed for both of the groups. The cephalograms were measured about cranio-facial structures at 3 stages which were the early mixed dentition, late mixed dentition and adult dentition according to the bone maturation by the hand-wrist radiograph. The maturity of bone as an index of growth was quantatively expressed by the percentages from 0 to 100 by the Ryokawa's method. The stage are as follows;

stage A early mixed dentition (Hellman dental stage IIIA), bone maturation=50~60%
about 6 years old of age

stage B mixed dentition (dental stage IIIB), bone maturation=60~70%
almost the time of adolescent growth initiation

stage C permanent dentition (dental stage IIIC), bone maturation=90~100%
almost the time of bone growth completed, when it is clearly to make a treatment planning which should be corrected by orthodontics alone or with orthognathic sur-gery.

2.2 Cephalometric analysis

Cephalograms provide a quantitative medium for describing dynamic changes in the patient and for growth studies as for the dentofacial pattern in general.
Lateral cephalograms were taken with the same x-ray device and by a single technician. Focus median plane distance was 150 cm and film median plane distance was 10 cm with an enlargement of 10%. No correction was made for this radiographic enlargement, as it affected all the cephalograms of both groups in the same way.

In longitudinal cephalometric studies on growing subjects, reference line should be traced through craniofacial stable structures. Radiographs were traced and put the following landmarks which were identified or constructed:sella trucica (S), nasion (N), orbitale (Or), anterior nasal spine (ANS), point A (A), point B (B), pogonion (Pog), gnathion (Gn), menton (Me), gonion (Go), articulare (Ar), condylion (Cd), porion (Po), posterior nasal spine (PNS).

Reference planes were adopted as follows;
S-N plane (connects S to N), A-B line (connects A to B), Facial plane (N to Pog), FH plane (Po to Or), Ramus plane (Ar to the posterior border of the mandibular ramus), Y-axis (S to Gn), Mandibular plane (Me to the lower border of the mandible), Palatal plane (ANS to PNS). The definition of all these landmarks and planes were correspond to those given by Downs, Riedel and associates. The coordinates of each landmark for each cephalogram were recorded by means of a WACOM digitizer interfaced with a NEC PC-98Vm computer. The output values for each point were stored by coordinate representation on a disk for computer analysis. Nine linear and seventeen angular measurements were selected for quantitative cephalometric evaluation(Fig. 2,3).

Linear measurements for the assessment of
cranial base dimensions: N-S.
maxilarry dimensions: N-ANS, S'-Ptm', A'-Ptm'.
mandibular dimensions: N-Me, Gn-Cd, Pog'-Go, Cd-Go.
Angular measurements for the assessment of
maxillary dimensions: SNA (S-N-A).
mandibular dimensions: SNB (S-N-B), SNP (S-N-Pog), mandibular plane angle, gonial angle, ramus inclination, Y-axis angle, facial plane angle.
Intermaxillary relationship: ANB (A-N-B), A-B plane, convexity (N-A-Pog).

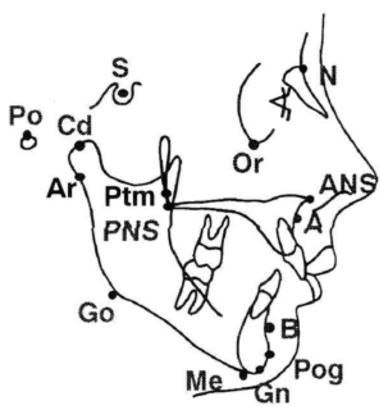

Fig. 2. Standard landmarks of roentogenocepharometrics

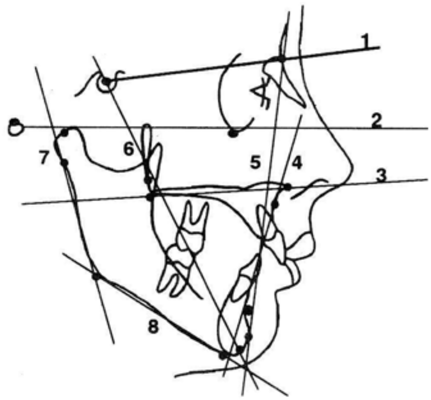

Fig. 3. Standard reference lines of roentogenocepharometrics
1, S-N plane (S to N). 2, FH plane (Po-Or). 3, Palatal plane (ANS to PNS). 4, A-B plane (A to B). 5, Facial plane (N to Pog). 6, Y-axis (S to Gn). 7, Ramus plane (Ar to construc-ted gonion). 8, Mandibular plane (Me to constructed gonion).

2.3 Statistical evaluation

Cepalogram data were evaluated using StatView II and JUSE/MA1, the Statistical Package for the Social Sciences designed for Apple and NEC compatible personal computers.

Initially, all the variable were tested for validity and robustness.Then, the morphological difference was tested by means of a nonparametric test, Mann-Whitney Utest between OPE and Non-OPE group at each stage. Moreover, the cephalometric data were analyzed by a multivariate statistical approach, discriminant analysis. Fisher's type linear discriminant analyses were cariried out, using treatment group (OPE or Non-OPE) as the dependent variable at each growth stage. Then, some variables were selected as an effective parameter to identify the Operation group.

3. Results

3.1 Descriptive statistics for the differences between the OPE and Non-OPE group

Table 1 summarizes the results of the nonparametric statistical comparison on the differences between the OPE and Non-OPE groups. At the stage A in male, gonial angle (Ar-Go-Me) exhibited significantly larger in OPE group ($p<0.001$); mandibular ramus inclination angle (FH-Ramus plane) exhibited significantly smaller in OPE group ($p<0.05$). Whereas in female, SNB angle which represents the anterior limit of the mandibular basal arch in relation to the anterior cranial base showed significantly larger in OPE group ($p<0.01$); mandibular plane angle and Y-axis angle showed significantly smaller in OPE group ($p<0.01$).

At the stage B in male, mandibular plane angle and gonial angle exhibited larger in OPE group ($p<0.05$, $p<0.001$); ramus inclination angle, posterior position of maxilla to cranial base (S'-Ptm') and mandibular ramus length (Cd-Go) appeared to be significantly smaller in OPE group. In female, both SNB and Y-axis angle showed significantly difference as the same as stage A ($p<0.01$, $p<0.05$). The linear measurement for the assessment of mandibular ramus and total length of the mandible (Gn-Cd) showed significantly larger in OPE group ($p<0.01$, $P<0.05$).

At the stage C in male, Both SNB and gonial angle showed significantly larger in OPE group ($p<0.05$, $p<0.001$); ramus inclination and ramus length showed significantly smaller in OPE group ($p<0.05$). On the other hand, SNB and Y-axis angle showed significant difference between OPE and Non-OPE groups ($p<0.05$, $p<0.01$); mandibular total length and ramus length exhibited significantly larger in OPE group ($p<0.05$).

Table 1 Means values for variables which were indicated significantly morphological differences between OPE and Non-OPE group at each growth stage for male and female.

	male				female			
		OPE	Non	p		OPE	Non	p
stage A	Gonial	134.1	125.9	***	SNB	78.9	75.8	**
	Ramus	79.1	82.3	*	Mand P	30.7	35.2	**
					Y-axis	63.2	66.2	**
stage B	Mand P	33.9	30.5	*	SNB	78.1	75.0	**
	Gonial	132.2	125.3	***	Y-axis	64.1	67.3	*
	Ramus	81.7	85.2	*	Ramus	81.7	85.2	*
	S'-Ptm'	17.2	19.8	**	Gn-Cd	107.9	103.0	**
	Cd-Go	51.2	55.4	**	Cd-Go	51.0	48.2	*
stage C	SNB	76.0	72.8	*	SNB	78.7	74.9	*
	Gonial	130.8	124.6	***	Y-axis	63.8	67.6	**
	Ramus	81.8	85.8	*	Gn-Cd	116.0	110.1	*
	Cd-Go	57.9	61.8	*	Cd-Go	55.5	51.6	*

*****p< 0.1%, **p< 1% and *p< 5% by Mann-Whitney test**

3.2 Discriminant analysis of all cases

At each stage the discriminant analysis was done, however, there were some difference in the eligble variable and correct classified percentage. In male, variables which showed over 2.0 of F-ratio at stage A were Mandibular plane (MP), Gonial angle, ramus inclination and Cd-Gn. On the other hand, these were MP, Gonial angle, ramus inclination, N-ANS, S'-Ptm' at stage B, convexity, AB plane, SNP angle, SNB, ANB, gonial angle, ramus inclination, Pog'-Go and Cd-Gn at stage C. The same findings were observed in female samples. Therefore from the point of clinical view, elgible variables were selected commnly at each stage. For male, 3-factor model which is composed of gonial angle, ramus inclination and Cd-Gn was generated, giving 77.8, 83.3 and 83.8 percent correct classification of the OPE group at each growth stage. In the other hand, 4-factor model which is composed of Y-axis angle, SNB, ramus inclination and Cd-Gn was generated, giving 76.7, 74.1 and 78.6 percent correct classification of the OPE group in female (Table 2).

Table 2 Discriminant analysis generated by MAI
Percentage of case correctly classified OPE group for male and female.

	male	female
stage A	77.8	76.7
stage B	83.3	74.1
stage C	83.8	78.6
Predictive vaiable	Gonial angle Ramus inclination Cd-Go	Y-axis SNB Ramus inclination Cd-Gn

4. Discussion

Early treatment of the cleft patient's malocclusion has beeen generally recommended by many authors for the favorable results on growth and occlusal relationship. However, some disadvantages of the problems that might be encountered during the early dentition tretment are: (1)it may be not always that early treatment bring easier and better results, (2)patient's cooperation may deteriorate because of long periods of active treatment, and (3) family financing may also have an influence on the length and timing of treatment. If prediction of maxillo-facial relationship at the time of its growth completed could be done at early growth such as a childhood, it could be free from a wasted treatment and various sufferings with it. There are many reports about the criteria of treatment adaptation to skeletal Class III patients which should be selected orthodontic treatment or surgical orthodontic treatment. However, these subjects are almost for adults, there are few for growing young people, especially children. It may be the main reason that it is very hard to predict skeletal changes by growth and orthodontic treatment at the raky growth stage. On the other hand, variables to express the morphological differences in both groups got increased according to the raising the bone maturity. It suggested that growth prediction could be easier by aging. At the stage C which is almost completed growth, it seems eaier to make a diagnosis and treatment plannings what could be finished by orthodontic treatment alone or combined with orthognathic osteotomy on earth by the reason of stopped growth. In the present study a correct methodologic approach for evaluation of borderline case with malocclusions was then initiated.

The cephalometric analysis we applied was suitable for a geometric evaluation of maxillo-facial components. Several significant differences in craniofacial skeletal structures were found between the OPE group and Non-OPE group. The following results were obtained.

1. There were significant morphological differences of dentofacial complex, especially in the Mandible, between the OPE and Non-OPE group in both sexes. No significant difference in the maxillary components were noted in both groups.
2. The differences became more clearly with growth.
3. In the male OPE group samples were characterized at short and anterior position of the ramus with wide gonial angle, while dominant anterior growth direction of the mandible and its larger size in females (Fig. 4).
4. The morphological information from the mandible were available for determination of future surgical case.

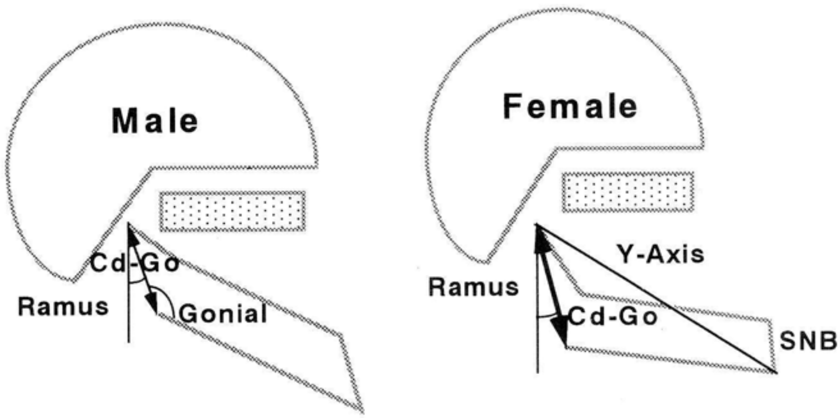

Fig.4. Schematic morphological characterisics in OPE case of male and female.
Male orthognathic surgical case has short ramus and downward rotated mandible with downward growth direction of its. On the other hand, larger mandible with its forward growth pattern is different from male one in female surgical case.

Comparing these data to the standard data which are gained from the subjects of normal occlusion by Iizuka and Ishikawa, the male gonial angle and ramus inclination showed larger than the standard. On the other hand, female Y-axis and ramus inclination showed almost same the standard except SNB which were larger by 2 degree. As they are substantively different from sample composed from size and criteria of growth stage, it coud not easily to compare the study and standard sample here.

In our opinion, a fundamental question arises from the obtained data. What were the reasons for morphological differences in the orthognathic surgical case between male and female? Moreover, why the differences were almostly found in the mandibular componets except by the maxillary components. There may be some important factors to be considered for the reason. One is the size of sampling in this study. The borderline case were selected from the poins of severity of maloocclusion with anterior and lateral crossbite. There is a data which indicated their similarity of malocclusion about inter-maxillary relationship in the term of ANB angle and SNA angle which shows no significant difference in both groups. In fact, there may be several morphological patterns for cleft patients. The male operation group shows the downward rotated of the mandible, the female cases show a typical skeletal class III which has overgrowth of the mandible relatively. The former is very difficult to correct anterior crossbite by the mandible backward rotation, since it makes the mandible more rotation result in a long face and shallow oberbite. On the other hand, the latter overgrowth of mandible is not easily controlled because of its size even if growth control would be begun from early growth stage. Treatment planning could be the other main cause to influence the results, since decision of treatment plannings may depend on some factors which are inter-maxillary relationship such as ANB angle, soft tissue profile from the point of the aesthetic sense, teeth movement in the orthodontic treatment and consent of the surgery by patient and parents. Therefore it could be said that bordeline case is multifactorial. That may be settled in the collecting more samples for borderline cases, which should be separated and examined by each factor.

The previous study suggested that there are some effective parameters between surgical and non-surgical orthodontic treatment for a cleft individual. The possibility of prediction for surgical case could be indicated in the earlier growth stage. After the patients had been treated for a period of time, from the first examination in mixed dentition, reexamination at about the initiation of puberal growth spurt on the hand-wrist radiographs may be of advantage in predicting future treatment procedures.

5. Concluding remarks

There were significant morphological differences in dentofacial complex, especially in the mandible, between OPE and Non-OPE group in both sexes. The differences became more and more clearly with growth. The male OPE group samples were characterized at short and anterior position of the ramus with wide gonial angle, while dominant anterior growth direction of the mandible and its large size are shown in females. The morphological information from the mandible were available for determination of future surgical case.
The previous study suggested that there are some effective parameters between surgical and non-surgical treatment for a cleft indvidual. The posssiblity of prediction for surgical case could be indicated in the early growth stage. We could not make our conclusion from the point of some problems by small sample, however, after this, we would like to collect more variable cases and examination them in detail. Although the growth prediction is really very hard things, we will do more in the future.

References:

Battagel J.M. (1994): The identification of Class III malocclusions by discriminant analysis, *European Journal of Orthodontics,* **16**, 71-80.

Cassidy D.W. et al. (1993): A comparison of surgery and orthodontics in "borderline" adults with Class II, Division1 malocclusions, *American Journal of Orthodontics and Dentofacial Orthopedics*, **104**, 455-470.

Downs, W.B. (1948) : Variation in facial relationships: their significance in treatment and prognosis, *American Journal of Orthodontics*, **34**, 812-840.

Iizuka T. and Ishikawa F. (1950): Points and landmark in head plates, *The Journal of Japan Orthodontic Society*, **16**, 66-75.

Sinclair P.M. et al. (1993): Combined surgical and orthodontic treatment, *In Contemporary orthodontics*, 2nd ed., Proffit W.R. (eds.), 607-631, Mosby Year Book, St. Louis.

Tollaro I., Baccetti T. and Franchi L. (1996): Craniofacial changes induced by early functional treatment of Class III malocclusion, *American Journal of Orthodontics and Dentofacial Orthopedics*, **109**, 310-318.

Valko R.M. (1968): Indications for selecting surgical or orthodontic correction of mandibular protrusion, *Journal of Oral Surgery*, **26**, 230-238.

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