Prediction of Need for Additional Orthognathic Surgery
in Patients with Cleft Lip and Palate

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ABSTRACT

This was a retrospective study of data collected from cleft lip and palate (CLP) patient records. All patient records were composed of intraoral and extra oral photographs (IO/EO), lateral cephalograms and panoramic radiographs including dental models and images of each patient. The objectives were: 1) to identify dentofacial parameters that discriminated cases which required additional orthognathic surgery and 2) to develop prediction formula and index score for additional orthognathic surgery cases or orthodontic treatment alone cases. The discriminant analysis was developed by comparing the scoring of treatment need by an expert with the series of measurements. The Index of Cleft Orthodontic or Surgery Predictions (ICOSP) score (1 to 5) assigned to all subjects by comparing with an expert’s clinical judgement of respective treatment needs twice. Using mean of the ICOSP score discriminate all subjects into one of the two group, orthodontic treatment alone cases were less than score 4 (mean of the ICOSP score < 4) and additional orthognathic surgery cases were not less than score 4 (mean of the ICOSP score ≥ 4). Cephalometric measurements (60 variables) as well as records of overjet, overbite, anterior crossbite and the number of missing teeth were subjected to discriminant analysis. Three variables were identified as the most meaningful predictors for additional orthognathic surgery in cleft lip and palate patients. The prediction formula was D = -1.861 - 0.378 ANB (deg) - 0.245 U1 - APog (mm.) + 0.129 L lip - Nperp. (mm.). Using this formula, the critical value of orthodontic treatment alone group was more than 0.06811 and the critical value of additional orthognathic surgery group was less than -0.11870. Regarding effective discriminant equation, 83.2% of original cases would be correctly classified. The results of this study can provide information about which dentofacial features could be used as outcome measurements in prediction further additional orthognathic surgery or orthodontic treatment alone for treatment planning correctly.

Key Words: Prediction, Orthognathic surgery, Cleft lip and palate

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บทคัดย่อ
การศึกษานี้ทำการรวบรวมข้อมูลแบบย่อหลัง โดยการวิเคราะห์จากรูปและใบหน้าที่สัมผัส โดยการศึกษานี้มีจุดประสงค์เพื่อ 1) ทำการวิเคราะห์จากรูปและใบหน้าที่สัมผัส และ 2) พัฒนามетодิกการที่ใช้ในการจัดจำแนกผู้ป่วยที่ควรได้รับการจัดฟันร่วมกับการผ่าตัดกระดูกขากรรไกรและใบหน้าหรือรับการรักษาโดยการจัดฟันเพียงอย่างเดียว จากการวิเคราะห์จำแนกกลุ่มโดยการจัดจำแนกกลุ่มผู้ป่วยจากการเปรียบเทียบความสามารถของการรักษาของผู้ป่วยโดยผู้ช่วยที่เป็นผู้วิจัย 5 ระดับโดยทั่วไป 2 ครั้ง และใช้ค่าเฉลี่ยของการวัดโดยกลุ่มผู้ป่วยที่ควรได้รับการรักษาโดยการจัดฟันเพียงอย่างเดียวและแนวโน้มการสูงกว่าระดับ 4 และ กลุ่มผู้ป่วยที่ควรได้รับการรักษาโดยการผ่าตัดกระดูกขากรรไกรและใบหน้ามีแนวโน้มสูงกว่าหรือเท่ากับระดับ 4 การวิเคราะห์ภาพถ่ายสกัดด้านข้าง (60 องศา) รวมถึง ระยะเฉลี่ยฟันในแนวระดับ ระยะเหลื่อมฟันในแนวระดับ ระยะฟันหน้าในแนวตั้ง ระยะฟันหน้าในแนวตั้ง และ จำนวนฟันที่หายไป ถูกนำมาใช้ในการวิเคราะห์จำแนกทางสถิติ จากผลการศึกษาพบว่ามีค่าการวัดจากกราฟและใบหน้า 3 คำสำคัญที่สุดในการพยากรณ์การจัดฟัน ร่วมกับการผ่าตัดกระดูกขากรรไกรและใบหน้า คือ D = -1.861 - 0.378 ANB(deg) - 0.245 U1 - APog (mm.) + 0.129 L lip - Nperp.(mm.) จากกราฟแสดงค่าในสมการ ค่าวัดตามการจัดจำแนกกลุ่มผู้ป่วยที่กู้ผู้ป่วยที่ควรได้รับการรักษา โดยการจัดฟันเพียงอย่างเดียวคือค่าจากสมการที่มากกว่า 0.06811 และค่าวัดตามการจัดจำแนกกลุ่มผู้ป่วยที่ควรได้รับการรักษา โดยการจัดฟันร่วมกับการผ่าตัดกระดูกขากรรไกรและใบหน้าคือค่าจากสมการที่น้อยกว่า -0.11870 ประสิทธิภาพของสมการสามารถที่จะแสดงได้ถูกต้อง 83.2 เปอร์เซ็นต์ จากการศึกษาจะทำให้ทราบว่าการวิเคราะห์จากกราฟ และใบหน้าที่สำคัญและใช้ในการพยากรณ์ผู้ป่วยปากแหว่งพบว่าเป็นกลุ่มที่ควรรักษาโดยการจัดฟันร่วมกับการผ่าตัดกระดูกขากรรไกรและใบหน้าหรือกลุ่มผู้ป่วยที่ควรรักษาโดยการจัดฟันเพียงอย่างเดียวซึ่งจะเป็นประโยชน์ในการวางแผนการรักษาได้ดีอย่างยิ่ง
Background and Significance

Cleft lip and palate deformities occur in high frequency throughout the world as compared with other congenital malformations. A deficient maxilla is one of the most common skeletal problems in cleft patients in which dental development is also impaired (Boyarskiy et al, 2006). Maxillary hypoplasia in patients with cleft lip and palate is variable because of the original embryological defect, corrective surgery during infancy, and subsequent orthodontics. It occurs not only in the sagittal plane but also in the transverse and vertical planes (Adlam et al, 1989 cited in Hirano and Suzuki, 2001).

The management of patients with clefts is complex, where the treatment outcome is judged on the balance between esthetics, speech and facial growth. Therefore, it is difficult to judge the effect of one area of treatment without taking into account its influence on other aspects of growth and development. One of the keys of interest is the quality of facial development. Good growth may result in a malocclusion that can be treated conventionally, avoiding surgical correction of the skeletal bases, and can thus provide optimal results in terms of facial appearance (Hathorn et al, 1996).

Deficient growth of the nasomaxillary complex in individuals with cleft lip and palate is variously attributed to early reconstructive surgery, tissue deficiency, and inherent growth retardation (Subtelny, 1966). The effect of treatment, particularly surgical technique, timing, and the expertise of the surgeon, has been studied and considered to have a great impact on the growth and development of the craniofacial complex in children with clefts (Ross, 1987; Roberts et al, 1991; Shaw et al, 1992). Other factors, such as presurgical orthopedics and orthodontic treatment, are also considered to influence the final growth outcome.

A wide range of surgical techniques is used for repairing cleft lip and cleft palate, but as yet there are no proven protocols for timing or technique (Pieter et al, 2005). Much attention has focused on the adverse effects of surgery in infants with cleft palate, with a number of publications indicating that the growth and development of the maxillary arch may be inhibited as a result of the nature of the primary repair (Mars and Houston, 1990; Mars et al, 1992). Much of the growth disturbance of the midfacial skeleton almost certainly results from surgical repair of the hard palate (Mars and Houston, 1990). At the time of hard palate repair, a common problem experienced by the cleft surgeon is insufficient tissue in the cleft region. The surgery can be done either by undermining with or without denudation of the palatal bone, or the surgeon can borrow tissue from the adjacent areas. Neither alternative is considered to be ideal from a maxillary growth point of view. To reduce the problem, some surgeons choose to postpone surgery, but this may have consequences for speech development (Liao and Mars, 2006).

Orthognathic surgery is often the final phase of treatment in the functional rehabilitation of patients afflicted with cleft lip and palate (CLP), and due to the prevalence of a hypoplastic upper jaw, maxillary osteotomy is most commonly performed for these patients (Fonseca et al, 2000). The purpose of orthognathic surgery is to restore normal jaw function, optimal facial esthetics, and long-term stability (Bell et al, 1986).

Evaluation of treatment outcome is essential to allow for identification and implementation of the highest possible standards of care. However, the range of outcomes of the treatment of cleft lip and palate can be considerable. Differences in treatment results
may be related to variation in the sequence, timing, and technique of treatment, the organization and delivery of care, as well as in the skills and experience of individual surgeons. (Pieter et al, 2005)

A reliable and reproducible method is required to evaluate and measure patient conditions which in turn reflect the quality of facial growth and also gives a practical indication of the proportion of those cases who can be treated by orthodontics alone or who will require a combination of orthodontics and skeletal correction. Furthermore, a precise and reproducible outcome measure is a necessity, at a time when evidence-based medical care and treatment guidelines regarding best practice are becoming an integral part of contemporary clinical practice.

The purposes of this study were to identify which dentofacial features could be used as outcome measurements and to develop prediction formula in prediction further additional orthognathic surgery or orthodontic treatment alone.

Protection of Human Subjects

According to ethical guidelines stated in the Helsinki’s Declaration, the study was granted approval by the Institutional Review Board (IRB) committee at Khon Kaen University.

Methods

This was a retrospective study of data from 119 patient with cleft lip and palate records. These records were composed of 54 males and 65 females in the Orthodontic Department, Faculty of Dentistry, Khon Kaen University. All patient records included dental models and intraoral and extraoral (IO/EO) photographs, lateral cephalo-grams and panoramic radiographs. The cepha-lometric measurement data followed Khon Kaen University (KKU) analysis were take from Tekunatorn’s study of the same group of patients with cleft lip and palate as with the present study. (Tekunatorn, 2007)

The discriminant analysis was developed by comparing the scoring of treatment need by an expert who has 40 years of experience in treating patients with cleft lip and palate with the series of measurements. The Index of Cleft Orthodontic or Surgery Predictions (ICOSP) score (1 to 5) assigned to all subjects assigned to all subjects by comparing with an expert’s clinical judgement of respective treatment needs twice. Using mean of the ICOSP score discriminate all subjects into one of the two group, orthodontic treatment alone cases were less than score 4 (mean of the ICOSP score < 4) and additional orthognathic surgery cases were not less than score 4 (mean of the ICOSP score ≥ 4).

Cephalometric measurements (35 variables) as well as records of overjet, anterior crossbite and the number of missing teeth were subjected to discriminant analysis.

Data Collection

Using patient with cleft lip and palate records from Orthodontic Department, Faculty of Dentistry, Khon Kaen University. The inclusion criteria were Thai cleft lip and palate patients, presented history of primary lip repaired and palate repaired, availability of pretreatment cephalometric films, pretreatment orthopantho-grams, pretreatment models, pretreatment photo-graphs. All lateral cephalometric radiograph have good quality of sharpness, brightness, and contrast and accepted to receive Orthodontics treatment from Orthodontics Department, Faculty of Dentistry at Khon Kaen University. Then, 119 patient records
were selected as the subjects in the study. These subjects composed of 54 males and 65 females.

From this study, there were 2 independent variables, need for additional orthognathic surgery and need for orthodontic treatment alone. The number of 119 patient samples were adequate for discriminant analysis.

Data Analysis

Discriminant analysis was performed to identify significant dentofacial variables which discriminate cases which required additional orthognathic surgery. Thirty-eight variables from skeletal, dental and soft tissue measurements, and models and radiograph analysis can be used as variables in discriminant analysis.

The variables suitable for distinguishing between the two groups were extracted from these 37 variables using a discriminant analysis with stepwise and trial-and-error approaches. The accuracy of the discriminant function was calculated on the basis of a 2 x 2 cross table.

File Maker Database and the Index of Cleft Orthognathic or Surgery Predictions (ICOSP) development

The present study developed the File Maker database. The File Maker database can be used as a standard in systemized patient records. The database composed of main 3 parts. These were photographs, radiographs and cephalometric measurements.

For assignment the ICOSP score, evaluation the patients from File Maker database with 8 cephalometric measurements. These measurements were SNA, SNB, ANB, Wits appraisal, SN to MP, Mx-Md differential, U1 to SN and L1 to MP. Each case would be assigned the ICOSP score (score 1 to 5) twice and then using mean of the ICOSP score for grouping as either the orthodontic treatment alone case (mean of the ICOSP score < 4) or additional orthognathic surgery (mean of the ICOSP score ≥ 4).

The ICOSP score were described as follows:

Score 1: Straightforward fixed appliance treatment (with or without pre-bone graft), alignment, and space closure
Score 2: Straightforward fixed appliance treatment - 2-phase, with pre-bone graft, alignment, and space closure
Score 3: Complex fixed appliance treatment, 2-phase camouflage with pre-bone graft, likely face mask, alignment, space closure
Score 4: Complex orthodontic treatment, 2-phase camouflage with pre-bone graft, face-mask, likely distraction osteogenesis, and/or pre- and post-orthognathic surgery orthodontics
Score 5: Complex orthodontic treatment, with likely 3-phase with pre-bone graft, face-mask or distraction osteogenesis, and/or pre- and post-orthognathic surgery orthodontics

Error of Methods

The reliability obtained from assignment the ICOSP score, all patient records were scored twice and the last assignment done again after 2 weeks later from first scoring. Then, the reliability of measurements obtained from calculated with SPSS version 14.0. (Statistical Package for Social Science for window) The intraclass correlation coefficient was 0.915.
Results

The most subjects were in 8-11 years (52.1%). The total number of subjects was 119, consisted of 54 males (45.4%) and 65 females (54.6%). Table 1 presented age range classified by gender

Table 1 Age range classified by gender

<table>
<thead>
<tr>
<th>Age range</th>
<th>Gender</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male n (%)</td>
<td>Female n (%)</td>
</tr>
<tr>
<td>8-11 years</td>
<td>30 (25.2)</td>
<td>32 (26.9)</td>
</tr>
<tr>
<td>12-14 years</td>
<td>13 (10.9)</td>
<td>12 (10.1)</td>
</tr>
<tr>
<td>15-18 years</td>
<td>10 (8.4)</td>
<td>15 (12.6)</td>
</tr>
<tr>
<td>18-24 years</td>
<td>1 (0.8)</td>
<td>6 (5.0)</td>
</tr>
<tr>
<td>Total</td>
<td>54 (45.4)</td>
<td>65 (54.6)</td>
</tr>
</tbody>
</table>

The subjects were classified into 4 categories including unilateral cleft lip and palate, bilateral cleft lip and palate, cleft lip only, cleft palate only. Table 2 presented cleft type classified by gender.

Table 2 Cleft type classified by gender

<table>
<thead>
<tr>
<th>Cleft type</th>
<th>Gender</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male n (%)</td>
<td>Female n (%)</td>
</tr>
<tr>
<td>UCLP*</td>
<td>33 (27.7)</td>
<td>42 (35.3)</td>
</tr>
<tr>
<td>BCLP**</td>
<td>21 (17.6)</td>
<td>18 (15.1)</td>
</tr>
<tr>
<td>Cleft lip only</td>
<td>0</td>
<td>3 (2.5)</td>
</tr>
<tr>
<td>Cleft palate only</td>
<td>0</td>
<td>2 (1.7)</td>
</tr>
<tr>
<td>Total</td>
<td>54 (45.4)</td>
<td>65 (54.6)</td>
</tr>
</tbody>
</table>

* Unilateral cleft lip and palate
** Bilateral cleft lip and palate

All subjects were assigned the ICOSP score (score 1 to 5) twice. Mean of the ICOSP score were use in the study. Table 3 presented the number of subjects classified by mean of the ICOSP score

All variables were tested for discriminant analysis. Two variables comprising interincisal angle and U lip to E-line which were not represented multivariate normal distribution, were excluded from the analysis. There were 35 cephalometric measurements as well as records of overjet, anterior crossbite and the number of missing teeth included in the analysis. Table 4 presented cephalometric measurements which included in discriminant analysis.

Table 3 The number of subjects classified by mean of the ICOSP score

<table>
<thead>
<tr>
<th>Mean of the ICOSP score</th>
<th>N = 119 n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1 (0.8)</td>
</tr>
<tr>
<td>2.0</td>
<td>18 (15.1)</td>
</tr>
<tr>
<td>2.5</td>
<td>8 (6.7)</td>
</tr>
<tr>
<td>3.0</td>
<td>31 (26.1)</td>
</tr>
<tr>
<td>3.5</td>
<td>8 (6.7)</td>
</tr>
<tr>
<td>4.0</td>
<td>15 (12.6)</td>
</tr>
<tr>
<td>4.5</td>
<td>8 (6.7)</td>
</tr>
<tr>
<td>5.0</td>
<td>30 (25.2)</td>
</tr>
<tr>
<td>Total</td>
<td>119 (100.0)</td>
</tr>
</tbody>
</table>
Table 4  Thirty-five cephalometric measurements which included in discriminant analysis

<table>
<thead>
<tr>
<th>Skeletal measurement</th>
<th>Dental measurement</th>
<th>Soft tissue measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSAr</td>
<td>U1-APog (deg)</td>
<td>Facial angle</td>
</tr>
<tr>
<td>SNA</td>
<td>U1-APog (mm.)</td>
<td>Li - SnV</td>
</tr>
<tr>
<td>FH-NA</td>
<td>L1-MP (IMPA)</td>
<td>Li-Ls to SnV differential</td>
</tr>
<tr>
<td>A-N perp.</td>
<td>L1-FH (FMIA)</td>
<td>L lip-U lip to E line differential</td>
</tr>
<tr>
<td>Co-A</td>
<td>L1-NB</td>
<td>Pog’ to SnV</td>
</tr>
<tr>
<td>SNB</td>
<td>L1-A pog (deg)</td>
<td>Sn to H line</td>
</tr>
<tr>
<td>FH-Npog</td>
<td>L1-A pog (mm.)</td>
<td>ILS to H line</td>
</tr>
<tr>
<td>Pog-Nperrp.</td>
<td></td>
<td>U lip length</td>
</tr>
<tr>
<td>SN-MP</td>
<td></td>
<td>L lip-N perp.</td>
</tr>
<tr>
<td>ANB</td>
<td></td>
<td>L lip-U lip to N perp. differential</td>
</tr>
<tr>
<td>Wits Appraisal</td>
<td></td>
<td>Mid U lip to Mid upper incisor</td>
</tr>
<tr>
<td>Mx-Md length</td>
<td></td>
<td>L lip-U lip thickness differential</td>
</tr>
<tr>
<td>Differential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP-MP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAFH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y-axis to FH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial angle angle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The discriminant analysis with three variables showed the highest accuracy. These were three cephalometric measurements ANB (deg), U1-APog (mm.) and L lip-Nperrp (deg) were finally selected as significant dentofacial variables for distinguishing between the need for additional orthognathic surgery and orthodontic treatment alone.

The discriminant formula was:

\[ D = -1.861 - 0.378 \text{ANB (deg)} - 0.245 \text{U1-APog (mm.)} + 0.129 \text{Lip-Nperrp.} \]

Using this formula, the critical value of orthodontic treatment alone group was more than 0.06811 and the critical value of additional orthognathic surgery group was less than -0.11870. Regarding effective discriminant equation, 83.2% of original cases would be correctly classified.

From test of equity of group means, the mean of the 3 variables were statistically significant differences between the orthodontic treatment alone group and additional orthognathic surgery group at \( p < 0.05 \). Table 5 presented Wilks’ Lambda of 3 variables.

Table 5 Wilks’ Lambda of 3 variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Wilks’ Lambda</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ANB (deg)</td>
<td>0.634</td>
<td>.000**</td>
</tr>
<tr>
<td>2. U1-APog (mm.)</td>
<td>0.795</td>
<td>.000**</td>
</tr>
<tr>
<td>3. L lip-N-perp.(mm.)</td>
<td>0.949</td>
<td>.014**</td>
</tr>
</tbody>
</table>

** indicated significant at \( p < .05 \)

Discussion

The samples data were collected from patients with cleft lip and palate records in Orthodontic Department, Faculty of Dentistry, Khon Kaen University. The cleft patient records which not in inclusion criteria were excluded from research subjects. The inclusion criteria included the availability of cephalometric films and panoramic radiographs in stage of pre-bone grafting or post-bone grafting but it should be in the stage of pre-orthodontic treatment. The subjects of the present study should present history of primary lip repaired and palate repaired. Finally, the research samples were 119 patient records, 54 males and 65 females.

For discriminant analysis, 119 research samples were adequate for the analysis.

The present study developed File Maker database. The database can be used as a standard in
Symmetrized patient records that performed complete information patient when evaluation of patients with cleft lip and palate. The main 3 parts were photographs, radiographs and cephalometric measurements. Only the 8 cephalometric measurements in the database (SNA, SNB, ANB, Wits appraisal, SN to MP, Mx-Md differential, U1to SN and L1 to MP) but in further study or other research could included the number of cephalometric measurements more than in the study depends on the objective of the study or demand of collecting data.

Regarding development of the Cleft Orthodontic or Surgery Predictions (ICOSP) is not a scoring of quality of outcomes, since no comparisons are made with other index. For applying the ICOSP, it is assumed that only repaired complete unilateral and bilateral clefts of primary and secondary palates are being evaluated. There will be a wider range of conditions than recorded in the index, with overlap of some morphological features shared among the separate scorings. For these reasons, it could increase the subjectivity and reduces reliability of clinical judgement in designating a whole number score to any particular condition of clefting. Thus, one should not expect more than one point difference between repeat scorings of the same patient. The index scoring is based on use of clinical photos only, without models or radiographs. However, the benefit of the ICOSP should be observed in further study.

In discriminant analysis, assignment of the Index of Cleft Orthodontic or Surgery Predictions (ICOSP) score, the mean of the ICOSP score were used for reducing bias from assignment the ICOSP score. All subjects were classified into one of two categories, orthodontic treatment alone (mean of the ICOSP score < 4) and additional orthognathic surgery (mean of the ICOSP score ≥ 4). There were 66 subjects (55.5 %) in orthodontic treatment alone category. In additional orthognathic surgery category presents 53 subjects (44.5 %).

From the prediction formula, three most meaningful dentofacial variables to discriminate between orthodontic alone cases and those indicating need for additional orthognathic were skeletal class III (negative value of ANB in degree), retroclined upper incisors (negative value of U1-Apog in millimeters), protruded lip position (positive value of L lip-Nperp. in millimeters)

Considering the craniofacial growth in patients with cleft lip and palate, in UCLP group, the smaller ANB angle of the UCLP group in comparison with non-cleft group indicated the retrusion of maxilla in relation to mandible with a significant difference at all age (Hayashi et al, 1976; Dahl, 1970; Smahel and Mullerova, 1986). With increase in age, both cleft and non-cleft group showed a decrease of the ANB angle. The SNB became larger than the SNA angle at 10 to 12 years of age for male clefts and at six to eight years of age for female clefts (Hayashi et al, 1976).

As Sakuda (Sakuda, 1976) found the intermaxillary relationship changed into a more severe skeletal III relationship. The SNA angle in cleft males was also larger than in females for all age. This sex difference was less mark in the non-cleft group (Hayashi et al, 1976) in cleft females was less than that of cleft males at almost all age, and the angle created by the mandibular and the S-N lines was significantly larger in cleft females than in cleft males after 10 years of age (Hayashi et al, 1976).
The craniofacial growth in patients with cleft lip and palate, in BCLP group, despite the extreme prominence, the length of the maxillary apical base (Co-A) in the BCLP group, does not exceed the equivalent measurement in the noncleft sample (Semb and Shaw, 1996). Another factor may be the inherent retrusion of the maxilla accompanying cleft palate, with or without cleft lip and alveolus. In patients with cleft palate only, it has been found both preoperatively in operated cases and in adult unoperated cases that both the mandible and the maxilla are retrusive (Dahl et al, 1982; Dahl, 1989).

Hermann et al found that infants born with a cleft of the secondary palate, with or without a cleft of the primary palate (unilateral complete cleft lip and palate, isolated cleft palate, and Robin sequence), have an intrinsic maxillary retrognathia (Hermann et al, 2004). Retrognathia of the basal parts of the maxilla in infants with BCLP has been reported (Dahl, 1989).

Dahl found reduced posterior height of the maxilla in infants with unoperated BCCLP (Dahl, 1970). A similar finding has been reported in older children, adolescents, and adults (Trotman and Ross, 1993). Hermann and Jensen also reported a reduced posterior height of the maxilla in subjects with unoperated UCLP (Hermann and Jensen, 1999). It would seem the finding is related to the cleft malformation of the secondary palate (Hermann et al, 2004).

The sagittal jaw relations were fairly normal in the BCLP group when measured to the basal part of the maxilla (Hermann et al, 2004). This finding showed that bimaxillary retrognathia was actually characteristic of the group and that the degree of retrognathia in the two jaws was fairly similar. These findings support the hypothesis that bimaxillary retrognathia was characteristic of infants born with a cleft of the secondary palate, with or without clefting of the primary palate (Hermann et al, 1999; Kreiborg and Hermann, 2002).

Regarding the retroclined of the upper incisors, in UCLP group, the retroclination of permanent maxillary incisors may result from the insertion into scar tissue of periodontal fiber from the teeth (Ross, 1970). Both upper and lower incisors showed a marked lingual inclination (Hayashi et al, 1976). The same as many studies reported that both upper and lower incisors showed retroclination (Dahl, 1970; Smahel and Brejcha, 1983; Drahoradova and Mullerova, 1997; Tateishi et al, 2001; Toygar and Akcam, 2004). The interincisal angle of the UCLP group was larger than the non-cleft group, and the difference was significant in all age groups. A significant increase found in the interincisal angle in UCLP group, indicates that the dentoalveolar region could not compensate for this impairment. This failure of compensation could be due to dysplastic influence from increased labial pressure after lip closure and from scar tissue left by palatal repair (Hayashi et al, 1976).

In BCLP group, there was a tendency to retroclination of the permanent maxillary incisors in both jaws in subjects with unoperated BCLP that reached statistical significance for the upper incisor inclination in the female BCLP group and for the incisor mandibular plane angle for both genders. In two samples of unoperated adult subjects with unilateral cleft lip and palate the upper incisors were found to be similar to those of noncleft subjects in one study (Mars and Houston, 1990) and proclined in another study (Capelozza Filho, 1993). The tendency to retroclination in many studies (Bishara, 1978; Da Silva Filho, 1998) was an interesting finding, because
where there was an unoperated cleft lip, the tongue activity is unopposed, and proclination of incisors could be expected. However, it has been found that the teeth within the primary palate affected by bilateral clefting are retroclined as they erupt, and the results from these studies indicate that this retroclination persists (Ross and Johnston, 1972; Semb, 1991).

Considering protruded lower lip, from the hypothesis that patients with UCLP would have voluminous and protrusive lower lips. The earlier study reported more prominent and thicker lower lips in cleft groups (Stoll et al., 2002). In contrast, Toygar and Akcam reported that lower lip areas were found to be smaller in the UCLP group when compared with the control group (Toygar and Akcam, 2004). The differences in the two studies may be due to the developmental changes in the pubertal growth stage and more recent changes in techniques of surgical repair of cleft lip (Blanchette et al., 1996; Bishara, 2000). However, the CLP subjects within the study of Toygar and Akcam were all growing individuals, whereas Stoll et al. studied adult patients. A longitudinal study of patients with CLP seems to be essential from puberty to early adulthood.

Regarding primary surgery, it was thus hypothesized midfacial deficiency is genetically predetermined. However, others have shown that in nontreated cleft patients, there are no visible deficiencies of the anteroposterior growth of midfacial skeleton and on the noncleft side (Bishara et al., 1976; Mars and Houston, 1990). The patients who underwent early palatoplasties (within the first year of life) usually ended up with severe scarring and maxillary growth retardation, compounded by velopharyngeal insufficiency (Furlow, 1986).

The primary lip and palate repair performed during infancy and early childhood provides the foundation for normal speech, occlusion, facial appearance, and self-esteem. One long-term negative effect of these early surgical interventions is a significant incidence of maxillary growth restriction that produces secondary deformities of the jaws and malocclusion, which also impacts on speech and self-esteem. Ross documented that in approximately 25% of adult males with a repaired unilateral cleft lip and palate, orthognathic surgery is necessary to permit an adequate functional relationship of the jaws and teeth (Ross, 1987). The prevalence and extent of residual maxillofacial deformities in the adolescent born with a cleft vary widely depending on a team philosophy about the staging of reconstruction and on available technical expertise (Posnick, 1991 cited in Posnick, 1996).

**Conclusions**

The results of the present research indicate that the Skeletal class III (ANB), retroclined upper incisors (U1-APog in mm.), protruded lip position (L lip-Nperp.) are important factors in the discriminating between prediction of need for orthodontics alone and for additional orthognathic surgery in cleft lip and palate patients. The discriminant formula established in this study was effective for predicting the type of further treatment need.
References


Roberts CT, Semb G, Shaw WC. Strategies for
the advancement of surgical methods in
cleft lip and palate. Cleft Palate Craniofac

Ross RB. Treatment variables affecting facial
growth in complete unilateral cleft lip and
palate. Part 1–7. Cleft Palate J 1987; 24:
5-77.

Ross RB, Johnston MC. Cleft Lip and Palate
Baltimore: Williams & Wilkins; 1972.

Sakuda M. Problems in the treatment of cleft
lip and palate patients. Dent Outlook 1971;
37: 727-30. cited in Hayashi I, Sakuda
M, Takimoto K, Miyazaki T. Craniofacial
growth in complete unilateral cleft lip and
palate: a roentgeno-cephalometric study.

Semb G. A study of facial growth in patients with
bilateral cleft lip and palate treated
by the Oslo CLP Team. Cleft Palate

Semb G, Shaw WC. Facial growth in orofacial
clefting disorders. In: Turvey TA,
Vig KWL, Fonseca RJ, eds. Facial clefts
and craniosynostosis. Philadelphia:

Shaw WC, Dahl E, Asher-McDade C,
A six-center international study of treatment
outcome in patients with clefts of the lip and
palate: part 5. General discussion and
conclusions. Cleft Palate Craniofac J 1992;
29: 413-8.

Smahel Z, Brejcha M. Differences in craniofacial
morphology between complete and
incomplete unilateral cleft lip and palate in

Smahel Z, Mullerova` Z. Craniofacial
morphology in unilateral cleft lip and palate
prior to palatoplasty. Cleft Palate J 1986; 23:
225-32.

Stoll C, Opitz C, Bauer S, Petzold D. The soft-
tissue facial profile of patients with
unilateral clefts of the lip, alveolus, and
palate compared with healthy adults. J

Subtelny JD. Orthodontic treatment of cleft lip
and palate, birth to adulthood. Angle Orthod

Tateishi C, Moriyama K, Takano-Yamamoto T.
Dentocraniofacial morphology of 12
Japanese subjects with unilateral cleft lip
with a severe class III malocclusion: A
cephalometric study at the pretreatment
stage of surgical orthodontic treatment.
Cleft Palate Craniofac J 2001; 38(6): 597-
605.

Tekunatorn K. Evaluation of dentofacial
characteristics of cleft lip and palate in
Thai [Master Thesis in Orthodontics].
Khon Kaen: The Graduate School,
Khon Kaen University; 2007.

Toygar T, Akcam M. A cephalometric evaluation
of lower lip in patients with unilateral cleft
lip and palate. Cleft Palate Craniofac J 2004;

Trotman CA, Ross RB. Craniofacial growth in
bilateral cleft lip and palate: ages six
years to adulthood. Cleft Palate Craniofac J
1993; 30: 261-73.