

**CHAPTER 3**  
**MATERIALS AND METHODS**

**3.1 Materials**

3.1.1 Radiographic study

Lateral cephalometric and occlusal (topographic) radiographs were used. The materials were obtained from 10 complete unilateral cleft lip and palate patients who were performed alveolar bone grafting at Maharaj Nakorn Chiang Mai Hospital, Department of Surgery, Faculty of Medicine during 2004-2008, 8-14 years of age with complete clinical records. All were operated by one of two surgeons with same surgical technique with the inform consent.

The radiographic records will be categorized as follows :

3.1.1.1 Lateral cephalometric radiographs

1. Within 1 month before alveolar bone grafting.
2. One year after alveolar bone grafting.

3.1.1.2 Occlusal radiographs (topographic)

1. One month after alveolar bone grafting.
2. One year after alveolar bone grafting.

Inclusion criteria for all subjects were:

- Complete unilateral cleft patients who received alveolar bone graft between 2004 - 2008.
- Age 8 – 14 yrs.
- Complete clinical records.
- Alveolar bone grafting surgery by same surgeon team, same treatment strategy.
- Received orthodontic treatment before bone grafting.

Exclusion criteria were consisted of:

- Syndromic clefts such as Pierre Robin Sequence, Treacher-Collins, Trisomies 13,18,21, Apert's syndrome, Stickler's syndrome, Waardenburg's syndrome.
- Not a congenital cleft.

### 3.1.2 Finite element study

Virtual 3D computer models of maxilla and lip of approximately 8-9 years old clefts were created using SolidWorks™ 2008 program. Then both models were transferred to finite element simulation program, FEMap™ 9.0. After describing, meshing and fixing the model property, they consisted of elements and nodes in the tetrahedral elemental shape. Parameters and conditions of simulated finite element models are described in Table 3.1.<sup>60,61</sup> For maxilla model, only superoposterior side was constrained and others were displaceable, lip model was constrained at both left and right corner of it. Analysis of the models was done under laptop computer, its specification is shown in Table 3.2.

Table 3.1 Parameters of model properties.

Parameter	Young's modulus (GPa)	Density(g/cm <sup>3</sup> )	Poisson's ratio
Bone	13.7	1.4	0.3
Lip	3	1.4	0.2

Table 3.2 Computer specification in this study

Parts	Properties
CPU	Intel Pentium Dual-core 1.86 GHz, 1024 MB L2cache (Merom)
RAM	3.0 GB bus 333 Hz
VGA control	Intel X3100
SolidWorks	Version 2008
FEMap	Version 9.0

## 3.2 Methods

### 3.2.1 Radiographic study

The occlusal and cephalometric radiographs of each subject were assessed. Each radiograph was measured twice manually. Differences of every pair of measurements were no more than 0.5 mm. Otherwise, the third measurement will be made, and the closest ones was selected. Means of those measurements will be assessed for statistic tests. The sequences of the study method were as the following.

Cephalograms were traced and relevant landmarks were identified. Measurements were done manually, and data were processed through Microsoft® Excel program to measure the upper lip thickness. The upper lip thickness was measured as a distance from vermilion border to labial surface of incisors along the line perpendicular to the Nasion(N) – Pogonion(Pg) line, as described by Filho *et al.*<sup>62</sup> (Figure 3.1)

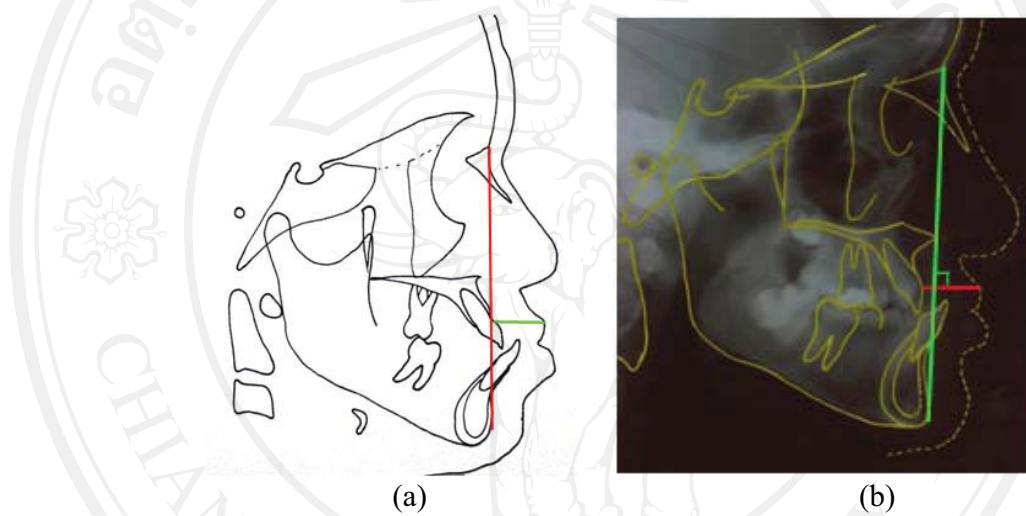


Figure 3.1 Measurement of upper lip thickness, a) Illustrated N-Pog line and a line tangent to it, b) Lip thickness measurement in lateral cephalometric radiographs (modified from Filho *et al.* 2003).<sup>62</sup>

Occlusal radiographs were assessed separately between the 3 groups : (1) presurgical radiographs taken of a minimum of 1 month prior to alveolar bone grafting. (2) postsurgical radiographs taken within 1 month following the bone grafting and (3) 1 year after the bone grafting. All occlusal radiographs were traced and scanned using the same scanner. Measurements of the bony architecture used in this study were followed the method described by Long *et al.*<sup>63</sup> Three reference points were digitized on each

radiograph (Figure 3.2). The ratio  $D/A$  represented the degree of bony notching of the alveolar ridge between the mesial and distal tooth where  $D$  is bony notch and  $A$  is the distance from cemento-enamel junction (CEJ) to root apex. Therefore the measurement errors from radiographic magnification and distortion will be eliminated or minimized.

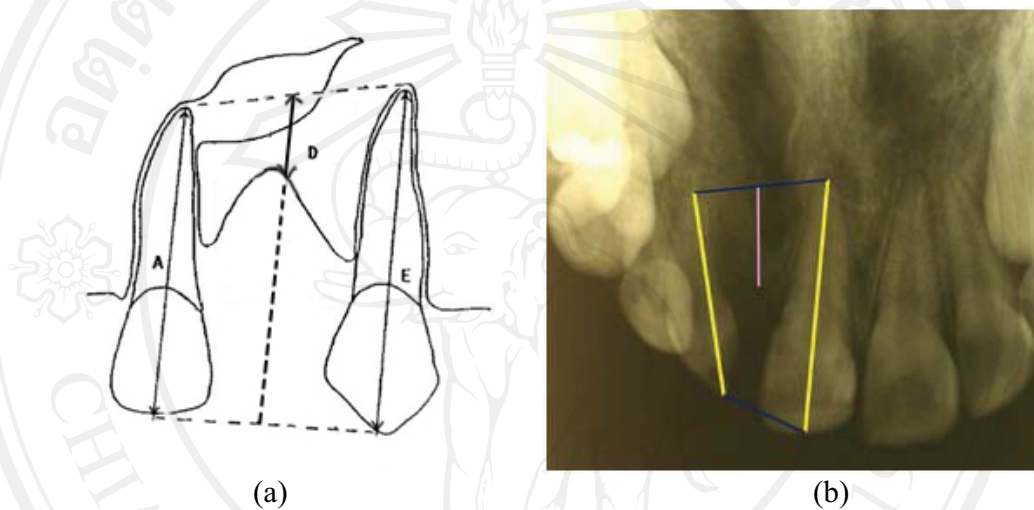


Figure 3.2 measurement of grafted bone height ratio, a) Illustrated  $D$ =Bone level,  $A$ =Adjacent tooth height. b) Illustrated radiographs measurement. (Modified from Long, 1995)<sup>63</sup>

Errors of the measurement methods will be determined by retracing each radiograph on separate occasions, each tracing pair takes a period of 2 weeks. The following calculation will be used for measurement errors.<sup>64</sup>

$$\text{Error}^2 = \frac{\sum d^2}{2n}$$

Where  $d$  is the difference between the two measurements of a pair and  $n$  is the number of subjects.

### Statistic analysis

Descriptive and regression analysis were used to assess any significance of the measurements. SPSS V.16 was performed to analyzing the statistical results.

#### 3.2.2 Finite element study

FEMap 9.0 was used to analyze the outcome of the grafted bone. This program was performed on Windows XP SP2 based laptop computer which full-time online connected while operating this program. The lip and cleft maxilla models of 9 years patient was constructed by SolidWorks™ 2008 seperately. Forces were applied to the corners of the upper lip at 30 degree posterolaterally (Figure 3.3a). Three different forces were inserted to determine the results. 559.02 Newton was used for described as light force, while the medium and heavy forces were substituted as 1118 and 1677.1 Newton respectively. The fixed area of lip models were constrained at the maxilla-closed area, where are the middle half of the palatal side of the lip model (Figure 3.3b).

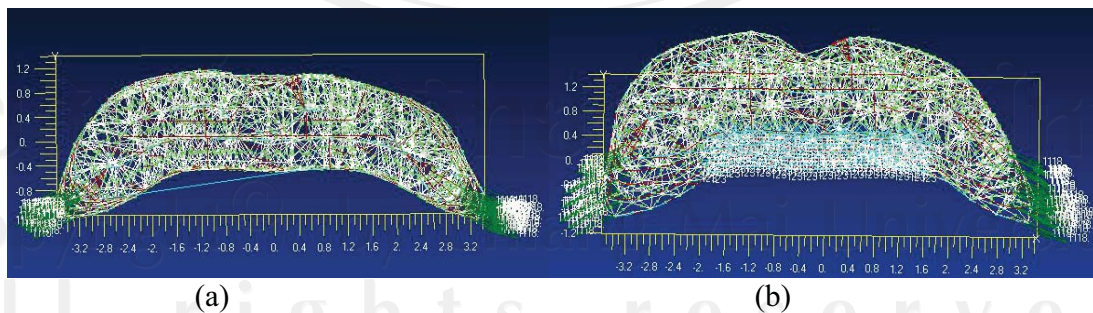


Figure 3.3 FEMap V9.0 interface. a) Clefted maxilla model was load into FEMap program. b) Meshing lip and maxilla model.

After analysis of the lip models were performed by FEMap structural solver, the resulting forces in the palatal side pushing-forces were only determined(Figure 3.4). Resulting forces were counted by mean of Newton per area, this method was done under simple calculation of force resulting on 10 nodes. The area that covering these nodes was measured and calculated for the following step(Figure 3.5).

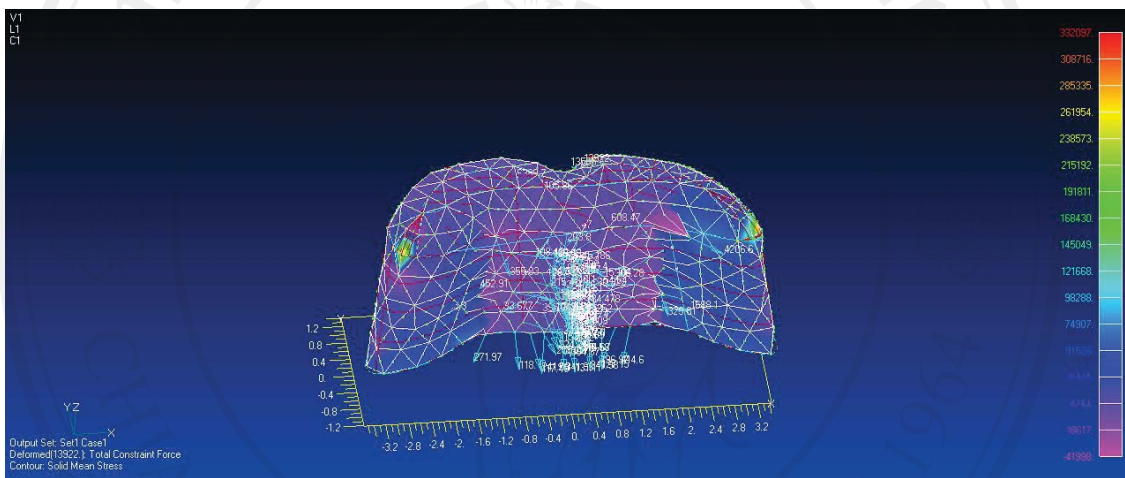


Figure 3.4 Resulting forces after analysis were selected to determined the palatal- pushing forces.

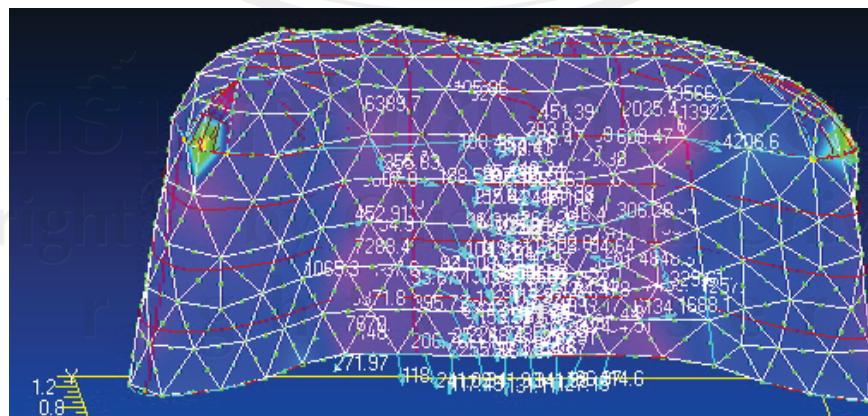


Figure 3.5 Ten nodes were selected to calculated force per area.

The 3 values of force per area were inserted in the cleft maxilla models with palatal-pushing direction. Light, medium and heavy forces then were described as the lip forces acting on 3 indifferent models. These models were fixed at the posterosuperior region far away from the forces(Figure 3.6). Forces were loaded onto the labial side of the maxilla, while the forces were pointed to the palatal side direction. Analysis were performed by using FEMap structural solver and the results are described in chapter 4.

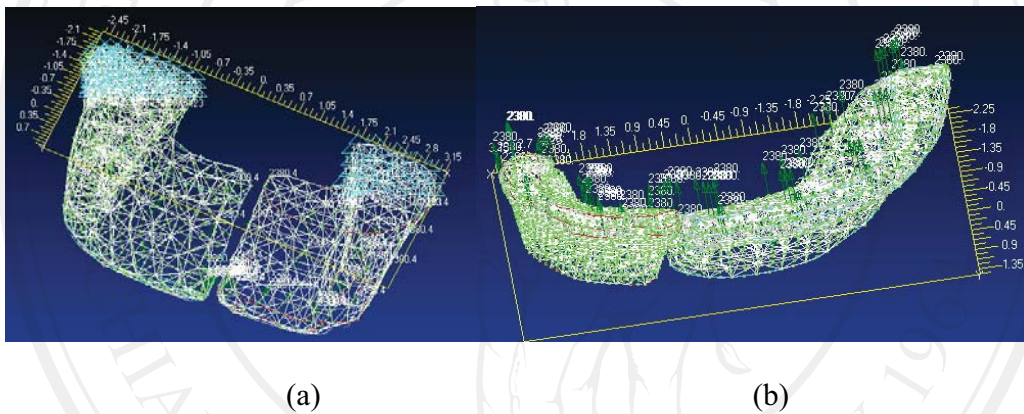


Figure 3.6 A) Model of maxilla was fixed at supero-posterior region. B) Palatal pointed direction forces were loaded on to labial surface of maxilla.