CHAPTER III
RESEARCH DESIGNS AND METHODS

The research designs and methods were divided into four parts.

I.   Sample selection

II. Examination of charts

- Definitions and explanations of examination factors

III. Examination of periapical radiographs

- Definitions and explanations of root measurements

IV. Statistical analysis

- Validity and reliability of the measurements
- Mann-Whitney test
- Kruskal-Wallis test

I. Sample selection

Examination charts and treatment records of 350 patients who completed orthodontic treatment during 1995-2005, in the post-graduate clinic of the Department of Orthodontics, Chiang Mai University were examined. This study was based on 181 of those patients who satisfied the study criteria; completed upper and lower arch fixed appliance treatment with examination records, treatment records and pre- and post-treatment intra-oral peri-apical radiographs. Records were excluded if crown dimensions were altered during the treatment period due to tooth fracture or abrasion or if the radiograph was poor, crown or apex was not fully visible or the cemento-enamel junction (CEJ) was blurred.

II. Examination of charts

Pre-treatment data and treatment factors were recorded. Those were evaluated as shown in Table 3.1.

Table 3.1 Associated factors for external apical root resorption

| Examination factors	Unit
Sex	Male/Female
Age at start of treatment	Years (≤16 / >16)
Overjet	mm(<1, 1-4, >4-6, >6)
Overbite	mm(≤0, >0-3, >3-5, >5)
Root shape of tooth 11	Normal/Abnormal(pointed or dilacerated)
Root shape of tooth 12	Normal/Abnormal(pointed or dilacerated)
Root shape of tooth 21	Normal/Abnormal(pointed or dilacerated)
Root shape of tooth 22	Normal/Abnormal(pointed or dilacerated)
History of trauma	Yes/no
Tongue thrusting habit	Yes/no
Allergic condition	Yes/no
Types of malocclusion	Angle's Class I, II, III
Treatment planning	Extraction / Non-extraction
Types of bracket	Standard / Pre-adjusted edgewise bracket
Treatment duration	Months(1-12, 13-24, 25-36, >36)

- **Definitions and explanations of examination factors**

Age at start of treatment

Patient age in this study was mainly divided into 2 groups; ≤16 years old and >16 years old (Table 3.2). Nabangxang et al,[76] who studied 0-18-year-old Chiang Mai children, found that the peak of the growth spurt in girls and boys was 12 years 3 months and 13 years 9 months, respectively. Moreover, they found that the velocity height of girls and boys almost stopped at age 15 and 17, respectively (Figure 3.1). Thus this study divided age at the start of treatment into ranges according to the growth velocity of Chiang Mai children. Individuals whose age at the start of treatment was 16 years or less were placed in the range in which velocity of growth

was not completed. Individuals whose age at the start of treatment was more than 16 years were placed in the range in which the velocity of growth was completed.

Table 3.2 Classification of age at start of treatment

Age group	Age range
1	Age ≤16 years
2	Age >16 years

Mean Height Gain: cm
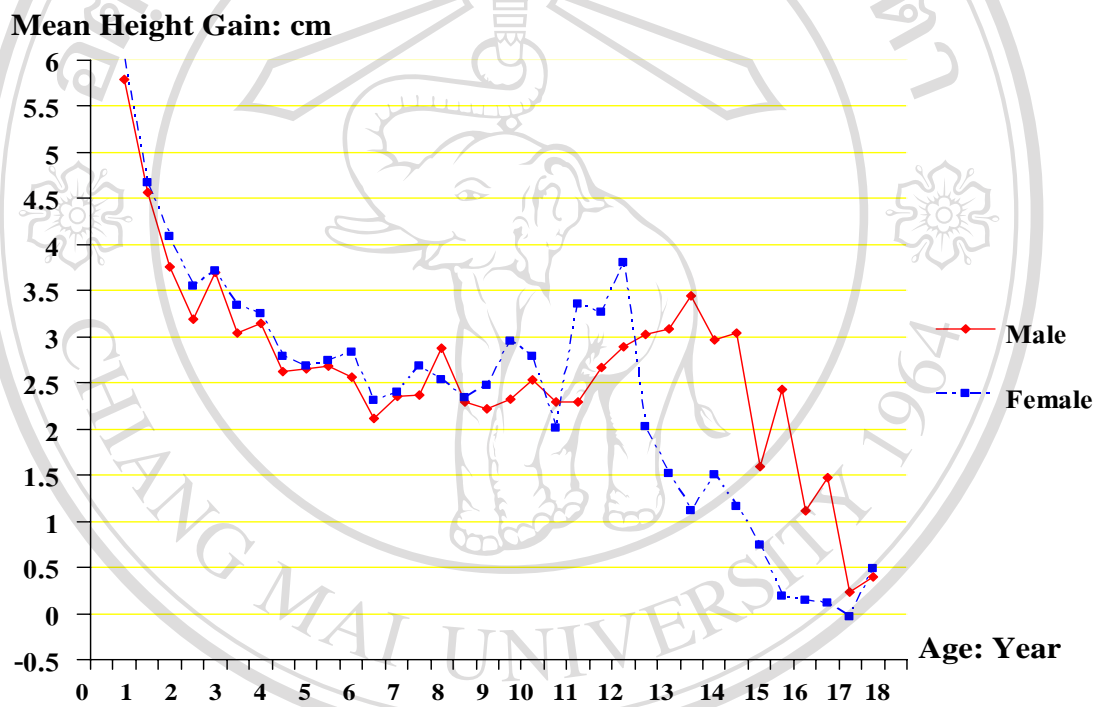
Figure 3.1 Velocity curves of differences in mean height between Chiang Mai male and female children (Redrawn from Nabangxang et al,[76])

Overjet

Overjet is defined as horizontal overlap of the incisors. Proffit et al,[77] the ideal overjet was 1-2 mm, mild overjet was 3-4 mm, moderate overjet was 5-6 mm and severe overjet was more than 6 mm. Moreover, Jarvinen[78] reported that the severity of injuries was greater in children with extreme overjet (> 6 mm) than in children with overjet ranging from 0 to 6 mm. Therefore, this study divided overjet into four groups according to severity: less than 1 mm (negative group), 1 to 4 mm (normal group), > 4 to 6 mm (moderate group) and greater than 6 mm (severe group). (Table 3.3)

Table 3.3 Overjet group classification

Overjet group	Overjet range
Negative group	< 1 mm
Normal group	1 - 4 mm
Moderate group	> 4 - 6 mm
Severe group	> 6 mm

Overbite

Overbite is defined as vertical overlap of the incisors. According to Proffit et al, [77] the ideal overbite was 0-2 mm, moderate overbite was 3-4 mm and severe overbite was 5-7 mm. Therefore, we divided the overbite into four groups according to severity: ≤ 0 mm (negative group), > 0 to 3 mm (normal group), > 3 to 5 mm (moderate group) and > 5 mm (severe group). (Table3.4)
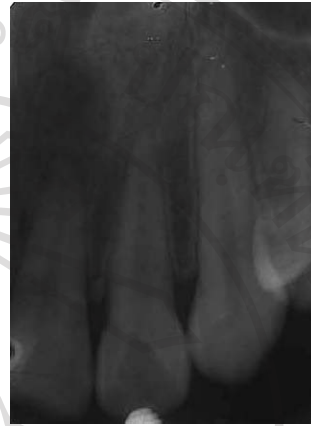
Table 3.4 Overbite group classification

Overbite group	Overbite range
Negative group	≤ 0 mm
Normal group	> 0 – 3 mm
Moderate group	> 3 – 5 mm
Severe group	> 5 mm

Root shape

In this study, root shape was classified into normal and abnormal root shape. Abnormal root shape included pointed and dilacerated roots, as illustrated in Figures 3.2 and 3.3**.**

Figure 3.2 Dilacerated root   **Figure 3.3** Pointed root

History of trauma

A history of traumatic injury before orthodontic treatment was recorded if any trauma to teeth or the face was reported in the examination charts of each patient. The severity of the trauma was not recorded.

Tongue-thrusting habit

The tongue thrusting habit is the habit of thrusting the tongue forward against or in between the teeth while swallowing. It is an infantile pattern of swallowing that has been retained by an individual. While the tongue is thrusting the teeth, constant pressure from the tongue is applied to the teeth. Besides the pressure exerted while swallowing, thrusting also pushes the tongue against the teeth while it is at rest. This habit was recorded in the examination charts of each patient.

Allergic condition

In general, allergies cause the immune system to overreact in a way that can cause sneezing, nasal blockage, a runny nose, itchy eyes, and wheezing. Allergies are caused by both environmental allergens from indoor and outdoor sources. Typical allergy symptoms include repetitive and prolonged sneezing, runny or plugged nose,

itchy, watery, red or swollen eyes, and itchy throat. Other common allergic reactions include skin and intestinal problems, such as hives, itchiness, rashes, diarrhea and headache.

Allergic asthma is the most common form of asthma. The symptoms of allergic asthma are coughing, wheezing, shortness of breath or rapid breathing and chest tightness. However, allergic asthma is triggered by inhaling allergens such as dust mites, pet dander, pollens, mold, etc. Through a complex reaction, these allergens then cause the passages in the airways of the lungs to become inflamed and swollen. This results in coughing, wheezing and other asthma symptoms.

Allergic condition was recorded in the examination charts of each patient, according to the allergy symptoms and other common allergic reactions.

Types of malocclusion

Pretreatment malocclusion was recorded according to Angle's classification. This classification is based on the occlusal relationships of the first molars. There are Angle Class I, Angle Class II and Angle Class III classifications.

Class I   Normal relationship of the first molars, but with an incorrect line of occlusion because of malposed teeth, rotations or other causes

Class II   Lower first molar distally positioned relative to upper first molar, line of occlusion not specified

Class III   Lower first molar mesially positioned relative to upper first molar, line of occlusion not specified

Treatment Planning (Non-extraction/ Extraction)

The investigated teeth in this study were maxillary incisors. Therefore, patients who had at least one upper premolar tooth extracted before orthodontic treatment were defined as extraction orthodontic cases. Patients who did not have any upper premolar teeth extracted before orthodontic treatment were defined as non-extraction orthodontic cases.

Types of bracket

Pre-adjusted and standard brackets were used in this study. Pre-adjusted brackets have a bracket base, that accurately fits each tooth at a predetermined point, and a bracket slot. The bracket slot is designed specifically to either tip, torque or rotate a tooth, allowing for less wire bending and less effort for the practitioner. Standard bracket slots are not designed to tip torque or rotate the teeth. Consequently, all treatment mechanics must be built into the archwires.

Treatment duration

Treatment duration was recorded in the treatment records starting and completion dates. The number of months of treatment was used in the evaluations in this study.

III. Examination of periapical radiographs

- **Definition or explanation of root measurement**

1. External apical root resorption (EARR)

External apical root resorption can define as circumferential apical root resorption. It is the third degree of root resorption according to the classification of Brezniak and Wasserstein.[14] In this process, full resorption of the hard tissue components of the root apex occurs, and root shortening is evident. Therefore, decreased root length was seen in periapical radiographs.

2. Percentage of external apical root resorption

Percentage of external apical root resorption is expressed as the percentage shortening per tooth. This value is a better comparative value for comparing root resorption of various teeth.

3. Median CEJ point

Median CEJ point is the midpoint between the mesial and distal CEJ point. It is the best reference point for measuring root length, especially when a correction factor was used.

4. Correction factor (CF)

Correction factor is the ratio that calculated for resolve enlargement difference of pre- and post-periapical radiographs. It is explained by assume that during orthodontic treatment the crown length does not change. CF is the ratio between the initial crown length (C1) and the final crown length (C2).

The pre- and post-treatment radiographs were measured by digital vernier caliper (KEIBA®, Japan) with a fine tip measuring 0.01 mm. The root length was measured from the median CEJ point to the most apical point of the root. Crown length was measured from the median CEJ to the mid-incisal point of the tooth.

Any image enlargement between pre- and post-treatment radiographs was corrected by using the crown length registrations, assuming crown lengths to be unchanged over the observation period. Therefore, the ratio between the initial crown length (C1) and the final crown length (C2) determined the correction factor (CF). For this reason, teeth with obviously fractured or abraded crowns were excluded from this study. A correction factor was calculated to relate the pre- and post-treatment radiographs.

CF = C1/C2

The EARR per tooth in millimeters was calculated:

EARR = R1 – (R2 × CF)

EARR was also expressed as the percentage EARR per tooth. This percentage value is a better comparative value, because the differences in the root lengths in millimeter of various teeth make them difficult to interpret the results.

Percentage of EARR per tooth   = $\dfrac{EARR \times 100}{R1}$

A. Pre-treatement   B. Post-treatment
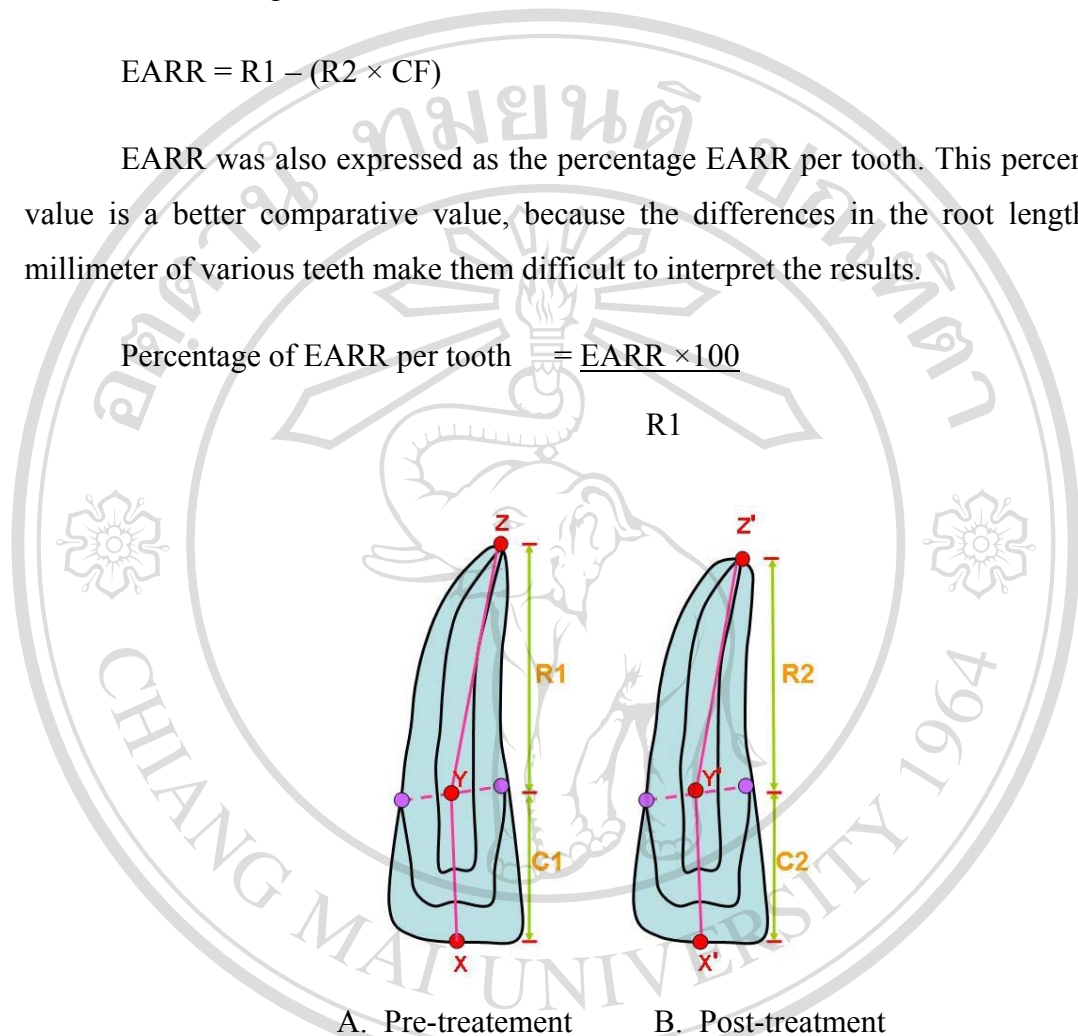
Figure 3.4 The points and measurement for examination of periapical radiographs

X = Mid incisal point of crown   X' = Mid incisal point of crown
Y = Median CEJ   Y' = Median CEJ
Z = Most apical point of root   Z' = Most apical point of root
C1 = Crown length before treatment   C2 = Crown length after treatment
R1 = Root length before treatment   R2 = Root length after treatment

There was no specific classification in degree of EARR after orthodontic treatment. Sameshima and Sinclair[79] identified severe EARR as the resorption occurred more than 20 percents of root length. In this study, degree of EARR was

divided into 3 degree, namely, mild, moderate and severe root resorption. Mild EARR was classified as resorption was occurred below 10 percents of root length. Moderate EARR was defined as resorption of which happen between 10 − 20 percents of root length. And severe EARR was classified when resorption occurred more than 20 percents of root length.
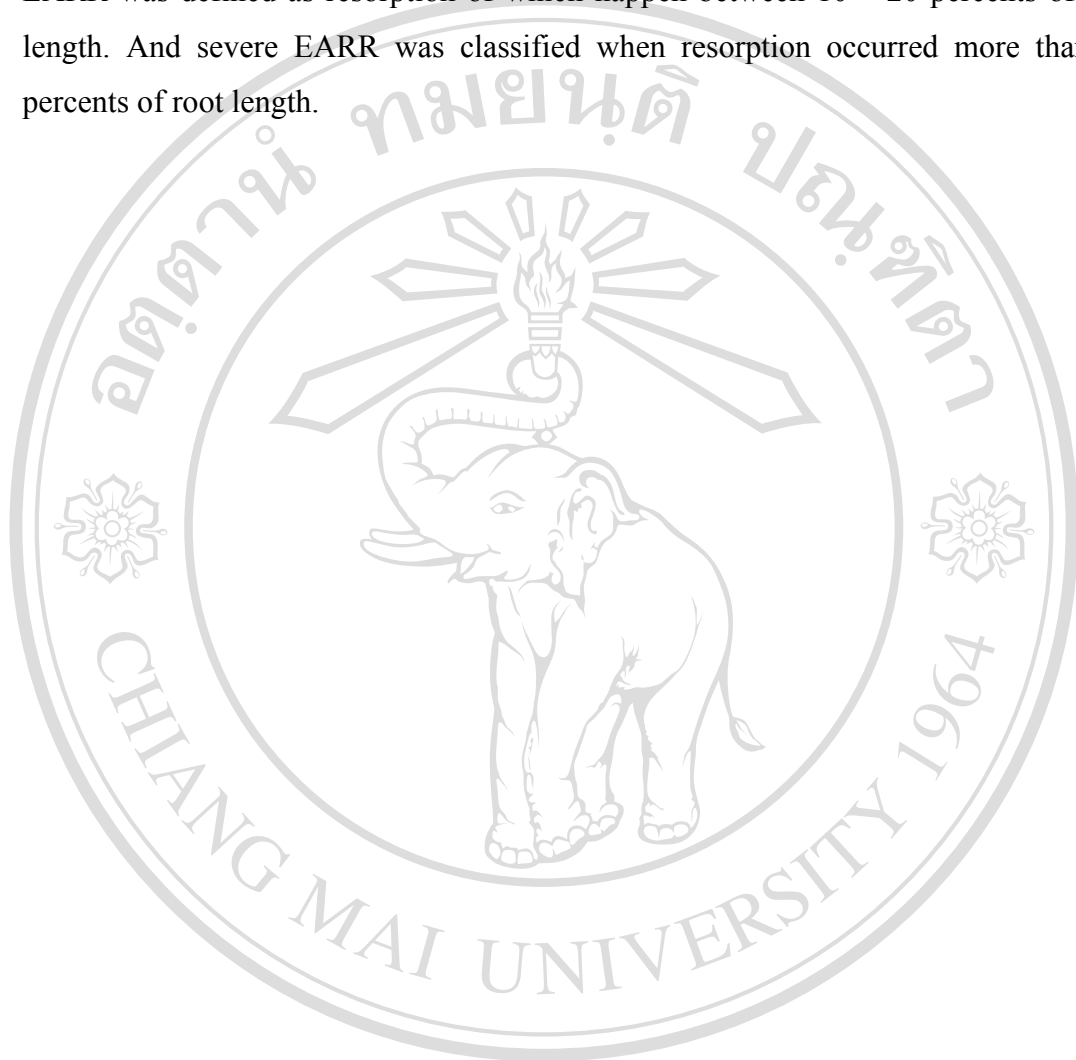
IV. Statistical analysis

- **Validity and reliability of the measurements**

To make measurement accuracy, the digital veneer caliper was calibrated with standard ruler before radiographic measurement. All measurements were performed twice on the radiographs of 20 patients by one examiner using Pearson's product-moment correlation which showed highly significant correlation ($r = 0.81$) between first and second measurement. The correlation was significant at $p < .01$ level.

- **Mann-Whitney U test**

Mann-Whitney U test is the two-independent samples tests procedure which compares two groups of cases on one variable. It is the most popular of the two-independent nonparametric samples tests.

- **Kruskal-Wallis H test**

Kruskal-Wallis H test is the tests for several independent samples procedure compares two or more groups of cases on one variable. It is an extension of the Mann-Whitney test. Kruskal Wallis H test is the nonparametric analog of one-way analysis of variance and detects differences in distribution location.