A Comparison of Cervical Vertebral Maturation Assessment of Skeletal Growth Stages with Chronological Age in Thai between Cleft Lip and Palate and Non-Cleft Patients

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Objective: *(1) To search for any difference in chronological age related to stages of the cervical vertebral maturation index stages (CVMIs) comparing groups of cleft lip and palate (CLP) and non-cleft (non-CLP) subjects; (2) To investigate the relationship between chronological age and CVMIs in both groups of subjects.*

Material and Method: *Cervical vertebrae C2, C3, C4 were assessed on 1,549 cephalometric films (503 CLP films, 1,046 non-CLP films of subjects aged 5 to 18 years) using Hassel and Farman's method.*

Results: *T-tests showed mean chronological ages of CVMIs 2, 3 and 6 were different at p = 0.001, 0.024 and 0.016, respectively. CVMIs 1, 4 and 5 showed no significant differences. The CLP group achieved each CVMI score one year ahead of the non-CLP group, except for CVMI 4. Spearman's rank order correlations were r = 0.80 (95% CI: 0.76-0.83) for CLP, and 0.77 (95% CI: 0.74-0.79) for non-CLP.*

Conclusion: *CLP subjects tended to have a slightly advanced growth compared with non-CLP subjects. A high correlation coefficient was found between chronological age and cervical vertebral skeletal maturation.*

Keywords: *Hassel and Farman's method, Cervical vertebral maturation, CVMI, Chronological age, Cleft lip and palate*

J Med Assoc Thai 2013; 96 (Suppl. 4): S9-S18
Full text. e-Journal: *http://jmat.mat.or.th*

All types of non-syndromic cleft lip and palate make up one of the most common congenital anomalies. The incidence of cleft lip and/or palate at Maharatnakorn Ratchasima Hospital in Northeastern Thailand was reported to be 1.4 in 1,000 live-births[1] and incidence of births with cleft lip and palate at Srinagarind Hospital in Khon Kaen was 1.1 in 1,000 live-births[2]. One of the problems with which this group of patients is often confronted is deficiency of maxillary growth, producing skeletal Class III pattern and causing facial esthetic problems. Thus, the investigation to determine the timing of facial growth in cleft lip and cleft palate (CLP) children is crucial because the type of correction provided will be different according to the skeletal age of patient, such as dentofacial orthopedics applicable during adolescent growth, and orthodontics with orthognathic surgery deferred until after adolescent growth is completed.

There have been many maturity indicators to identify stages of growth. These indicators include chronological age, stage of dental development, height and weight changes with age, sexual maturation characteristics, and skeletal bone age determination using hand-wrist radiographs (HWR). Although use of HWR has been considered as the best indicator for assessment of maturity stage[3-5], they have disadvantages including extra radiation exposure of the patient, complexity of landmark identification and cost. Recently, assessment of cervical vertebrae in lateral cephalometric film, part of routine orthodontic diagnostics, has been introduced as an alternative to the HWR because good correlation has been found comparing these two assessment methods applied to different populations[3,6-8]. Images of the first five cervical vertebrae provide the opportunity for simultaneous assessment of the skeletal maturation determined according to the cervical maturation stage

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(CVMI)[6], therefore removing added radiation risks and cost associated with the use of the HWR. The cervical maturation index (CVMI) was introduced by Lamparski[9] who developed a series of standards for the developmental stages of cervical vertebrae C2-C6 in male and female. O'Reilly and Yanniello[10] evaluated the relationship between maturation of the cervical vertebrae and mandibular growth maturation. Hellsing[11] evaluated cervical vertebral growth in a sample of 8-, 11-, and 15-year-old children. She found that the cervical vertebrae show correlations in their dimensional changes (height and length increments) with statural height at different ages. In 1995, Hassel and Farman[6] analyzed the CVMI stage standards developed by Lamparski, and evaluated only the second, third and fourth cervical vertebrae. They matched the hand-wrist radiographs relating the 11 stages of skeletal maturation indicators of Fishman[12] with six stages of cervical vertebral maturation (Table 1 and Fig. 1)[6]. Franchi et al and Baccetti et al[13,14] reported that the CVMI method can be used as a biological indicator both for mandibular and for somatic maturation. Chen et al[15] developed formulae using regression analysis to predict mandibular length increment by identifying the stage of cervical vertebrae maturation.

Currently, there is controversy about whether cleft lip and cleft palate children have different rates of growth achievement from normal people. Some studies have reported that growth and development of cleft lip and cleft palate patients is normal[16-19], whereas other studies have reported that they may have risk of growth problems[20,21], or tend to have gender and age-related delay of growth[22,23]. Although there have been numerous published reports about growth and development of CLP patients, only three

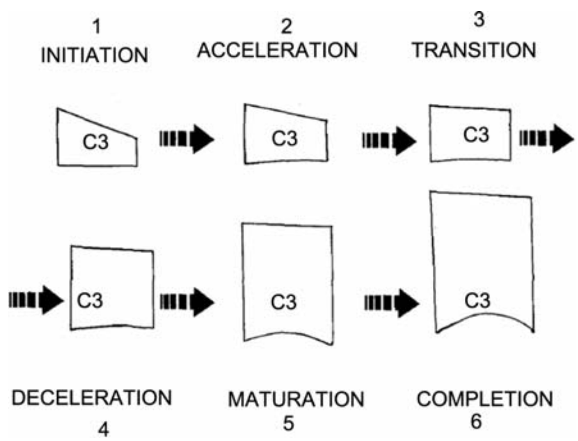

Fig. 1 Diagrammatic representation of CVM indicators stages using C3 as a guide (From Hassel and Farman[6]).

Table 1. Six stages in evaluation of cervical vertebrae maturation indicator according to Hassel and Farman[6]

CVMI Stages	Characteristic of maturation changes on cervical vertebrae
Initiation	Very significant amount of adolescent growth expected C2, C3, and C4 inferior vertebral body borders are flat Superior vertebral borders are tapered from posterior to anterior
Acceleration	Significant amount of adolescent growth expected Concavities developing in lower borders of C2 and C3 Lower border of C4 vertebral body is flat C3 and C4 are more rectangular in shape
Transition	Moderate amount of adolescent growth expected Distinct concavities in lower borders of C2 and C3 C4 developing concavity in lower border of body C3 and C4 are rectangular in shape
Deceleration	Small amount of adolescent growth expected Distinct concavities in lower borders of C2, C3 and C4 C3 and C4 are nearly square in shape
Maturation	Insignificant amount of adolescent growth expected Accentuated concavities of inferior vertebral body borders of C2, C3, C4 C3 and C4 are square in shape
Completion	Adolescent growth is completed Deep concavities are present for inferior vertebral body borders of C2, C3 and C4 C3 and C4 heights are greater than widths

reports on the use of the CVM index applied to the study of skeletal growth of children with cleft lip and palate have been found[21,24,25]. This present study attempts to determine whether the skeletal maturation of subjects with CLP is significantly delayed compared with unaffected subjects.

Material and Method

This retrospective cross-sectional study used all available lateral cephalometric radiographs of 1,549 subjects (503 CLP and 1,046 non-CLP) at the Orthodontic Department, Faculty of Dentistry, Khon Kaen University, Thailand. The subjects ranged in age from 5 to 18 years. The selection criteria included patients who lived in Northeastern Thailand, without systemic disease and serious illness, no previous trauma effecting craniofacial growth and development, no congenital and acquired malformations of the cervical vertebrae, no developmental abnormalities, and no hormonal disorders. Moreover, all radiographs were required to have good quality of sharpness, brightness, and contrast.

Each cephalometric film was traced at the vertebrae C2, C3, C4 by one tracer, using a 0.3 mm 3H pencil on acetate paper, using the Hassel and Farman method[6] (Table 1, Fig. 1) to evaluate cervical vertebrae stages (CVMI 1 to CVMI 6) by identifying changes at inferior vertebral body border, and of body morphology. Chronological age in whole years for each subject was calculated by subtracting date of birth from date of radiograph. The differences of mean chronological age at each CVMI stage between CLP and non-CLP groups were the main outcomes of the present study.

Statistical analysis

Descriptive statistics were used for identifying the general characteristics of subjects such as date of birth, date of x-ray film, gender, cleft type.

With each lateral cephalometric radiograph, patient's name and hospital number were covered, and numbered in random order. Vertebrae tracings were evaluated by two assessors and repeated by each assessor with three weeks separation. Weighted Kappa test was used to evaluate agreement using STATA version 10 (STATA Corp, LP Station Tx).

Independent t-test was used for comparing mean chronological ages between both groups. The Spearman's rank correlation was used to assess the relationship between chronological ages and CVMIs in both groups. All were reported with exact p-values and 95% confidence intervals (CIs). The present study was approved by the Khon Kaen University Ethic Committee (number HE552083).

Results

Intra- and inter-assessor reliability assessments of a sample of 30 subjects were very good. The weight kappa value was 0.952 and 0.957 for intra-assessor reliability, and 0.956 and 0.952 for inter-assessor reliability before and three weeks later, respectively.

The total of 1,549 films used consisted of 1,046 non-cleft case films of 357 males and 689 females and 503 cleft case films (of 231 males and 272 females). The number of films for different cervical bone stages classified as non-CLP and CLP cases are shown in Table 2. The major cleft type in the present study was unilateral CLP (65.01%). Bilateral CLP (22.27%) was the second, whereas cleft lip with or without cleft alveolus and cleft palate only were 8.75% and 3.98%, respectively.

The distribution of different chronological ages for different CVMI stages in CLP group and non-CLP group are shown in Fig. 2 and 3, respectively. The CLP group showed CVMI 1 was most frequent at 5 years whereas the non-CLP group was shared between 6 and 9 years. CVMI 2 was most frequent at 8 years for the CLP group but at 9 years of non-CLP group. CVMI

Table 2. Frequencies of non-cleft and cleft subjects for each maturation stage

Stage of cervical bone maturation	Non-cleft cases n (%)	Cleft cases n (%)
Initiation (CVMI1)	11 (1.05)	36 (7.16)
Acceleration (CVMI2)	62 (5.93)	87 (17.30)
Transition (CVMI3)	125 (11.95)	131 (26.04)
Deceleration (CVMI4)	228 (21.80)	141 (28.03)
Maturation (CVMI5)	341 (32.60)	77 (15.31)
Completion (CVMI6)	279 (26.67)	31 (6.16)
Total	1,046	503

3 and CVMI 4 were most frequent at 10 and 12 years, respectively, in both groups. CVMI 5 was most frequent at 14 years for the CLP group, whereas it was 15 years for the non-CLP group. CVMI 6 was most frequent at 15 and 17 years in the CLP group but at 17 years for the non-CLP group.

The results of independent t-tests comparing mean chronological ages between both groups and 95% CIs are shown in Table 3. Fig. 4 illustrates the percentage of films from the KKU sample that were ranked in the six stages of CVMI. The X-axis indicates CVMI stages 1 to 6, while the Y-axis shows chronological ages in each stage.

Comparative data indicates that there was no significant difference in chronological age between patients with and without cleft lip and palate patients at initiation phase (p = 0.225, 95% CIs -0.52-2.16), deceleration phase (p = 0.617, 95% CIs -0.49-0.29) and maturation phase (p = 0.142, 95% CIs -0.13-0.88). However, likely significant differences were noted when comparing the two subject groups at the acceleration phase (p = 0.001, 95% CIs 0.42-1.57), transition phase (p = 0.024, 95% CIs 0.07-0.95) and completion phase (p = 0.016, 95% CIs 0.13-1.28). Obviously, the cleft patients reached each stage of CVMI earlier than the non-cleft group with least difference at the deceleration phase.

The correlations between chronological age and CVMI stages in CLP and non-CLP patients are shown in Fig. 5, 6, respectively. Spearman's rank order test showed high correlation between stage of CVMI and chronological age of cleft group (r = 0.797) and normal group (r = 0.767). There are correlations between

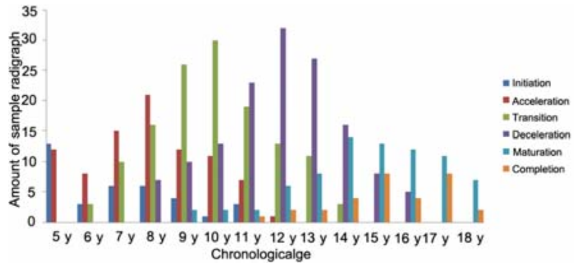

Fig. 2 Distribution of different chronological ages with six CVMI stages (CLP group).

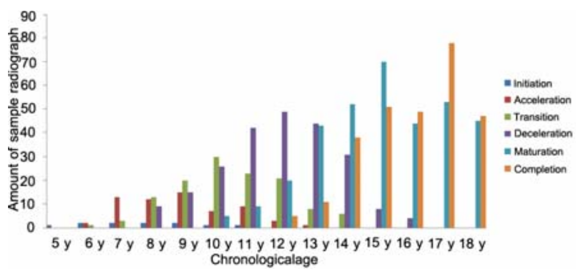

Fig. 3 Distribution of different chronological ages with six CVMI stages (non-CLP group).

Table 3. A comparison of means, standard deviations, p-values, and 95% CIs of chronological ages for the two study samples at each CVMI

Stage of cervical bone maturation	n	Mean age	SD	Mean diff	95% CIs	p-value
Initiation 1				0.82	-0.52 to 2.16	0.025
Non-cleft	11	7.82	1.83			
Cleft	36	7.00	1.96			
Acceleration 2				0.99	0.42 to 1.57	0.001
Non-cleft	62	8.90	1.66			
Cleft	87	7.91	1.83			
Transition 3				0.51	0.07 to 0.95	0.024
Non-cleft	125	10.43	1.72			
Cleft	131	9.92	1.85			
Deceleration 4				-0.10	-0.49 to 0.29	0.617
Non-cleft	228	11.87	1.79			
Cleft	141	11.97	1.93			
Maturation 5				0.38	-0.13 to 0.88	0.142
Non-cleft	341	15.08	1.98			
Cleft	77	14.70	2.19			
Completion 6				0.71	0.13 to 1.28	0.016
Non-cleft	279	15.97	1.53			
Cleft	31	15.26	1.81			

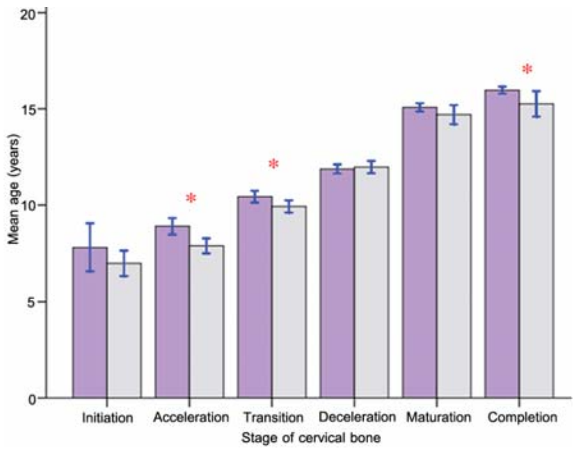

Fig. 4 Mean chronological age (years) with 95% CIs in each stage. The non-cleft groups (purple bar) and the cleft group (grey bar) were compared for each stage, while the blue lines show 95% CIs (*significantly different at $\alpha = 0.05$).

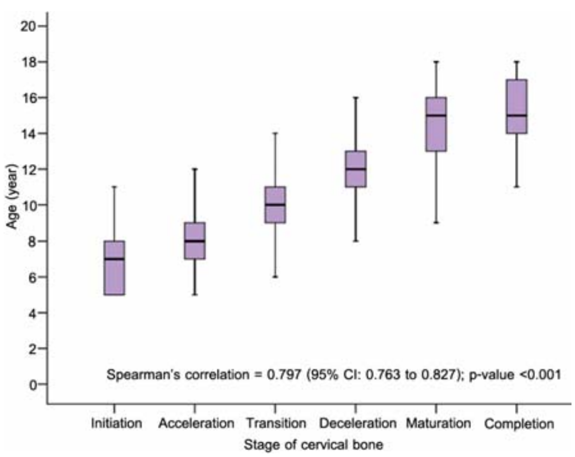

Fig. 5 Correlations of each CVMI stage and chronological age in cleft group.

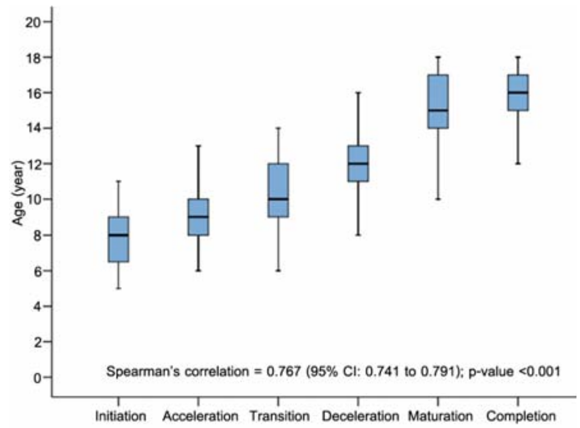

Fig. 6 Correlations of each CVMI stage and chronological age in non-CLP group.

chronological age and CVS stages in CLP and non-CLP patients ($p<0.001$) with 95% CIs = 0.763-0.827 and 95% CIs = 0.741-0.791, respectively.

Discussion

The numbers of lateral cephalometric radiographs at CVMIs 1, 2, 3 and 4 were larger in the CLP group than non-CLP group because CLP patients had been receiving treatment with comprehensive clinical records since an early age. In the non-CLP group, on the other hand, the numbers of subjects progressively increased from very few at 5 years to large numbers at 15 to 17 years (Fig. 2, 3).

Many researchers have reported that the CVM index is a reliable maturational indicator[6,9,13,26] although others have reported poor reproducibility[27-29]. In a systematic review of CVMI studies[30], there were questions about the reliability of the CVMI method as a growth maturation index. Because of the need to identify the morphology of the vertebral body as accurately as possible, the CVMI stages for comparing chronological age of the two sample groups, tracings of vertebral bodies in lateral cephalometric were made. The high-reproducibility of results for the CVMI method in the present study may have resulted from making the tracing while simultaneously identifying a particular CVMI stage of cervical vertebral bodies instead of simply viewing their radiographic images, the latter being the more common method.

Previous cervical vertebrae assessment studies used subjects over various chronological age ranges. Most research studies had not included subjects younger than 8 years old[6,15,21,24,26,31-35) and covered the circumpubertal period. Roman et al[3] and Uysal et al[36] used a wider age range of 5 to 18 and 5 to 24 years old, respectively. Although these two studies reported high correlations of CVMI with HWR assessments, neither study had even distributions of sample sizes covering the total age ranges, the focus of the available subjects being with the first three CVMI stages. Wong et al[35] claimed the CVMI method is not sensitive for detecting growth maturity apart from the growth spurt period. Too young or too old age ranges of subjects may reduce the ability of the CV method to detect precisely changes in skeletal maturity. The present study included subjects 5 to 18 years old in order to find basic data of all CVMI stages distributed over different chronological ages. From Fig. 2, 3, with age range of 5 to 7 years, the authors found 11.3% of the CLP group and most of them were in CVMI 1 and 2 compared with only 1.9% for the non-CLP group. Moreover, the authors had difficulty in detecting initial chronological age for CVMI 1 because it may include any age before change to CVMI 2. The results of studying the samples indicate that the CVMI assessment may be mainly useful for identification from CVMI 3 on wards.

Although results of the present study showed that both CLP and non-CLP groups did not differ at initial, deceleration and maturation phases, subjects aged 5 to 7 years who showed CVMIs 1 and 2 were quite different for the same age range and CVMIs in non-CLP patients. This may be assumed to be before the start of increased growth rate, with some of the CLP group likely experiencing delayed growth. Most of CLP patients in this study seem to have slightly advanced growth because their chronological ages tended to be younger than those of the non-CLP group in each of these CVMI stages. However, it should be noted the mean age of the non-CLP group in the deceleration phases (CVMI 4) was higher than that of the CLP group, but the age difference was not significant. The mean chronological age in the non-CLP group was earlier than the CLP group only by 0.1 of a year in this stage.

The present study showed that generally CLP patients have no difference in ages of achievement of growth stages compared with non-CLP patients. This is in agreement with Jaruratanasirikul et al[37] showed that non-syndromic CLP patient have physical growth in weight, height and head circumference matching the general population. However, they found 4.5% of non-syndromic CLP patient as young as 2 years of age had delayed development when compared with Thai reference data. Prahl-Andersen[38] reported that an advancement in skeletal maturity was greater in females with clefts than in females without clefts, while males with clefts did not show a remarkable difference in skeletal maturity compared with unaffected males. Bowers et al[22] reported that males with bilateral CLP had skeletal age delay from unaffected children whereas girls with unilateral CLP did not show skeletal age delay using serial hand and wrist radiographs. Their study showed that, in most results comparing chronological age, a CLP group achieved skeletal age stages earlier than a non-CLP group by less than one year. Krogman[39] reported that cleft children who received cleft lip/palate surgery can catch-up normal growth, both hard and soft tissue, by the age of six years.

Menius et al[40] showed 56% of cleft palate with or without associated of cleft lip subjects had younger skeletal ages than the age standards for normal subjects using HWR assessment. However, their study group was limited to 48 subjects, which made for inconclusive results. Jensen et al[41] showed boys with CLP had retarded skeletal maturity and concluded that early feeding problems, infections of the upper respiratory airway and surgical procedure resulted in delayed growth. Sun and Li's studies[21,24] showed CLP patients had risk of delayed growth when compared with a control group. They suggested stress reaction to surgical procedures may result in CLP's growth problems. Moreover, CVMI method seems to be useful in their subjects because CVMIs 1 and 2 can be detected for most of them in the 8 to 11 years age group. Conversely, the present study, especially for the non-CLP group at CVMI 3 had the largest proportion at 8 to 9 years old with CVMI 1 rarely found in this age range. The conflicting findings reported may be attributed to racial variations, local environmental conditions, and research methodology associated with the sample size and sample distribution, type of clefts, sex and the variety of growth indicators.

The present study showed that chronological age has high positive relationships with skeletal development. The correlation with "r" values of 0.80 and 0.77 for CLP and non-CLP patients, respectively, agreeing with previous studies[33,36,42,43]. However, the chronological age is not reliable for assessment of growth maturation[12,32,44].

To enhance or restrict the maxilla growth may be effective in the prepubertal stages or before the peak of mandibular growth, whereas with mandibular growth, the greater magnitude at circumpubertal period, especially after the peak of growth spurt[45-49]. CLP children often have skeletal Class III due to maxillary deficiency with or without mandible prognathism.

Hassel and Farman[6] assessed skeletal maturity using cervical vertebrae compared with the SMI for hand-wrist radiographs developed by Fishman[12]. They concluded from this comparison that the proper treatment time for growth modification in the maxilla should be initiated during CVMIs 1, 2 (Fishman's SMI 1, 2, 3 and SMI 4, 5 and sustained through CVMIs 3, 4 (SMIs 6, 7 and SMIs 8, 9) for maximum correction. From the present study, CVMI assessment may be useful to evaluate individual growth status in circumpubertal period. It is doubtful whether younger patients who are in CVMIs 1 and 2 would have onset of growth spurt during 5 to 7 years old.

In clinical practice, attempting to find accurate growth predictors of craniofacial changes may be less useful than expected. Xi and Roche[50] observed that skeletal age assessment from one part of the skeleton may be misleading if applied to another unrelated part. The accurate determining of the timing of jaw growth spurt would best be assessed by measuring the jaw changes themselves but would be difficult if not impossible to carry out without frequent cephalometric radiographs. Santiago et al[30] concluded that there was low level of evidence supporting CVMI methods that can be applied to skeletal maturity assessment. They stressed the skeletal assessment should not used by assessing cervical vertebrae maturation alone. Moreover, Ball et al[51] stated that CVMI should be a supplemental method for evaluating growth because it could not accurately specify prepubertal mandibular growth minimum, nor the onset of any mandibular growth spurt. However, an interesting point of observing bone ossification may be to provide the final cut-off point of adolescent growth. In the present study both groups of patients achieved the end of growth (completion stage or CVMI 6) within 18 years of age. Greulich and Pyle[52] indicate the final adult height is achieved at 17 years old. Lewis and Roche[53] studied serial cephalometric radiographs. They concluded that after 18 years old, small, total increment growth change in cranial base and mandible were shown.

As mentioned above, CVMI assessment may have some limitations. However, the CVMI may be useful to confirm cases waiting the cessation of mandibular growth such as with mandibular set-back surgery that should be delayed as long as after the completion stage of growth and to confirm that growth modification cannot help. Although the present study showed CLP patients tend to show a slightly advanced growth spurt, it is not possible from a single radiograph that reveals a particular stage of bone ossification to determine whether the growth is in an early or late phase of its development[54].

Limitation of this study

1. The sample size in this study requires a large group of subjects especially initial and acceleration phases. Larger sample size of each group would provide more precise results.

2. The absence of longitudinal data and using simple growth accomplishment at one point of time may make application of these results of only moderate value, although they compare favorably with other similar studies.

3. The present study did not separate male and female groups for controlling confounding factors because some CVMIs had small sample sizes.

4. The usefulness of including subjects younger than 8 or 9 years of age is questionable.

Conclusion

The present study showed that CLP subjects tended to have slightly advanced growth compared with non-CLP subjects. A high correlation coefficient was found between chronological age and cervical vertebral skeletal maturation. However, the use of skeletal age would be more accurate and more clinically beneficial than simply relying on chronological timing of growth stages. Applying the cervical vertebral maturation index (CVMI) method to estimate growth status should be used as a supplemental method. It is only of moderate value in clinical practice to rely on evaluation of vertebral growth from a single lateral cephalometric radiograph for predicting individual growth. Further study would be to use a more powerful research design such as case-control study or longitudinal study, separate sexes, and focus on age range over the circumpubertal period that could provide valuable information to help make decisions on the timing of orthodontic treatment.

Acknowledgement

The authors wish to thank the Tawanchai Foundation for Cleft Lip-Palate and Craniofacial Deformities and the Center of Cleft Lip-Cleft Palate and Craniofacial Deformities, Khon Kaen University, in association with the Tawanchai Project.

Potential conflicts of interest

None.

References

1. Virarat P, Ritthagol W, Limpattamapanee K. Epidemiologic study of oral cleft in Maharatnakornratchasima Hospital between 2005-2009. J Thai Assoc Orthod 2010; 9: 3-13.
2. Ratanasiri T, Junthathamrongwat N, Apiwantanakul S, Wongkam C, Chowchuen B. The birth incidence of cleft lip and palate at Srinagarind Hospital, 1990-1999. Srinagarind Med J 2001; 16: 3-7.
3. San Roman P, Palma JC, Oteo MD, Nevado E. Skeletal maturation determined by cervical vertebrae development. Eur J Orthod 2002; 24: 303-

11.
4. Chapman SM. Ossification of the adductor sesamoid and the adolescent growth spurt. Angle Orthod 1972; 42: 236-44.
5. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. 2nd ed. Champaign, IL: Human Kinetics; 2004.
6. Hassel B, Farman AG. Skeletal maturation evaluation using cervical vertebrae. Am J Orthod Dentofacial Orthop 1995; 107: 58-66.
7. Kucukkeles N, Acar A, Biren S, Arun T. Comparisons between cervical vertebrae and hand-wrist maturation for the assessment of skeletal maturity. J Clin Pediatr Dent 1999; 24: 47-52.
8. Chang HP, Liao CH, Yang YH, Chang HF, Chen KC. Correlation of cervical vertebra maturation with hand-wrist maturation in children. Kaohsiung J Med Sci 2001; 17: 29-35.
9. Lamparski D. Skeletal age assessment utilizing cervical vertebrae [thesis]. Pittsburgh: University of Pittsburgh; 1972.
10. O'Reilly MT, Yanniello GJ. Mandibular growth changes and maturation of cervical vertebrae—a longitudinal cephalometric study. Angle Orthod 1988; 58: 179-84.
11. Hellsing E. Cervical vertebral dimensions in 8-, 11, and 15-year-old children. Acta Odontol Scand 1991; 49: 207-13.
12. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod 1982; 52: 88-112.
13. Baccetti T, Franchi L, McNamara JA, Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod 2002; 72: 316-23.
14. Franchi L, Baccetti T, McNamara JA Jr. Mandibular growth as related to cervical vertebral maturation and body height. Am J Orthod Dentofacial Orthop 2000; 118: 335-40.
15. Chen L, Liu J, Xu T, Long X, Lin J. Quantitative skeletal evaluation based on cervical vertebral maturation: a longitudinal study of adolescents with normal occlusion. Int J Oral Maxillofac Surg 2010; 39: 653-9.
16. Felix-Schollaart B, Hoeksma JB, Prahl-Andersen B. Growth comparison between children with cleft lip and/or palate and controls. Cleft Palate Craniofac J 1992; 29: 475-80.
17. Nackashi JA, Rosenbloom AL, Marks R, Williams WN, Seagle MB, Frolova LE. Stature of Russian children with isolated cleft lip and palate. Cleft Palate Craniofac J 1998; 35: 500-2.
18. AlBarakati SF, Alkofide EA. Growth status of Saudi patients with cleft lip and palate. Saudi Med J 2002; 23: 823-7.
19. Shetye PR. Facial growth of adults with unoperated clefts. Clin Plast Surg 2004; 31: 361-71.
20. Matthews-Brzozowska T, Flieger R. Comparative analysis of skeletal age in patients with cleft palate. IADR General Session; Barcelona, Spain, July 14-17, 2010.
21. Sun L, Li WR. Cervical vertebral maturation of children with orofacial clefts. Cleft Palate Craniofac J 2012; 49: 683-8.
22. Bowers EJ. Growth in children with clefts: serial hand-wrist x-ray evidence. Cleft Palate Craniofac J 2011; 48: 762-72.
23. Lipman TH, Rezvani I, Mitra A, Mastropieri CJ. Assessment of stature in children with orofacial clefting. MCN Am J Matern Child Nurs 1999; 24: 252-6.
24. Sun L, Li W. Cervical Vertebral Maturation of Female Children With Orofacial Clefts. Cleft Palate Craniofac J 2012 Nov 20. doi: http://dx.doi.org/10.1597/11-215R2.
25. Marcelino E, Tavano O, de Carvalho IMM. Cervical vertebrae as growth and development estimator in cleft lip/palate patients. Salusvita 2005; 24: 21-8.
26. Soegiharto BM, Moles DR, Cunningham SJ. Discriminatory ability of the skeletal maturation index and the cervical vertebrae maturation index in detecting peak pubertal growth in Indonesian and white subjects with receiver operating characteristics analysis. Am J Orthod Dentofacial Orthop 2008; 134: 227-37.
27. Gabriel DB, Southard KA, Qian F, Marshall SD, Franciscus RG, Southard TE. Cervical vertebrae maturation method: poor reproducibility. Am J Orthod Dentofacial Orthop 2009; 136: 478.e1-7.
28. Nestman TS, Marshall SD, Qian F, Holton N, Franciscus RG, Southard TE. Cervical vertebrae maturation method morphologic criteria: poor reproducibility. Am J Orthod Dentofacial Orthop 2011; 140: 182-8.
29. Zhao XG, Lin J, Jiang JH, Wang Q, Ng SH. Validity and reliability of a method for assessment of cervical vertebral maturation. Angle Orthod 2012; 82: 229-34.
30. Santiago RC, Miranda Costa LF, Vitral RW, Fraga MR, Bolognese AM, Maia LC. Cervical vertebral maturation as a biologic indicator of skeletal

maturity. Angle Orthod 2012; 82: 1123-31.
31. Mahajan S. Evaluation of skeletal maturation by comparing the hand wrist radiograph and cervical vertebrae as seen in lateral cephalogram. Indian J Dent Res 2011; 22: 309-16.
32. Kamal M, Goyal S. Comparative evaluation of hand wrist radiographs with cervical vertebrae for skeletal maturation in 10-12 years old children. J Indian Soc Pedod Prev Dent 2006; 24: 127-35.
33. Rasool G, Shaheed S, Adil S. Age related changes in the morphology of cervical vertebrae in adolescent period of development. Pak Oral Dent J 2010; 30: 363-70.
34. Garcia-Fernandez P, Torre H, Flores L, Rea J. The cervical vertebrae as maturational indicators. J Clin Orthod 1998; 32: 221-5.
35. Wong RW, Alkhal HA, Rabie AB. Use of cervical vertebral maturation to determine skeletal age. Am J Orthod Dentofacial Orthop 2009; 136: 484-6.
36. Uysal T, Ramoglu SI, Basciftci FA, Sari Z. Chronologic age and skeletal maturation of the cervical vertebrae and hand-wrist: is there a relationship? Am J Orthod Dentofacial Orthop 2006; 130: 622-8.
37. Jaruratanasirikul S, Chichareon V, Pattanapreechawong N, Sangsupavanich P. Cleft lip and/or palate: 10 years experience at a pediatric cleft center in Southern Thailand. Cleft Palate Craniofac J 2008; 45: 597-602.
38. Prahl-Andersen B. Biological age in children with clefts. Stomatol DDR 1979; 29: 816-22.
39. Krogman WM. Craniofacial growth, prenatal and postnatal. In: Cooper HK, Harding RL, Krogman WM, Mazaheri M, Millard Rt, editors. Cleft palate and cleft lip: a team approach to clinical management and rehabilitation. Philadelphia: WB Saunder; 1979: 22-107.
40. Menius JA, Largent MD, Vincent CJ. Skeletal development of cleft palate children as determined by hand-wrist roentgenographs: a preliminary study. Cleft Palate J 1966; 3: 67-75.
41. Jensen BL, Dahl E, Kreiborg S. Longitudinal study of body height, radius length and skeletal maturity in Danish boys with cleft lip and palate. Scand J Dent Res 1983; 91: 473-81.
42. Baidas L. Correlation between cervical vertebrae morphology and chronological age in Saudi adolescents. J King Saud Univ Dent Sci 2012; 3: 21-6.
43. Alkhal HA, Wong RW, Rabie AB. Correlation between chronological age, cervical vertebral maturation and Fishman's skeletal maturity indicators in southern Chinese. Angle Orthod 2008; 78: 591-6.
44. Kopecky GR, Fishman LS. Timing of cervical headgear treatment based on skeletal maturation. Am J Orthod Dentofacial Orthop 1993; 104: 162-9.
45. Proffit WR. The timing of early treatment: an overview. Am J Orthod Dentofacial Orthop 2006; 129 (4 Suppl): S47-9.
46. Melsen B. Palatal growth studied on human autopsy material. A histologic microradiographic study. Am J Orthod 1975; 68: 42-54.
47. Ngan P. Early treatment of Class III malocclusion: is it worth the burden? Am J Orthod Dentofacial Orthop 2006; 129: S82-S85.
48. King EW. Cervical anchorage in Class II, Division I treatment, a cephalometric appraisal. Angle Orthod 1957; 27: 98-104.
49. Pancherz H, Hagg U. Dentofacial orthopedics in relation to somatic maturation. An analysis of 70 consecutive cases treated with the Herbst appliance. Am J Orthod 1985; 88: 273-87.
50. Xi HJ, Roche AF. Differences between the hand-wrist and the knee in assigned skeletal ages. Am J Phys Anthropol 1990; 83: 95-102.
51. Ball G, Woodside D, Tompson B, Hunter WS, Posluns J. Relationship between cervical vertebral maturation and mandibular growth. Am J Orthod Dentofacial Orthop 2011; 139: e455-61.
52. Greulich WW, Pyle SI. Radiographic atlas of skeletal development of the hand and wrist. 2nd ed. California: Stanford University Press; 1959.
53. Lewis AB, Roche AF. Late growth changes in the craniofacial skeleton. Angle Orthod 1988; 58: 127-35.
54. Houston WJ. Relationships between skeletal maturity estimated from hand-wrist radiographs and the timing of the adolescent growth spurt. Eur J Orthod 1980; 2: 81-93.

การศึกษาเปรียบเทียบอายุปฏิทินระหว่างผู้ป่วยปากแหว่งเพดานโหว่และคนปกติในประเทศไทยโดยใช้กระดูกต้นคอในการประเมิน

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วัตถุประสงค์: *(1) เพื่อหาค่าความแตกต่างของอายุปฏิทินระหว่างผู้ป่วยปากแหว่งเพดานโหว่และคนปกติ โดยใช้ระดับการเจริญเติบโตของกระดูกต้นคอในการประเมิน (2) เพื่อทดสอบความสัมพันธ์ระหว่างอายุปฏิทิน และระดับการเจริญเติบโตของกระดูกต้นคอในผู้ป่วยทั้งสองกลุ่ม*

วัสดุและวิธีการ: *วิเคราะห์กระดูกต้นคอระดับสอง สามและสี่ ในภาพถ่ายรังสีกะโหลกศีรษะด้านข้างทั้งหมด 1,549 ภาพ จำแนกเป็นกลุ่มผู้ป่วยปากแหว่งเพดานโหว่ 503 ภาพ และคนปกติ 1,046 ภาพ อายุ 5 ถึง 18 ปี โดยใช้วิธีฮาสเซล แอนด์ฟาร์แมน*

ผลการศึกษา: *ค่าเฉลี่ยอายุปฏิทินมีความแตกต่างในการเจริญกระดูกต้นคอในการเจริญเติบโตระยะที่สอง ระยะสามและระยะที่หก อย่างมีนัยสำคัญ (p = 0.001, 0.024 และ 0.016 ตามลำดับ) ในขณะที่การเจริญเติบโต ในระยะที่หนึ่ง ระยะที่สี่และระยะที่ห้า ไม่มีความแตกต่างอย่างมีนัยสำคัญ กลุ่มผู้ป่วยปากแหว่งเพดานโหว่บรรลุการเจริญเติบโตก่อนคนปกติเล็กน้อยไม่เกินหนึ่งปี ยกเว้นการเจริญเติบโตกระดูกต้นคอในระยะที่สี่ที่คนปกติ มีค่าอายุเฉลี่ยมากกว่า ค่าสัมประสิทธิ์สหสัมพันธ์สเปียร์แมน ระหว่างอายุปฏิทินและกระดูกต้นคอในกลุ่มผู้ป่วยปากแหว่งเพดานโหว่ r = 0.80 (95% CI: 0.76-0.83), ในคนปกติ r = 0.77 (95% CI: 0.74-0.79)*

สรุป: *ผู้ป่วยปากแหว่งเพดานโหว่มีแนวโน้มการเจริญเติบโตมากกว่าเล็กน้อยเมื่อเทียบกับการเจริญเติบโตของคนปกติและมีความสัมพันธ์กันของอายุปฏิทินและกระดูกต้นคออยู่ในเกณฑ์ดี*