COMPARATIVE STUDY BETWEEN HAND-WRIST METHOD AND CERVICAL VERTEBRAL MATURATION METHOD FOR EVALUATION OF SKELETAL MATURITY IN SAUDI BOYS

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ABSTRACT

The hand-wrist method and cervical vertebral maturation (CVM) are two common diagnostic approaches to assess skeletal maturity in clinical orthodontics. The objective of this study was to evaluate the correlation between CVM method and hand-wrist method in estimating the skeletal maturity level of Saudi male children. Lateral cephalograms and hand-wrist radiographs of 145 Saudi male children ranging from 10 to 15 years of age were utilized. The CVM method of Franchi and Baccetti (Franchi and Baccetti, 2002) was used to analyze the maturational morphologic characteristics of the cervical vertebrae from lateral cephalometric radiographs; whereas Bjork's skeletal maturity standards (Bjork, 1972) were utilized to determine the skeletal maturity stage from hand-wrist radiographs. Skeletal age for each subject was established using Greulich and Pyle's standard hand and wrist radiographic atlas (Greulich and Pyle, 1959).

The mean chronological age of the sample was 12.13±1.54 years, while the mean skeletal age was found to be 11.51± 1.9 years. High correlation (0.89, P<0.01) was established between CVM stages and hand-wrist skeletal maturity stages. The findings of this study suggest that CVM method is a valid and reliable method to assess skeletal maturity in Saudi male children.

Key words: *Hand-wrist, Lateral cephalometry, Cervical vertebra, Skeletal maturity, Skeletal age.*

INTRODUCTION

The assessment of skeletal maturation is considered an integral part of daily clinical practice in multiple health professions[1,2,3]. In orthodontics and dentofacial orthopedics, intervention to modify the growth potential of one or more of the craniofacial skeletal components is a common treatment modality[4,5]. Genetic and acquired abnormalities often lead to variation in the rate and magnitude of skeletal development. Discrepancies in skeletal maturation are closely associated with the variation in timing and magnitude of growth[6]. Generally, skeletal mal-relationships in the craniofacial region are manifested because of differential growth potential of various components of the craniofacial skeleton[5]. Timing of craniofacial orthopedic growth modification is typically linked to the period of maximum pubertal growth potential[7,8]. Therefore,

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estimating the peak of individual's growth potential, known as growth spurt, is an essential element of contemporary orthodontic diagnosis and treatment planning.

Several biologic indicators have been evaluated as potential markers of an individual's peak of growth. It is generally accepted that chronological age alone is considered a poor indicator of the level of skeletal maturity due to significant individual growth variation[1,9]. Although some biologic markers, such as secondary sexual characteristics and physical body measurements, are considered suitable indicators of the skeletal maturation, they cannot be used to predict the timing of maximum growth due to their retrospective nature[10]. Alternatively, direct evaluation of skeletal maturity level by observing certain bony maturation markers among different parts of the body is more valuable as a diagnostic tool in forecasting the prospective adolescent growth spurt and planning the growth modification therapy[8,11].

Conventionally, hand-wrist comparisons have been used to indicate the stage of skeletal maturity and predict the onset of pubertal growth spurt[10,12,13]. Generally, the assessment of hand-wrist radiograph is performed either by estimating the skeletal age of a patient from a hand-wrist radiographic atlas[14] or by relating specific bone maturational indicators to the pubertal growth curve to predict the timing of the maximum growth spurt[13,15]. The skeletal age and skeletal maturity stage of growing Saudi male subjects using hand-wrist method have been previously established[16].

More recently, the evaluation of skeletal maturity utilizing lateral cephalometric radiographs through the assessment of cervical vertebral maturation has gained more attention[17-20]. The ability to estimate skeletal maturity stage from routine diagnostic lateral cephalometric radiographs has the additional benefit of saving the patient from an additional exposure to radiation by eliminating the need for a hand-wrist radiograph.

The aim of this investigation was to evaluate the correlation between the cervical vertebral maturation (CVM) method and the hand-wrist method in determining the skeletal maturity stage of growing Saudi male children.

MATERIALS AND METHODS

The sample of this study consisted of the hand-wrist radiographs and lateral cephalograms of 145 Saudi males, obtained from the initial records of patients attending the Dental Clinics of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. The inclusion criteria for subjects in this study were as follows:

- Chronological age range from 10 to 15 years
- Free of any serious illness
- Normal overall growth and development
- No previous history of trauma or disease to the face or to the hand-wrist region
- No history of orthodontic treatment

The assessment of the skeletal maturity stage from the hand-wrist radiograph was based on Bjork's skeletal maturity indicators[11]. The following ossification stages were identified:

– Pre-PP2 Stage: Width of the epiphysis of the proximal phalanx of the 2nd finger is not yet equal to the width of its diaphysis. This stage was introduced because some children in the present study have not reached the PP2 Stage, which is considered the first stage in Bjork's system[11].

– PP2 Stage: Epiphysis of the proximal phalanx of the 2nd finger equals its diaphysis.

– MP3 Stage: Epiphysis of the middle phalanx of the 3rd finger equals its diaphysis.

– S Stage: First mineralization of ulnar sesamoid bone.

– MP3cap Stage: Epiphysis of the middle phalanx of the 3rd finger caps its diaphysis.

– DP3u Stage: Visible union between epiphysis and diaphysis of the distal phalanx of the 3rd finger.

– MP3u Stage: Visible union between epiphysis and diaphysis of the middle phalanx of the 3rd finger.

The CVM method described by Franchi and Baccetti[21] was followed for evaluation of skeletal matu-

rity stage from lateral cephalometric radiographs. This method comprises observation of the following five distinct stages of anatomic modifications in the 2nd (C2), 3rd (C3) and 4th (C4) cervical vertebrae:

- CVMS I: The lower borders of all three vertebrae are flat, with possible exception of a concavity at the lower border of C2. The bodies of both C3 and C4 are trapezoid in shape.
- CVMS II: A concavity at the lower borders of both C2 and C3 is present. The bodies of both C3 and C4 may be either trapezoid or rectangular horizontal in shape.
- CVMS III: A concavity at the lower border of C2, C3 and C4 is now present. The bodies of both C3 and C4 are rectangular horizontal in shape.
- CVMS IV: A concavity at the lower border of C2, C3 and C4 is present. The bodies of both C3 and C4 are square in shape. If not square, one of the two cervical vertebrae still is rectangular horizontal in shape.
- CVMS V: A concavity at the lower border of C2, C3 and C4 still present. The bodies of both C3 and/or C4 are rectangular vertical in shape. If not rectangular vertical, one of the two cervical vertebrae is still square in shape.

All radiographic assessments were performed by three trained dentists using an illuminated viewing box in a dark room. The Skeletal age for each subject was determined using Greulich and Pyle's radiographic atlas of skeletal development of hand and wrist[14]. The chronological age was obtained by referring to the date of birth in the personal data section of each subject's dental chart. For all subjects, the cephalometric and hand-wrist radiographs were taken on the same day of chronological age documentation. All readings related to each subject were recorded in a special form designed for this purpose.

All statistical analyses were performed using SPSS software package (Version 12, SPSS Inc., Chicago, IL, USA). Paired *t*-test and correlation values were assessed to determine the intra-examiner reliability of readings performed by the same examiner two weeks later for 15 randomly selected hand-wrist and lateral cephalometric radiographs. Pearson's correlation coefficient was used to test the inter-examiner variability between the three examiners. Descriptive statistics were performed to demonstrate sample distribution and mean chronological and skeletal age among various experimental groups. A nonparametric Spearman's correlation test was used to correlate the skeletal maturation stages in the hand-wrist and CVM methods. In addition, the correlation between different CVM stages and both chronological and skeletal ages was determined.

RESULTS

The sample distribution among different chronological age groups is shown in Fig. 1. The mean chronological age of the whole sample was 12.13±1.54 years while the mean skeletal age was 11.51± 1.9 years. Significant differences between chronological age and the mean skeletal age were detected for all chronological age groups except at 15-year group (Fig. 2). The intra- and inter-examiner correlations showed significant reliability of all readings as demonstrated by high coefficient values ranging from 0.98 to 0.99 ($P<0.001$).

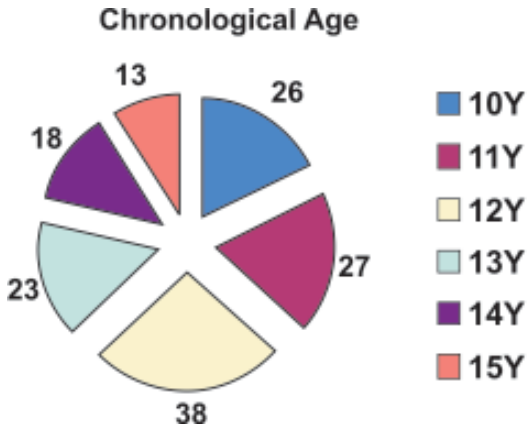

Fig. 1: Sample distribution based on chronological age.

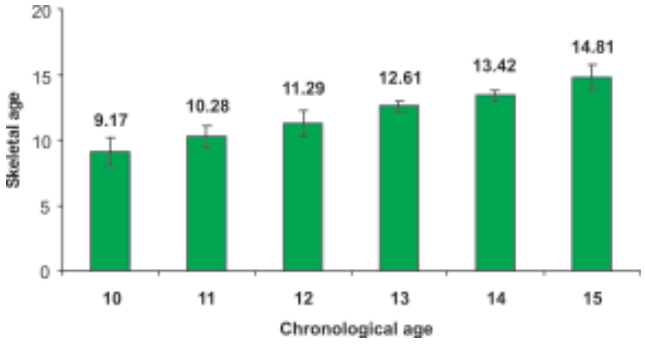

Fig. 2: Bar graph showing the mean skeletal age at different chronological age group.

CVM stage		Chronological age mean	Skeletal age mean
I	Mean	10.69	9.646
	N	48	48
	SD	.829	1.1530
II	Mean	11.92	11.323
	N	48	48
	SD	.794	.8902
III	Mean	13.23	13.016
	N	31	31
	SD	.805	.5984
IV	Mean	14.60	14.067
	N	15	15
	SD	.507	.8423
V	Mean	15.00	16.000
	N	3	3
	SD	.000	.5000
Total	Mean	12.13	11.510
	N	145	145
	SD	1.538	1.8971

TABLE 1: MEAN CHRONOLOGICAL AND SKELETAL AGE AT EACH CERVICAL VERTEBRAL MATURATION (CVM) STAGE.

The mean chronological age and the mean skeletal age at each CVM stage is presented in Table 1. High correlation between CVM stages and chronological age was found (0.86, $P<0.01$). Likewise, a significant correlation was found between CVM stages and skeletal age (0.87, $P<0.01$). The association between hand-wrist maturity stages and various CVM stages in all subjects is shown in Table 2. High correlation value was obtained (0.89, $P<0.01$) when the association between the CVM stages and the hand-wrist maturity stages was examined.

DISCUSSION

Chronological age has been regarded as a poor indicator of the skeletal maturity level and hand-wrist radiographs have been typically used to evaluate skeletal maturation[15]. Validity of skeletal maturity assessment using the hand-wrist radiograph has been established for Saudi male children[16], as well as for other racial groups[22-24]. Recently, the use of the CVM method has gained more attention in the literature and orthodontic clinical practice as a potential and valid replacement to the conventional hand-wrist radiographic technique[8,17,19]. The major advantage of the CVM evaluation method is the ability to perform the evaluation from conventional lateral cephalogram; thus eliminating the need for hand-wrist radiographs that are associated with additional exposure of the patient to radiation[25]. Most orthodontists are familiar with the diagnostic reading of the lateral cephalometric radiographs and no need for special training like in the case of hand-wrist radiographic interpretation. In addition, combined interpretation of hand-wrist and CVM stages has been reported to augment the early management of skeletal jaw discrepancies by enhanced prediction of the adolescent growth spurt[26].

This study represents a cross-sectional investigation to evaluate the validity and reliability of CVM method in establishing the skeletal maturity level of Saudi male children. The CVM method described by Franchi and Baccetti[21] was adopted in the present study because of its wide utilization in the current literature and the demonstrated applicability for several populations[8,27]. In the present study, the validity and reliability of the CVM method to assess skeletal maturity level of Saudi male children was evaluated against the well-recognized Bjork's standards of hand-wrist skeletal

CVMS	Hand-wrist maturation stage						
	pre-PP2	PP2	MP3	S	MP3cap	DP3u	MP3u
CVMS I	19	22	7	–	–	—	–
CVMS II	–	12	33	3	–	–	–
CVMS III	–	–	7	12	12	–	–
CVMS IV	–	–	–	1	9	5	–
CVMS V	–	–	–	–	–	1	2

TABLE 2: DISTRIBUTION OF HAND-WRIST MATURITY STAGES OF THE SAMPLE AMONG DIFFERENT CVM GROUPS.

maturity[11]. Skeletal maturation of Saudi male children has been studied previously using Bjork's hand-wrist standards[16]. In addition, the Greulich and Pyle's standard atlas of hand-wrist radiographs[14] was used in this study to establish the skeletal age. Both, Bjork's skeletal maturity indicators and Greulich and Pyle's atlas method, are commonly used in related studies because of their simplicity, popularity and reliability[13,28].

In harmony with a previous study[16], the current findings demonstrated statistically significant differences between the mean skeletal age and the chronological age at different age groups except at age 15 years. The general tendency of skeletal age to be lower than chronological age at most age groups possibly signifies that Saudi male children have a propensity to be late maturing. However, at a later phase of pubertal growth (15-year group), skeletal maturity rate seems to be "catching-up" and no significant difference between chronological and skeletal age was detected. A similar tendency for late skeletal maturation has been reported for Turkish children[29]. However, the tendency for early skeletal maturation has been established for Thai subjects[30]. In general, different contributing factors such as diverse racial backgrounds, dissimilar environmental conditions, and/or different methodology approaches, could explain the differences between multiracial studies of skeletal maturity. The relative implication of the present study's finding of significant differences between the mean skeletal age and chronological age at different age groups emphasizes the fact that chronological age is not a reliable predictor of skeletal maturity.

The validity and reliability of the CVM method in predicting the skeletal maturity level in Saudi male children have been demonstrated in the present study by the high correlation value (0.89) between the CVM stages and the hand-wrist maturity stages. Previous investigations have reported variable correlation values (from 0.45 to 0.97) between skeletal maturity stages determined by the two methods[17,18,31-34]. This considerable variability between the results of the reported studies and the present study may be explained on the basis of multiple factors such as gender, sample size, and/or specific methodology. Nonetheless, the high correlation values observed between the CVM stages and the skeletal age hand-wrist stages implies valuable clinical reliability in the use of the CVM approach in estimating the skeletal maturity level and predicting the pubertal growth peak in Saudi male children.

Within the scope and limitations of this study, the high correlation established between the skeletal maturity stages as measured by the CVM method and the hand-wrist method entitles CVM method to be thoughtfully considered when assessing the skeletal maturity in Saudi male children. Recommendations for future work include increasing the sample size to be more representative of Saudi male children and evaluating the same study parameters among growing Saudi girls.

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