Skeletal maturation of cervical vertebrae and hand-wrist region

Correlação entre maturação óssea das vertebras cervicais e da região de mão e punho

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ABSTRACT

Evaluation of bone maturation is highly important for orthodontics planning and treatment. Various parts of the body can be used for that purpose. The objective of the research was to check the correlation between the bone maturation stages of the cervical vertebrae and the bone maturation stages found at the hand-wrist region. Lateral X-rays were taken . Also hand and wrist X-rays were obtained. The Hassel and Farman method was used for the cervical vertebrae and the simplified Singer method was used for hand and wrist. The sample was compounded of 60 patients from the orthodontics clinic, FO-UERJ, 30 males and 30 females, ages between 7 and 14. The Spearman(r1) and Kendall(r2) coefficients were used to establish a correlation between the 6 stages proposed by each method. The study revealed a high correlation between the stages for both methods, not only for males (r1= 0.608 and r2= 0.656) and females (r1= 0.666 and r2= 0.634) but also for the total sample (r1= 0.743 and r2= 0.696). All results were statistically significant (p<0.001 or equal to 0.001). The conclusion was that the lateral X-ray evaluation of morphological alterations of hand-wrist vertebrae is trustworthy and practical for bone evaluation since it has a high correlation with a method that is already commonly used. It also adds to the information already furnished by such X-rays and avoids additional exposure to X-ray radiation.

UNITERMS

Cervical vertebrae; osteogenesis; growth and development.

INTRODUCTION

The growth's acceleration during puberty is the most favorable moment to treat malocclusions [1] and the estimation of skeletal age is very useful, since chronological age, dental development, body weight, body height, voice and breast changes have been shown to be unreliable and impractical for estimating the pubertal growth spurt [2-8].

Any method that might be used for identity growth acceleration or deceleration is helpful. Determining residual growth is also an important factor in orthodontic treatment. Sometimes the whole treatment plan depends on the growth factor [9, 10].

Several areas of the body may be used to analyze ossification centers, such as foot, elbow, knee, cervical vertebrae, hip, pelvis and skull. However, the hand- wrist region is the most used one because it has a great number of ossification centers in a relatively small area [2, 11].

Ossifications or epiphysary growth phases in the hand-wrist bones were developed in order to determine the onset of pubertal growth spurt and an important study was undertaken by Singer [12], who evaluated hand-wrist radiographs using six distinct stages in the analysis criteria: early, prepubertal, pubertal onset, pubertal, deceleration and growth completion; at each stage, existing alterations were described. Although

it is a simple, efficient and widely used method, there is a need for a specific radiograph of the hand-wrist region to evaluate bone maturation.

Also, Hassel and Farman [13] developed a method to evaluate skeletal maturity using lateral cephalometric radiograph as reference. The authors evaluated skeletal maturity of the second (C2), third (C3) and fourth (C4) cervical vertebrae, which are visualized in this kind of radiograph. This method consists of six stages that were divided into: initiation, acceleration, transition, deceleration, maturation and completion.

Both methods are divided into six stages and despite having different nomenclatures, have similar growth expectations for each stage.

Lateral cephalometric radiograph is a routine exam in the orthodontic treatment. Thus, the purpose of this study was to verify the correlation between the cervical vertebrae evaluation of Hassel and Farman's method [16] and Singer's simplified method [13], which is already widely used in hand-wrist radiographs.

Material And Methods

The research outline of this study was submitted to and approved by the Pedro Ernesto University Hospital Ethical Committee.

The sample comprised 60 patients submitted to orthodontic treatment whose initial documentation was evaluated. There were 30 male and 30 female patients, with ages varying from 7 to 15. All patients were radiographed at UERJ Dental School – Radiology Clinic.

Hand-wrist radiographs and lateral cephalometric radiographs were taken as a conventional procedure. Radiographs of high quality and good contrast were used.

Radiographs were analyzed using a negatoscope and a magnifying glass that enlarged the image 5 times its size in an environment with reduced luminosity. A mask made of dark paper was used so that the exceeding light would not interfere with radiographic interpretation.

Radiographic analysis was done by the same operator, who was submitted to a calibration process and error quantification method. Efforts were made to keep the research process as blind as possible. At first, lateral cephalometric radiographs were analyzed, followed by the carpal ones, at random, to avoid tendencies in observations.

The Hassel and Farman's [13] method establishes six stages. In this method, C2, C3 and C4 vertebrae are analyzed according to their shape and classified into one of these six stages: initiation, acceleration, transition, deceleration, maturation and completion (Figure 1).

The evaluated hand-wrist radiographic images and bone maturation events of interest to this study were identified using the inspection method which consists of comparing the radiograph of each individual with the representative standards of bone development presented in Singer's [12] study (Frame 1).

Statistical Analysis

All statistical analyses were performed with the software package (SPSS for Windows 98, version 10.0, SPSS, Chicago).

A one-way random Intraclass Correlation Coefficient (ICC) was used to determine the diagnosis reliability of both methods. Statistical analysis was conducted in order to evaluate the correlation between Singer's simplified hand-wrist radiographic evaluation [12] and Hassel and Farman's cervical vertebrae evaluation method [13].

The Spearman (r1) and Kendall (r2) rank order correlation coefficients (with p-value ≤ 0.001) were used to assess the relationship between cervical vertebrae and hand-wrist maturation stages.

Results

The intra-examiner reliability (ICC) for both methods was calculated from 6 triplicate hand-wrist and lateral cephalograms from the same patients. An ICC coefficient of 0.973 (p < 0.001) was obtained from hand-wrist evaluation and an ICC of 0.914 (p < 0.001) was obtained from cervical vertebrae evaluation. The reproducibility of all assessments was good, with high coefficient values.

When Spearman (r1) and Kendall (r2) rank order correlation coefficients were applied to assess the relationship between Hassel and Farman [13] and the simplified Singer [12] methods, a significant positive correlation between them was found (r1 = 0.743 and r2 = 0.696) with p-value < 0.001 (Table 1).

When evaluating the sample with regard to gender, results were similar to those obtained in the total sample. In the male group (Table 2), coefficients indicated a statistically significant correlation among bone maturation stages presented by both methods (r1 = 0.680 e r2 = 0.656) with p-value < 0.001. The same occurred in the female group (Table 3), which also presented a significant correlation among the stages (r1 = 0.666 e r2 = 0.634) with p-value < 0.001. Just one patient in this group presented very different re-

sults: stage I in Singer's method [12] and stage VI in Hassel and Farman's method [13].

DISCUSSION

A significant correlation among the stages of both methods was observed. This result is supported by other authors who reported that radiographic evaluation of morphological alterations in cervical vertebrae in lateral cephalometric radiograph is a reliable and practical alternative parameter for skeletal evaluation [10, 13, 14-18].

When evaluating the total sample (table 1), it was observed that 75% of patients were in the first stages; thus, most part of the sample population was in the early stages of bone maturation. In 61.67% of patients, equivalence among the stages in both methods was observed and whenever there was no direct correlation, they were very close. It should be highlighted that just one patient in the sample presented very different stages, as he was in the early stage in Singer's method [12] and in the growth completion stage in Hassel and Farman's method [13]. This is due to a number of variables involved in analysis of cervical vertebrae, which range from radiographic quality, superposition of images, position of patient at the moment of radiograph, and anatomical variations, among others [19].

When sample was analyzed with regard to gender, results were similar to those of the total sample, there being no differences between genders.

In the male group (Table 2), the coefficient indicated a statistically significant correlation among bone maturation stages presented by both methods. 56.7% of patients were in the same stage in both methods, whereas 43.3% were classified into very close stages. When a patient was in a stage of Singer's simplified method [12], he was in a subsequent stage of analysis of cervical vertebrae and showed a tendency of Hassel and Farman's method [13] to underestimate growth expectation in relation to Singer's simplified method [12]. Most sample (86%) was in stages I and II, reflecting these patients' high growth expectation.

The same occurred in the female group (Table 3), which also presented a significant correlation among stages. 66.7% of these patients were in equivalent stages. The others were in stages very close to them and presented the same standard as the male group, except for one patient, already mentioned in the total sample. As to the female group, a higher number of patients were in higher bone maturation stages when compared to the male group. This is probably due to the fact that girls reach skeletal maturation stages earlier than boys [11, 12, 17].

CONCLUSIONS

- Comparison of Hassel and Farman's method with Singer's simplified method showed that there is a significant correlation among maturation stages presented by both methods (r1 = 0.743 and r2 = 0.696, with p-value < 0.001).

- Observations of morphological changes in cervical vertebrae shown in lateral radiographs is an additional observation method of skeletal maturation, complements the range of information furnished by those radiographs and avoids extra radiographs.

RESUMO

A avaliação da maturação óssea é de grande importância no planejamento e tratamento ortodôntico e várias áreas do corpo podem ser utilizadas para esta análise. O objetivo deste estudo foi verificar a correlação entre os estágios de maturação óssea das vértebras cervicais e os estágios de maturação encontrados na região carpal. Foram utilizadas teleradiografias de perfil e radiografias de mão e punho e aplicados os métodos de Hassel e Farman para as vértebras cervicais e o método simplificado proposto por Singer para mão e punho. A amostra foi composta por 60 pacientes da clínica de especialização em ortodontia da FO-UERJ, com idades variando entre 7 e 14 anos. Deste total, 30 eram do gênero masculino e 30 do gênero feminino. Foram utilizados os coeficientes de Spearman (r1) e de Kendall (r2) para estabelecer a correlação entre os 6 estágios propostos por cada método. Os estudos revelaram uma alta correlação entre estes estágios em ambos os métodos estudados tanto para o grupo masculino (r1 = 0.680 e r2 = 0.656), para o grupo feminino (r1 = 0.666 e r2 = 0.634), quanto para a amostra total (r1 = 0.743 e r2 = 0.696), sendo todos os resultados estatisticamente significativos (p ≤ 0.001). Concluiu-se que a avaliação radiográfica das alterações morfológicas das vértebras cervicais nas teleradiografias laterais constitui um parâmetro alternativo, confiável e prático na avaliação esquelética, já que possui alta correlação com um método já comumente aplicado, vindo a complementar a gama de informações já fornecidas por tais radiografias e evitando exposição radiográfica adicional

UNITERMOS

Vértebras cervicais; osteogênese; crescimento e desenvolvimento.

I - INITIATION	II - ACCELERATION	III - TRANSITION
Flat inferior border of C2, C3 and C4; Superior borders of C2, C3 and C4 are tapered from posterior to anterior.	Beginning of concavity on inferior borders of C2 and C3; Flat inferior edge of C4; C3 and C4 tending to rectangular shape.	C2 and C3 with deep concavity on inferior borders; Beginning of concavity on inferior border of C4; C3 and C4 with rectangular shape.
IV - DECELERATION	**V - MATURATION**	**VI – COMPLETION**
Deep concavity on inferior borders of C2, C3 and C4; C3 and C4 tending to quadrangular shape.	Deep concavity on inferior borders of C2, C3 and C4; C3 and C4 with square shape.	Deep concavity on inferior borders of C2, C3 and C4; Height of C3 and C4 surpasses their width.

Figure 1 - Hassel and Farman's stages of bone maturation.

FRAME 1 - SIMPLIFIED SINGER'S STAGES OF BONE MATURATION.

I - EARLY	II – PREPUBERAL	III –PUBERAL ONSET
Absence of the pisiform and of hook of the hamate; Proximal phalanx epiphysis of 2nd finger is narrower than its diaphysis.	Epiphysis of proximal phalanx of 2nd finger is as wide as its diaphysis; Early ossification of the hook of the hamate and the pisiform	Early sesamoid calcification Increase in epiphysis width of proximal phalanx of 2nd finger; Increase in ossification of the pisiform.
IV – PUBERAL	**V – PUBERAL DECELERATION**	**VI – GROWTH COMPLETION**
Sesamoid ossification; Capping of the epiphysis on the diaphysis of the medial phalanx of the middle finger.	Total sesamoid ossification; Union of epiphysis and diaphysis of distal phalanx of middle finger.; Total ossification of all phalanxes and carpal bones; Radius and ulnar bones epiphyses not totally united to their diaphyses.	No reminiscent growth region; Total union of radius and ulnar bones epiphyses and diaphyses.

TABLE 1 – DISTRIBUTION AND CORRELATIONS BETWEEN HASSEL AND FARMAN AND SINGER SIMPLIFIED METHODS OF THE WHOLE SAMPLE.

Methods		SINGER						total
	stages	I	II	III	IV	V	VI	
	I	17	0	0	0	0	0	17
	II	12	10	0	0	0	0	22
HASSEL	III	2	3	9	0	1	0	15
	IV	0	0	3	0	0	0	3
and FARMAN	V	0	0	0	0	1	0	1
	VI	1	0	0	0	1	0	2
total		32	13	12	0	3	0	60

Spearman's coefficient: $r_1 = 0.743$
Kendall's coefficient: $r_2 = 0.696$
p-value ≤ 0.001

TABLE 2 – DISTRIBUTION AND CORRELATIONS BETWEEN HASSEL AND FARMAN AND SINGER SIMPLIFIED METHODS OF THE MALE GROUP.

Methods		SINGER						total
	Stages	I	II	III	IV	V	VI	
	I	11	0	0	0	0	0	11
	II	10	5	0	0	0	0	15
HASSEL	III	0	1	1	0	0	0	2
	IV	0	0	2	0	0	0	2
and FARMAN	V	0	0	0	0	0	0	0
	VI	0	0	0	0	0	0	0
total		21	6	3	0	0	0	30

Spearman's coefficient: $r_1 = 0.680$
Kendall's coefficient: $r_2 = 0.656$
p-value ≤ 0.001

TABLE 3 – DISTRIBUTION AND CORRELATIONS BETWEEN HASSEL AND FARMAN AND SINGER SIMPLIFIED METHODS OF THE FEMALE GROUP.

Methods		SINGER						total
	stages	I	II	III	IV	V	VI	
	I	6	0	0	0	0	0	6
	II	2	5	0	0	0	0	7
HASSEL	III	2	2	8	0	1	0	13
	IV	0	0	1	0	0	0	1
and FARMAN	V	0	0	0	0	1	0	1
	VI	1	0	0	0	1	0	2
total		11	7	9	0	3	0	30

Spearman's coefficient: $r_1 = 0.666$
Kendall's coefficient: $r_2 = 0.634$
p-value ≤ 0.001

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