Maturation of the Middle Phalanx of the Third Finger: A Comparative Study between Right and Left Hand

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Objectives: Recently a classification of patient's skeletal age based on the phalanx maturation, The Middle Phalanx Maturation of the third finger (MPM) method, was suggested. The aim of this study is to evaluate if there is a difference in MPM between the right and left hand. ***Study design:*** Two hundred fifty-four patients were obtained from the Complex Operating Unit of Orthodontics of Padua University Hospital. The total sample size has been selected by appropriate statistical calculations resulting in 130 patients. It was decided to further double the sample size *of a previous study* to ensure a robust statistical analysis. Radiographs of the right and left were obtained using the MPM method. Stages were compared using the right hand as a reference. The statistical analysis (Fisher exact test) was performed for the entire sample and related to gender in order to compare the right and the left hand stages. ***Results:*** In MPS2, 6 out 49 (12.2%) males and 7 out 27 females (25.9%) showed MPS3 in the left hand (p-value < 0.05). In all other stages, a total agreement (100%) was found. ***Conclusion:*** The authors confirm the use of the right hand as reference. In patients with MPS2 an additional radiograph on the left hand can be taken in order to increase the diagnostic accuracy. In all other stages other radiographs are not needed as a total agreement between the right and left hand was found.

Key words: skeletal age, orthodontics, middle phalanx maturation

INTRODUCTION

In orthodontics, a precise evaluation of a patient's skeletal age is essential to establish the best time to start orthodontic therapy. When to start treatment is dependent on the fact that the maxilla and mandible have differential means and rates of growth and development. The maxillary complex has sutural growth with bone apposition until the sutures fuse in post pubertal growth[1,2]. Most of the growth potential is in the prepubertal period. The mandibular complex has condylar growth, which proceeds slowly during prepubertal age, increases during puberty and then reduces until complete maturation[3,4]. Due to the difference in maxillary and mandibular growth patterns, an orthopedic therapy for maxillary transversal expansion is used during childhood while functional therapy to resolve skeletal Class II malocclusion should be used during the pubertal growth spurt[5].

Various methods have been used to evaluate a patient's skeletal age. Chronological age, dental development and secondary sex characteristics are unreliable due to their high variability and low predictability[6,7]. The method most frequently used is cervical vertebral maturation (CVM) analysis described by Baccetti *et al* in 2005. In this study a connection was found between skeletal age and the second, third and fourth cervical vertebra's shapes on lateral RX[3,8]. In the '70s, Fishman evaluated skeletal age proving sesamoid bone presence, proximal, medium, and distal phalanx fusion in the third and the fifth finger and finally radio bone fusion in a full hand and wrist radiograph[9]. Recently, Perinetti *et al* simplified Fishman's method. They suggested a new classification based only on the third finger middle phalanx radiograph of the right hand made with an intraoral sensor (MPM method)[10]. Six stages were found: two pre-pubertal, two at the pubertal growth spurt and two post-pubertal (Fig. 1). Finally, they proved a correlation between CVM and MPM stages suggesting the use of MPM as a CVM support or as an alternative in absence of a latero-lateral radiograph. Moreover, Dr. Fishman conventionally evaluates the left hand for his analysis [9,11].

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On the contrary, Dr. Perinetti evaluates the radiograph of the middle phalanx of the third finger of the right hand for his analysis [10]. In a recent article [11,] authors compared the right and the left hand and wrist maturation, according to Fishman's method, and they found different growth patterns between the two hands in the prepubertal age and at the end of the growth. In the conclusion of their article they suggested to investigate this phenomenon by increasing the sample size in further studies.

The aim of this study is to evaluate if there is a difference between the right and the left hand using MPM method. At this moment, no articles have been published that evaluate differences within the MPM method between the two hands. If a significant difference occurs between the right and the left hand, then the radiograph of only one side would not be sufficient for a precise evaluation of skeletal maturation.

MATERIALS AND METHOD

A radiograph of the middle phalanx of the middle finger was taken in 254 patients. Radiographs were taken for both hands in the first orthodontic examination. The total sample size was selected by appropriate calculations (using Statxact 11, Cytel Corporation, USA) resulting in 130 patients. It was decided to double the sample size from Safer et al. study[11] to ensure a robust statistical analysis. This study was approved by the local ethical committee. Informed consent was obtained to enroll each patient in the study.

Subjects were selected from the patients of the Complex Operating Unit of Orthodontics of Padua University Hospital according to these inclusion parameters: Caucasian patients aged from 6 to 16 years old in good general health and no syndromes, absence of anomalies of hand and wrist complex, no history of trauma on the left or right hand.

Every radiograph was obtained with the finger on a 2x3cm intraoral sensor (Sirona Dental Systems, Inc. USA). The cone of the x-ray machine was positioned orthogonal to the sensor and as close as possible to the finger. The x-ray settings were 7mA, 70kV and 0.03s of exposure time. The right hand radiograph was always taken before the left one. Every radiograph was performed by the same operator using a lead shield. Finally, every stage was evaluated by the same operator.

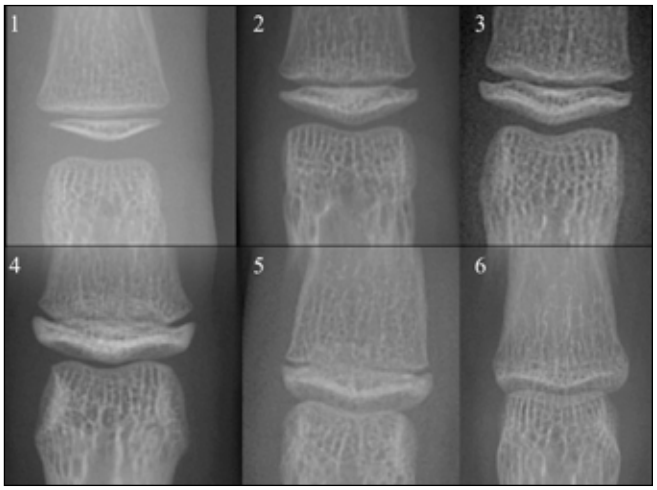
The sample was divided into six groups according to MPM method classification using the right hand as a reference. The MPM method describes a six stages classification[10] (Fig. 1), every stage is called MPS (Middle phalanx stage):

MPS1: The epiphysis is narrower than the metaphysis, or when the epiphysis is as wide as metaphysis, but with both tapered and rounded lateral borders. Epiphysis and metaphysis are not fused. This stage precedes the onset of the pubertal growth spurt at least one year before.

MPS2: the epiphysis is as wide as the metaphysis with sides increasing thickness and showing a clear line of demarcation at right angle. In cases of asymmetry between the two sides, that is, one typical of MPS2 and the other less mature, the former is used to assign the stage. This stage coincides with one year before the onset of the pubertal growth spurt.

MPS3: the epiphysis is either as wide as or wider than the metaphysis with lateral sides showing an initial capping towards the metaphysis and no sign of fusion. In case of asymmetry between the two sides, for example, one typical of MPS3 and the other less mature, the former is used to assign the stage. This stage coincides with a pubertal growth spurt.

Figure 1. Six stages classification in the middle phalanx maturation (MPM) method.



MPS4: the epiphysis begins to fuse with the metaphysis although contour of the former is still clearly recognizable. Both sides of the epiphysis form an obtuse angle to the distal border, and the capping is still clearly detectable. This stage is correlated to the deceleration of the curve of growth, after the pubertal growth spurt.

MPS5: the epiphysis is mostly, but not completely fused with the metaphysis and the distal contour of the former begins to be less clearly recognizable. This stage is correlated toward the end of the pubertal growth spurt.

MPS6: the epiphysis is totally fused with the metaphysis and the distal contour of the former is not recognizable. This stage is correlated to the end of the pubertal growth spurt.

Statistical analysis

The six groups included: 52 subjects (30 male, 22 female) in MPS1, 76 subjects (49 male, 27 female) in MPS2, 36 subjects (21 male, 15 female) in MPS3, 30 subjects (12 male, 18 female) in MPS4, 30 subjects (13 male, 17 female) in MPS5, 30 subjects (12 male, 18 female) in MPS6.

Twenty-five out of 254 patients were left-handed. The right and left hand stages were compared.

Statistical analysis was performed using the right hand as the reference for each group and comparing it with the stage on the left hand. The analysis was performed on the entire sample and related to gender (males and females). To verify the association between the right and left hand, the Fisher exact test was performed. The authors used the Fisher exact test because it is robust for a small sample size. Related p-values were significant at alpha < 0.05. Furthermore, the mean age was calculated for each stage and related to gender. Statistical analysis was performed using StatXact 11 (Cytel Corporation, USA).

RESULTS

The mean age for each group was calculated to be 8.8 years in MPS1, 10.7 years in MPS2, 12.5 years in MPS3, 12.7 years in MPS4, 14.0 years in MPS5, 15.1 years in MPS6 (Fig. 2). The female mean age in every stage was significantly lower than male mean age, due to previous female skeletal maturation[12]. The age difference between MPS3 and MPS4 was minimal (0.2 years); this could be explained as these two stages are close to the pubertal growth spurt.

Thirteen out of 254 patients showed a disagreement between right and left hand stages (5.1%). All 13 patients showed MPS2 in right hand and MPS3 in left hand (Fig. 3). In all other stages (MPS1, MPS3, MPS4, MPS5, MPS6) a total agreement (100%) between right and left hand stages was found (Table 1).

In the MPS2 stage 13 out of 76 patients showed a disagreement (17.1%). All these 13 patients showed the following stage (MPS3) in the left hand. Fisher exact test resulted in a statistically significant p-value < 0.05.

In MPS2 stage group, 49 males and 27 females were analyzed (Table 2). Six out of 49 males showed MPS3 in the left hand (12.2%). The Fisher exact test resulted in a statistically significant p-value < 0.05. On the other side, 7 out of 27 showed MPS3 in the left hand (25.9%); The Fisher exact test resulted in a statistically significant p-value < 0.05.

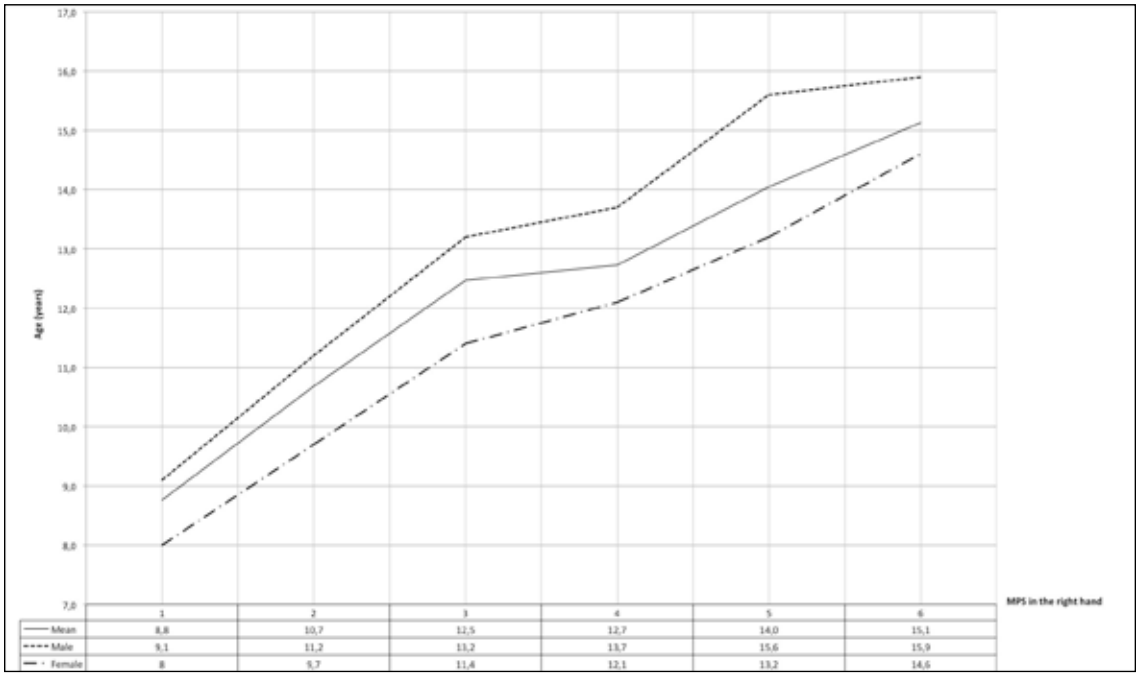
Table. 2. Differences of maturation stage between the right and the left hand related to gender. Data are presented as number of patients.

MPS	M	F	Total
2 right and 2 left	43	20	63
2 right and 3 left	6	7	13
Total	49	27	76

Table 1. Evaluation of the difference in the maturation between the right and the left hand. Data are presented as percentage and number of patients in parentheses.

	Middle phalanx maturation stage (MPS)						
	MPS1 left hand	**MPS2 left hand**	**MPS3 left hand**	**MPS4 left hand**	**MPS5 left hand**	**MPS6 left hand**	**Total**
MPS1 right hand	100% (52)						52
MPS2 right hand		82.9% (63)	17.1% (13)				76
MPS3 right hand			100% (36)				36
MPS4 right hand				100% (30)			30
MPS5 right hand					100% (30)		30
MPS6 right hand						100% (30)	30
							254

Figure 2. Graphic of mean age for male, female and both groups related to the right hand MPS, the middle phalanx maturation stage.



DISCUSSION

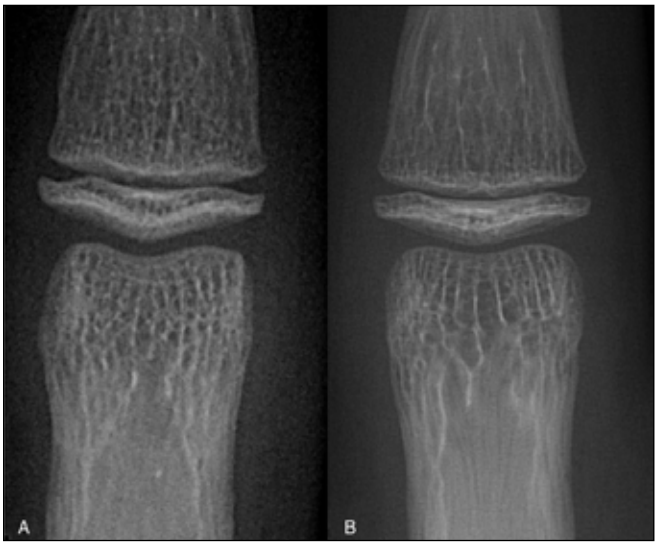
In orthodontics, it is fundamental to establish the right skeletal age of the patient in order to find the pubertal growth spurt[5,13]. There are different methods used to evaluate the patient's skeletal age. The most common method is the analysis of cervical vertebral maturation (CVM) in a lateral radiograph suggested by Baccetti *et al* [3]. Many studies in medical literature related CVM to pubertal spurt, stature and mandibular growth[14,15]. Recently, other authors related CVM to blood and salivary markers such as IGF-1 e PTHrP16–20. CVM can be generally used because a lateral radiograph is necessary as the initial patient's record for cephalometric evaluation to start the orthodontic treatment.

Thus, in some cases, the right moment to start treatment does not correspond with the time when the lateral radiograph was taken. When a patient is too young, a long time can pass before reaching the pubertal growth spurt. In these cases other lateral cranial or hand-wrist radiographs are needed to evaluate skeletal age. However, modern radioprotection guidelines suggest avoiding supplementary lateral cranial radiographs only with this aim[21]. Recently, Perinetti *et al* simplified Fishman's hand-wrist analysis9 and proposed MPM method: it consists of the evaluation of the ossification of the middle phalanx of the third finger of the right hand (Fig. 1). Their study showed a statistically significant correspondence between MPM and CVM (p-value < 0.001)10. Moreover, the middle phalanx radiograph can be taken using an intraoral sensor so it can be performed with ease in a dental practice. The radiation exposure is significantly lower than with lateral cranial and hand-wrist radiographs. For this reason, MPM can be periodically repeated in order to increase the accuracy of the pubertal growth spurt evaluation. MPM shows an easier interpretation than CVM because quite often lateral radiographs have a low resolution or vertebrae are hidden by the lead apron. Furthermore, some authors have questioned the validity and reliability of the cervical vertebrae maturation staging[22,23].

In this study the agreement in the maturation of the middle phalanx of the third finger between right and left hand was evaluated in a sample of growing Caucasian patients in order to find a differential maturation. The right hand was taken as reference and the stage in the left hand was compared. Our data shows a different maturation only in stage MPS2 in which 17.1% of the patients have stage (MPS3) in the left hand (Fig. 3). This difference is found in 12.2% of males and 25.9% of females. Both results are statistically significant (p-value < 0.05). These results are particularly interesting because MPS3 coincides with the onset of the pubertal growth spurt. This is the optimal time to apply an oral functional device5. This discrepancy is important when attempting to identify a patient's critical growth period.

In fact, the use of a right phalanx radiograph could estimate an imprecise time of the pubertal growth spurt in a significant percentage of patients. This would risk starting functional appliance therapy during a non-optimal time. Our data confirms the lateral difference in the maturation of the hand and wrist complex found by Safer et al[11]. They highlighted a critical premature maturation of the left hand in proximity of the pubertal age suggesting the use of an additional left hand radiograph for confirmation in addition to the right hand.

Figure 3. Different stages of maturation in the same patient: MPS2 in the right hand (B), MPS3 in the left hand (A).



For those clinicians who use MPM evaluation as reference of skeletal maturation, the authors of this study suggest to take an additional radiograph of the left hand phalanx in patients showing MPS2 in the right hand in order to increase diagnostic accuracy of the pubertal growth spurt.

Moreover, our data shows a higher disagreement percentage in females than males. This could be explained by more precocious pubertal development of female subjects[12].

Current medical knowledge does not explain why previous left hand maturation appears; further studies are necessary to analyze and to understand the disagreement shown in this and other studies.

CONCLUSIONS

The authors confirm the use of the right hand stage as reference according to Perinetti. In patients with MPS2, an additional radiograph of the middle phalanx of the third finger of the left hand can be taken in order to increase the diagnostic accuracy of the growth pubertal spurt. Low radiation dose does not produce radioprotection problems. In all other stages other radiographs are not needed because a total agreement between the right and left hand was found. Further studies are needed to explain the reasons for the ossification difference between the right and left hand near the pubertal growth spurt found in this study.

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