Clinical and radiographic guidelines to predict pubertal growth spurt

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Abstract

Objective: The aim of this paper is to emphasize the organization of the information available in exams and along the orthodontics treatment of growing individuals, which are used as guidance to predict the pubertal growth spurt. **Conclusion:** Such information provide opportunities to increment the diagnosis and prognosis of these cases and in making planning decisions, treatment evolution and the retention phase, mainly for those patients presenting malocclusions associated to skeletal disharmonies.

Keywords: Growth. Prediction. Diagnosis. Prognosis. Malocclusion.

INTRODUCTION

The use of clinical and radiographic guidelines to predict a patient's skeletal maturation is a routine practice for healthcare workers that adopt an integrated approach to examinations. Using these findings, the pubertal or adolescent growth spurt may be assessed to define whether it is imminent, present or complete.[4,28]

This type of knowledge is useful when patients are referred to orthodontic treatment, particularly because certain stages of pubertal growth spurt may benefit the treatment of some types of malocclusion associated with skeletal disorders.[17]

However, the detection of pubertal growth spurt in each individual is complicated because it occurs at different chronological ages.[18] Its prediction at least one year in advance may be essential if the purpose is to take advantage of it during orthodontic treatment.[17,20,24]

The direct clinical application of this prediction, when made before orthodontic treatment, complements orthodontic diagnosis, planning and prognosis,[2,23] particularly because growth increments are maximized during this phase.[2] Therefore, in specific cases, less tooth movement may be required, and growth may be an ally; under other clinical conditions, tooth movement will have a predominant role in treatment results,[20] and growth should be controlled or even redirected, depending on whether its pattern is favorable or unfavorable.[24]

All individuals undergo a pubertal growth spurt, but there are differences in onset, duration, velocity and amount of growth.[10,18,29] This life phase is characterized by growth acceleration and achievement of velocity peak, which then slows down until adulthood is reached.[29]

This paper describes methods to predict the adolescent growth spurt focusing on the clinical applications of this knowledge and the variability of the characteristics described.

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LITERATURE REVIEW

Along the history of orthodontics, authors and clinicians have been interested in craniofacial growth and bone development.

The regular assessment of physical maturation stages in adolescence provides extra information for treatment planning and progression and for decisions about retention type and duration after orthodontic treatment. Such decisions should be based on the evaluation of occlusal stability after treatment, which may be completed before the end of the growth spurt peak.[2,23,25]

Maturation may be described as the development process that completes physical growth, and its current level or stage can be measured and graphically represented in simple ways.[2] Growth potential, in contrast, is defined as the increase that may occur between current and final bone size, and this information is more difficult to obtain.[25]

The interpretation of some clinical and radiographic signs as a whole may provide an evaluation of an individual's level of maturation.[6] Among these physiological parameters are chronological, skeletal and dental ages, sex, sexual development, genetic factors[2,6] and ethnicity.[12,25]

Chronological age

Mental maturity, physical capacity, height, weight and number of teeth in the mouth are usually estimated according to chronological age. However, there are differences between individuals, even in groups of people with common traits and the same sex and age, particularly during adolescence, a phase when physiological differences become more evident.[2,15] Other variables, such as nutritional and endocrine status and certain metabolic diseases, affect adolescent development.[5,9,14]

Chronological age alone may not be used as a valid parameter to estimate growth velocity or skeletal maturity and is not, therefore, a relevant diagnostic element for treatment when used alone.[9,10]

Skeletal age

The evaluation of skeletal age using radiographs is widely used in healthcare to predict the phase of pubertal growth and to estimate growth velocity and remaining growth (growth potential).

The wrist and hand radiograph provides the best indication of skeletal maturation, particularly because it provides visualization of several ossification points in a small area.[16] Some methods have been developed to estimate skeletal age, such as those described by Greulich and Pyle (GP), Tanner et al (TW3), and Eklöf and Ringertz (ER). The GP method uses an atlas that contains a sequence of radiographs of the hand and wrist obtained every six months of healthy American boys and girls with similar characteristics. For each radiograph, a chronological age corresponding to the skeletal age is assigned.[14] The TW3 method also compares radiographic reference standards of skeletal maturation of white children of the same sex and similar ages to define skeletal age.[10,16] It assesses specific ossification centers in the hand and wrist (radius, ulna, metacarpal bones and specific phalanges) and assigns values to estimate skeletal age.[16] The ER method calculates skeletal age using ten linear measures of certain bones and comparing them with pre-established values.[8]

For those not familiar with the anatomy and sequence of calcifications of the carpal and finger bones,[14] authors have simplified the clinical application of some reliable bone maturation guidelines, such as the appearance of the sesamoid ulnar bone in the metacarpophalangeal joint of the first finger (thumb) and the capping between epiphysis and diaphysis of the proximal and middle phalanges of the second (index) and the third (middle) fingers.[30] For that purpose, the use of periapical radiographic films is an excellent option.[3,30]

All the data about growth spurt and body height are useful because the curves of both

maximum facial pubertal growth and body height are strictly associated in the same individual.[10,29]

Moreover, the close association between maximum body and facial growth and ulnar sesamoid ossification was longitudinally studied and confirmed for boys[1,4] and girls.[4,7]

The conclusions drawn from those studies have direct clinical applications because they confirm differences between sexes regarding onset, duration and intensity of the maximum pubertal growth spurt.

However, some studies in the literature criticize the fact that chronological ages are assigned to certain skeletal development phases based on conclusions whose reliability is uncertain.[9] Moreover, the possibility of exposing patients to X-rays several times is reason for concern.[23]

The wrist and hand radiograph should be seen as a complement, rather than a replacement, to other valid methods to evaluate a child's physical condition.[14]

A practical alternative is the lateral extraoral radiograph, usually requested for orthodontic diagnosis and which may also be used for growth predictions by evaluating bones of the spinal column[19] and the development of the frontal sinuses.[23] The end of the spurt phase peak in adolescent boys may be identified by the development of the frontal sinuses.[23]

Recent attempts to obtain more reliable data to estimate growth potential have been made using mathematical and computational methods that are, however, still based on hand and wrist radiographic guidelines[25] and the visualization of the cervical column on lateral extraoral radiographs.[19]

However, body, maxillary and specially mandibular growth are not stagnant at the end of the maximum growth spurt, even in patients with Angle Class II or Class III malocclusion, which affects the prognosis of orthodontic treatment.[13,22]

Lateral extraoral radiographs may also be used to predict the resulting craniofacial growth when studied using one or more of the methods available: Longitudinal, metric or structural. It is not enough to estimate the amount of growth, but also the direction towards which growth will be more intense.[20]

Dental age

Studies in the literature, such as the ones conducted by Demirjian et al[6] and Nolla[21], assigned scores to define the several calcification and mineralization stages of permanent teeth.

Despite their practicality and easy clinical application,[6] general tooth development indices are not reliable in predicting an individual's skeletal maturation stage.[4,5,7,10]

Some authors tried to correlate certain permanent teeth, such as mandibular canines,[4,5,6,26,27] mandibular second premolars[28] and third molars,[11] with skeletal age.

The development of mandibular canines is more strictly associated with height velocity peak than other teeth.[4,5,6,26,27] There is a strong positive correlation between root mineralization of mandibular canines — before apical closure, usually at the same time as it erupts into the oral cavity — and the onset of pubertal growth spurt, at a degree similar to that of the sesamoid bone calcification. When the dental apex is closed, the finger epiphyses and diaphyses are usually already fused, and growth spurt peak has already been achieved.[4,5]

The degree of calcification of mandibular second premolars and third molars should not be used[11] as radiographic indices of pubertal growth spurt in boys and girls.[11,28]

Sex

Girls usually mature earlier, with a mean difference of two years for the onset of pubertal growth spurt.[2,30] Boys not only reach maturation later, but the magnitude of their growth velocity peak is also considerably greater than that of girls.[2]

In a similar way, there are remarkable differences in the distribution of tooth calcification and mineralization phases between sexes.[4,21] Girls usually begin and end their dental development earlier than boys.[21]

Clinically, these differences suggest the need to start orthodontic treatment earlier in girls than in boys.[2]

Sexual maturation

Skeletal maturation, maybe the most common index in clinical routine, is believed to be associated with sexual and physical maturation.[7]

Profound hormonal changes are seen during puberty.[2] Androgenic secretions in men are composed of testicular and adrenal secretions, whereas in women they are primarily adrenal. These hormones have metabolic effects, promote bone growth and govern the development of the primary and secondary sexual traits.[5]

During adolescence, the reproductive system undergoes major development, and secondary sexual traits appear. In boys, the voice changes, and the mustache and beard grow, frequently during the beginning of the pubertal growth spurt. The appearance of pubic and axillary hairs, together with the growth of external genitals, reflects the progressive stages of male sexual maturation. These changes are followed or preceded by the pubertal growth peak.[2]

In girls, the appearance of pubic and axillary hairs and the growth of breasts indicate the development of the reproductive system, and there is a constant association between menarche (first menstruation) and the time at which pubertal growth peak occurs.[2] Height velocity peak is reached about one year before menarche, and is an excellent guideline to measure the sexual maturation of girls.[2,7,14]

Girls with greater skeletal ages also have an earlier menarche and usually grow more after menarche than those that have a later menarche.[2]

Skeletal maturation and the appearance of the ulnar sesamoid bone are associated,[4,5,7] and the correlations between their appearance and menarche are also consistently strong.[7]

Ethnicity

Comparative studies with populations from different ethnic groups have been conducted.[7,12,19,25] A longitudinal study between groups of African-American, Hispanic and Asian-American adolescents of both sexes collected hand and wrist radiographs, lateral cephalometric radiographs and measurements of body height to compare their data with those for white Americans.[9] Significant differences were found in onset, duration, intensity and end of pubertal growth spurt in the sample of 922 adolescents.[12]

Marked ethnic differences have also been found in the comparison of tooth calcification patterns.[4] Signs of variation in bone shape and ossification rate were found in comparisons between white and Japanese individuals.[19,25]

Genetic factors

Genetic factors should be evaluated when predicting pubertal growth spurt.[2,6] The number and size of teeth are genetically determined. Shape, function and skeletal growth are also affected by genetic factors, but may also be changed by environmental factors.[2,6]

DISCUSSION

The complexity of data in general dentistry literature about the prediction and clinical use of the pubertal growth spurt may be one of the difficulties to use maturation guidelines in dental diagnoses.

As seen before, there is a positive correlation between physical and facial pubertal growth spurt.[1,4] The treatment of some orthodontic problems may be facilitated or complicated by the patient's growth potential and type. Therefore, it is useful to identify physical maturation indices when examining children and adolescents that

present with malocclusion,[2,23] particularly when associated with skeletal disorders.[20] Growth rates may also affect the choice of timing and treatment type for cases that should be treated only with orthodontic procedures and for those that may actually benefit from complementary orthognathic surgery.[20]

The prediction of facial growth spurt peak is more reliable if based on knowledge associated with maturation guidelines.[2,23] Therefore, during clinical examination and history taking, the observation and recording of some simple information may enrich diagnoses and guide general clinicians and pediatric dentists to refer patients to orthodontic treatment. Such information may also affect treatment plans established by orthodontists.[2,23] As a consequence, questions are raised and findings about chronological age should be taken into consideration.[2,6] The appearance of some secondary sexual traits,[2] such as the menarche in girls;[2,7,14] height records for the patients, parents and older siblings[1,2,14] and the presence of permanent mandibular canines in the oral cavity[4,5,6,26,27] should be analyzed and checked at each visit, and the information collected may be used for the prediction of pubertal growth spurt.

Routine radiographs in dental clinic, such as panoramic and periapical films, may be used to define the stage of mandibular canine calcification and mineralization, a reliable guideline to define adolescent growth spurt stages.[4,5,6,26,27] For further investigation and confirmation, periapical radiographs, radiographs of some hand bones[3,30] or even hand and wrist radiographs[1,4,7,14] may be requested and used for longitudinal comparisons of the same patient.[9]

Moreover, genetic factors,[2,6] as well as differences between sexes and ethnic group,[4,7,12,19,25] may be associated with the onset, duration, intensity and end of the pubertal growth spurt. Therefore, they may affect the time and way that information about growth potential should be used in orthodontic treatments, which should also include additional care in preventing relapses.

This knowledge and its applications should be kept in mind when making decisions about treatment. Data may be retrieved from treatment routine practices, and they should be used timely as guidelines.

CONCLUSION

The addition of clinical and radiographic indicators of physical maturation to the dental record of children and adolescents may be simple, and findings may be useful for referral, diagnosis, planning and prognosis of the treatment of certain types of malocclusion.

The inclusion of such information in routine examinations may also provide a general overview of the patient as an integrated organism.

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