Skeletal-age Assessments in Timing Facial Growth and Orthodontic Treatment

A radiograph of the hand and wrist can predict the oncoming pubertal growth spurt several years before its occurrence. For example, one can predict within seven months' variation the beginning of the spurt 70% of the time even 4½ years prior to the spurt.[1] In fact, all cases can effectively be predicted to within ± one year of the start of the spurt if the estimates are made with the use of a hand film two years prior to this spurt. An orthodontist is, therefore, able to successfully time the beginning of the pubertal spurt so that orthodontic treatment can be closely coordinated with the massive facial growth that takes place at this time. If a hand-film assessment is not used, and instead, treatment timing is based on average age occurrence of the spurt, the timing will be missed by more than a year, 30% of the time.[1]

Facial growth during the first year of the pubertal growth spurt (which usually lasts approximately two years) is almost twice that of any one of several preceding years.[1] Therefore, if growth aids certain types of orthodontic treatment, it becomes extremely essential and meaningful to be able to successfully predict the timing of this spurt. In the same manner, it is also extremely important to be able to determine the termination of the spurt so that retention success can be predicted. Growth can, in certain cases (such as in a Class III skeletal problem), be a detriment to successful treatment. In these cases the use of skeletal-age assessments with the use of hand-films can be extremely helpful in timing the initiation of a final treatment stage with the end of the spurt, and in determining the prognosis in such a case.

To simplify the technique, one compares the maturity of the hand-film (exposed at 1/5 the exposure time and developed in the same way as a lateral cephalometric head film) to the examples in the Greulilch and Pyle Atlas[2] and assigns a "skeletal age" to the individual's maturity. The beginning of the male pubertal growth spurt coincides with a skeletal age of 12½ years, while the female spurt begins at about 11 years of skeletal age. This is quite independent of birthday or chronological age or the dental eruption schedule.

The most important area one looks at for this analysis is the appearance of the shafts and epiphyses of the five digits. Approximately one year before the pubertal spurt begins, the distal epiphyses begins to cap or curve up toward the base of the shaft (Figure 1, 11½ yrs.). The first finger to show this characteristic is usually the third digit but is quite variable. The progress of this capping and eventual sealing to the shaft begins usually at the tips of the fingers and works towards the radius and ulna in the wrist. Also very closely correlated to the beginning of the pubertal spurt is the first appearance of the sesamoid bone of the abductor pollicis muscle[1] . Its first appearance, which develops in the area just medial to the head of the first metacarpal (Figure 2), precedes the end of the spurt by about two years.

The first closure of the epiphyses to the base of the shaft of the distal phalanx usually occurs in the third finger, however, it often occurs in the first finger (thumb) shown in Figure 3, 15½ yrs.). This is highly correlated to the end of the growth spurt in the body and face,[1,3] to the first menstrual period in the female (menses) and to axillary hair in the male (under-arm hair)[4,5] . This signifies approximately 97% to 98% completion of growth.

Estimating the beginning of pubertal growth can be extremely helpful in determining the optimum time to begin major orthodontic treatment in order for it to coincide with the major facial growth spurt that occurs at this time. Charts for this purpose can be found at the end of this monograph.[1] In order to properly use these charts, it is necessary to calculate the skeletal age of the prospective patient. This can be done anytime prior to treatment from approximately eight years of age with relatively acceptable accuracy using the Greulich- Pyle Atlas. Once the skeletal age (SA) is determined, it is read across the upper horizontal scale (Tables I and II) and the child's actual age (chronological age, CA) is read down the vertical scale and the birthday age at which the male or female should ideally be started in orthodontic treatment, to utilize the major portion of this pubertal spurt, is read from the estimate in the body of the chart.

For example, if a male has been determined to have a skeletal age (SA) of 12-6 while he is also 12-6 chronologically (CA), he should be started in treatment at 12 years and 7 months (Table I) and a female should be started at 11 years and 1 month (Table II). If on the other hand, this same male (having a SA of 12-6) was only 10½ years of age, his pubertal spurt will start at 10 years 4 months while a similar female will start her pubertal spurt at 8 years 10 months of age. Orthodontic treatment utilizing the majority of the pubertal spurt should be started at these predicted ages.

These same charts can be useful in also determining the approximate end of most of the major facial growth by simply adding 2 years onto the beginning estimates, or to determine the approximate end of almost all of the facial growth by adding 3 years to the same beginning estimate.

This, therefore, very briefly describes the technique of skeletal-age assessment and a more detailed description together with its implications in orthodontic timing and treatment can be obtained from the following references[1-6].

References:

1. Bergersen, E.O.; The Male Adolescent Facial Growth Spurt; Its Prediction and Relation to Skeletal Maturation , *Angle Orthod*. 42: 319-338, 1972.
2. Greulich, W.W. and Pyle, S.L.: *Radiographic Atlas of Skeletal Development of the Hand and Wrist,* Stanford, California: Stanford University Press, 1957.
3. Hunter, C.J.: The correlation of facial growth with body height and skeletal maturation at adolescence, *Angle Orthod*., 36: 44 - 54, 1966.
4. Simmons, K. and Greulich, W.W.: Menarcheal Age and the Height . Weight, and Skeletal Age of Girls 7 to 17 Years, *J. Pediat*. 22: 518-548, 1943.
5. Hansman, C.F. and Maresh, M.M.; A Longitudinal Study of Skeletal Maturation, *AM. J. Diseases of Child.,* 101:305-321. 1961.
6. Bjork, A.: Timing of Interceptive Orthodontic Measures Based on Stages of Maturation , *Trans. Europ. Orthod. Soc.* 48th Cong., 61-74, 1972.

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Figure 1. MALE (FEMALE IS 1½-2 YEARS EARLIER)

3 Yrs. 6 Yrs. 9 Yrs. 11½ Yrs. 12½ Yrs. 15 Yrs.

EPIPHYSES GRADUALLY CAPPING THE SHAFT
(of the Distal Phalanx of Third Finger)

Figure 2.

12½ Yrs. 13½ Yrs. 15 Yrs.

ADDUCTOR SESAMOID DEVELOPMENT
(of the First Finger or Thumb)

Figure 3.

13½ Yrs. 14½ Yrs. 15½ Yrs. 17 Yrs.

GRADUAL OBLITERATION OF EPIPHYSEAL CARTILAGE
(of the Distal Phalanx of the Third Finger)

TABLE I

FACIAL GROWTH

PREDICTION TABLE FOR THE BEGINNING OF THE MALE PUBERTAL GROWTH SPURT IN THE FACE

SA	8-0	8-6	9-0	9-6	10-0	10-6	11-0	11-6	12-0	12-6	13-0	13-6	14-0
Rate of Prediction													
67%	± 7 mo.	7 mo.	7 mo.	6 mo.	7 mo.	6 mo.	6 mo.	5 mo.	6 mo.	5 mo.	5 mo.	5 mo.	5 mo.
95%	±15 mo.	13 mo.	14 mo.	13 mo.	13 mo.	12 mo.	11 mo.	11 mo.	12 mo.	10 mo.	9 mo.	9 mo.	10 mo.
CA													
6-0	10-3												
6-3	10-6												
6-6	10-9	10-3											
6-9	11-0	10-7											
7-0	11-4	10-10	10-3										
7-3	11-7	11-1	10-6										
7-6	11-10	11-4	10-10	10-1									
7-9	12-1	11-8	11-1	10-5									
8-0	12-4	11-11	11-4	10-8	10-4								
8-3	12-8	12-2	11-8	11-0	10-7								
8-6	12-11	12-5	11-11	11-4	10-11	10-4							
8-9	13-2	12-8	12-2	11-7	11-2	10-7							
9-0	13-5	13-0	12-6	11-11	11-5	10-11	10-5						
9-3	13-9	13-3	12-9	12-2	11-9	11-2	10-8						
9-6	14-0	13-6	13-0	12-6	12-0	11-6	10-11	10-4					
9-9	14-3	13-9	13-4	12-10	12-4	11-9	11-3	10-7					
10-0	14-6	14-0	13-7	13-1	12-7	12-1	11-6	10-11	10-5				
10-3	14-9	14-4	13-10	13-5	12-11	12-4	11-9	11-2	10-9				
10-6	15-1	14-7	14-2	13-9	13-2	12-8	12-1	11-6	11-0	10-4			
10-9	15-4	14-10	14-5	14-0	13-5	13-0	12-5	11-9	11-3	10-7			
11-0	15-7	15-1	14-9	14-4	13-9	13-3	12-8	12-1	11-7	10-0	10-4		
11-3	15-10	15-4	15-0	14-8	14-0	13-7	13-0	12-5	11-10	11-2	11-2		
11-6		18-8	15-3	14-11	14-4	13-10	13-3	12-8	12-1	11-5	10-7	10-5	
11-9		15-11	15-7	15-3	14-7	14-2	13-7	13-0	12-5	11-9	11-2	10-8	
12-0			15-10	15-6	14-11	14-5	13-10	13-3	12-8	12-0	11-5	10-11	10-7
12-3			16-1	15-10	15-2	14-9	14-2	13-7	12-11	12-3	11-9	11-3	10-10
12-6				16-2	15-6	15-1	14-5	13-10	13-3	12-7	12-0	11-6	11-1
12-9				16-5	15-9	15-4	14-9	14-2	13-6	12-10	12-4	11-9	11-4
13-0					16-0	15-8	15-0	14-6	13-9	13-2	12-7	12-1	11-8
13-3					16-4	15-11	15-4	14-9	14-1	13-5	12-10	12-4	11-11
13-6						16-3	15-7	15-1	14-4	13-8	13-2	12-8	12-2
13-9						16-6	15-10	15-4	14-7	14-0	13-5	12-11	12-5
14-0							16-2	15-8	14-11	14-3	13-8	13-2	12-9
14-3							16-5	15-11	15-2	14-7	14-0	13-6	13-0
14-6								16-3	15-9	15-2	14-6	14-0	13-6
15-0									16-0	15-5	14-10	14-4	13-9
15-3									16-3	15-8	15-1	14-7	14-1
15-6										16-0	15-4	14-10	14-4
15-9										16-3	15-8	15-2	14-7
16-0											15-11	15-5	14-10
16-3											16-2	15-9	15-2
16-6												16-0	15-5
16-9												16-3	15-8
17-0													15-11
17-3													16-3
r	0.802**	0.839**	0.850**	0.853**	0.868**	0.800**	0.891**	0.899**	0.881**	0.918**	0.931**	0.928**	0.907**
Sy	0.608	0.562	0.576	0.537	0.543	0.491	0.469	0.452	0.488	0.410	0.378	0.384	0.436

** The confidence level of "p" (probability) is less than 1%.

TABLE II

PREDICTION TABLE FOR THE BEGINNING OF THE FEMALE PUBERTAL GROWTH SPURT IN THE FACE

SA	8-0	8-6	9-0	9-6	10-0	10-6	11-0	11-6	12-0	12-6	13-0	13-6	14-0
Rate of Prediction													
67%	±7 mo.	7 mo.	7 mo.	6 mo.	7 mo.	6 mo.	6 mo.	5 mo.	6 mo.	5 mo.	5 mo.	5 mo.	5 mo.
95%	±15 mo.	13 mo.	14 mo.	13 mo.	13 mo.	12 mo.	11 mo.	11 mo.	12 mo.	10 mo.	9 mo.	9 mo.	10 mo.
CA													
6-0	8-9												
6-3	9-0												
6-6	9-3	8-9											
6-9	9-6	9-1											
7-0	9-10	9-4	8-9										
7-3	10-1	9-7	9-0										
7-6	10-4	9-10	9-4	8-7									
7-9	10-7	10-2	9-7	8-11									
8-0	10-10	10-5	9-10	9-2	8-10								
8-3	11-2	10-8	10-2	9-6	9-1								
8-6	11-5	10-11	10-5	9-10	9-5	8-10							
8-9	11-8	11-2	10-8	10-1	9-8	9-1							
9-0	11-11	11-6	11-0	10-5	9-11	9-5	8-11						
9-3	12-3	11-9	11-3	10-8	10-3	9-8	9-2						
9-6	12-6	12-0	11-6	11-0	10-6	10-0	9-5	8-10					
9-9	12-9	12-3	11-10	11-4	10-10	10-3	9-9	9-1					
10-0	13-0	12-6	12-1	11-7	11-1	10-7	10-0	9-5	8-11				
10-3	13-3	12-10	12-4	11-11	11-5	10-10	10-4	9-8	9-3				
10-6	13-7	13-1	12-8	12-3	11-8	11-2	10-7	10-0	9-6	8-10			
10-9	13-10	13-4	12-11	12-6	11-11	11-6	10-11	10-3	9-9	9-1			
11-0	14-1	13-7	13-3	12-10	12-3	11-9	11-2	10-7	10-1	9-4	8-10		
11-3	14-4	13-10	13-6	13-2	12-6	12-1	11-6	10-11	10-4	9-8	9-1		
11-6		14-2	13-9	13-5	12-10	12-4	11-9	11-2	10-7	9-11	9-5	8-11	
11-9		14-5	14-1	13-9	13-1	12-8	12-1	11-6	10-11	10-3	9-8	9-2	
12-0			14-4	14-0	13-5	12-11	12-4	11-9	11-2	10-6	9-11	9-5	9-1
12-3			14-7	14-4	13-8	13-3	12-8	12-1	11-5	10-9	10-3	9-9	9-4
12-6				14-8	14-0	13-7	12-11	12-4	11-9	11-1	10-6	10-0	9-7
12-9				14-11	14-3	13-10	13-3	12-8	12-0	11-4	10-10	10-3	9-10
13-0					14-6	14-2	13-6	13-0	12-3	11-8	11-1	10-7	10-2
13-3					14-10	14-5	13-10	13-3	12-7	11-11	11-4	10-10	10-5
13-6						14-9	14-1	13-7	12-10	12-2	11-8	11-2	10-8
13-9						15-0	14-4	13-10	13-1	12-6	11-11	11-5	10-11
14-0							14-8	14-2	13-5	12-9	12-2	11-8	11-3
14-3							14-11	14-5	13-8	13-1	12-6	12-0	11-6
14-6								14-9	13-11	13-4	12-9	12-3	11-9
14-9								15-1	14-3	13-8	13-0	12-6	12-0
15-0									14-6	13-11	13-4	12-10	12-3
15-3									14-9	14-2	13-7	13-1	12-7
15-6										14-6	13-10	13-4	12-10
15-9										14-9	14-2	13-8	13-1
16-0											14-5	13-11	13-4
16-3											14-8	14-3	13-8
16-6												14-6	13-11
16-9												14-9	14-2
17-0													14-5
17-3													14-9