Original Article

Is Radius-Union an Indicator for Completed Facial Growth?

Maria Deicke[a]; Hans Pancherz[b]

Abstract: The purpose of this study was to determine if facial or dentoalveolar growth takes place after the occurrence of the radiographic handwrist stage R-J (completed fusion of the proximal epiphysis and diaphysis of the radius), which generally defines the completion of facial growth. Handwrist roentgenograms and lateral head films (LHFs) from 56 subjects (31 male and 25 female) aged 14 to 21 years were examined. Eight cephalometric distances (3 sagittal, 4 vertical, and 1 diagonal) and their changes during 2 different examination periods (from 1 year before to 2 years after the occurrence of R-J) were assessed. The investigation revealed that after the occurrence of R-J vertical dentoalveolar growth changes between 0.5 and 1.75 mm took place in the mandible and in the maxilla in 20% and 10% of the subjects, respectively. Comparing the 2 periods the frequency of the measured growth changes before and after R-J was, on average, almost equal. Because chronological age cannot be used for the assessment of facial growth termination, a reliable indicator for the assessment of facial growth termination is of major importance. After the occurrence of the handwrist stage R-J, most subjects revealed growth changes of less than 1 mm. Especially in the field of tooth implantology, it is important to forecast even small vertical dentoalveolar growth changes. The detected amount of growth after the insertion of an implant can cause esthetic and functional problems. (*Angle Orthod* 2005;75:295–299.)

Key Words: Dental implants, Infraocclusion, Radius-union, Dentoalveolar growth, Facial growth, Growth termination

INTRODUCTION

A reliable indicator in the assessment whether facial growth is completed or not is of major importance in the fields of tooth implantology, dentofacial orthopedics, and orthognathic surgery.

In tooth implantology, a failure can result if vertical dentoalveolar growth persists after the placement of the implant.[1,2] Because of the ankylosis connection between the tooth implant and the jaw bone, continuing growth can lead to a vertical step between the implant and the neighboring natural teeth. In the anterior region, the progressing infraocclusion can lead to esthetically unacceptable results (Figure 1) and in the molar region to functional disturbances.

In dentofacial orthopedics, the patient's growth stage is of clinical importance because functional appliances will work only if growth persists. Furthermore, to prevent relapses, retention after treatment has often to be extended to the end of the growth period. In orthognathic surgery, treatment usually has to be postponed until the end of the growth period to minimize the risk for a rebound of the malocclusion.

The patient's stage of growth is generally determined indirectly by the assessment of skeletal maturity using handwrist roentgenograms.[3–5] At the Department of Orthodontics, University of Giessen, the method of Hägg and Taranger[5] is used to assess skeletal maturity. Three radius ossification stages at the end of the growth period (R-I, R-IJ, and R-J) are used in the analysis of the hand radiographs (Figure 2).

Stage R-I: fusion of the epiphysis and diaphysis has begun.

Stage R-IJ: fusion of the epiphysis and diaphysis is almost completed but there is still a small gap at 1 or both margins.

Stage R-J: fusion of the epiphysis and diaphysis is completed. Completion of facial growth is generally defined by this stage.

Because single observations disclose that facial and especially mandibular growth can continue after R-J, but no systematic scientific studies exist in this field, the aim of this investigation was to answer the following questions:

- Does facial growth continue after the attainment of R-J?
- If so, is there growth to such an extent that it has clinical importance in the fields of tooth implantology, dentofacial orthopedics, and orthognathic surgery?

[a] Postgraduate student, Department of Orthodontics, University of Giessen, Giessen, Germany.

[b] Professor and Head, Department of Orthodontics, University of Giessen, Giessen, Germany.

Corresponding author: (e-mail: m.deicke@gmx.de).

Accepted: February 2004. Submitted: December 2003.

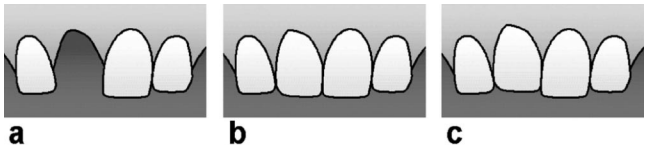

FIGURE 1. Schematic illustration of tooth implant changes in a growing subject. (a) Missing upper left central incisor. (b) After placing an implant and a superconstruction. (c) Shortening of the incisor when further dentoalveolar growth had taken place.

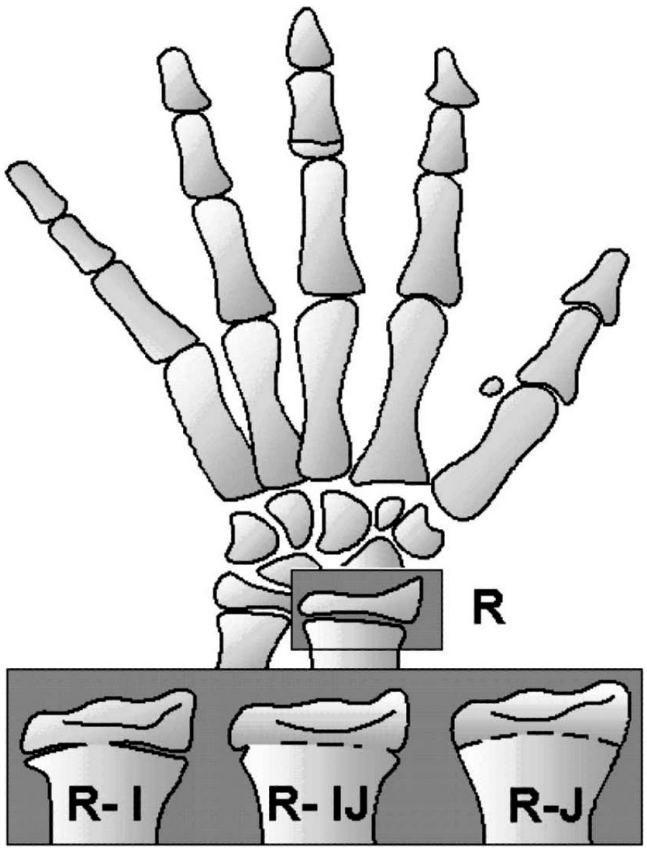

FIGURE 2. Illustration of the handwrist stages R-I, R-IJ, and R-J Hägg and Taranger[5] used at the end of the growth period.

MATERIALS AND METHODS

Serial handwrist radiographs (HRs) and LHFs in habitual occlusion from 56 subjects (31 male and 25 female) were examined. Orthodontic treatment/retention was completed at least 2 years before the radiographs were taken. Both the HRs and the LHFs were taken pairwise annually for approximately 5 to 10 years. The 2 authors appraised the radiographs independently and, in case of disagreement about the skeletal maturity stage, consensus was reached by discussion.

The following radiographs were analyzed: 1 HR and 1 LHF taken 1 year before the R-J stage (ie, in the R-IJ stage), 1 HR and 1 LHF at the R-J-stage, and at least 1 LHF taken 1 or 2 years after R-J. In Figure 3, the age distribution of the subjects at the time of R-J is shown.

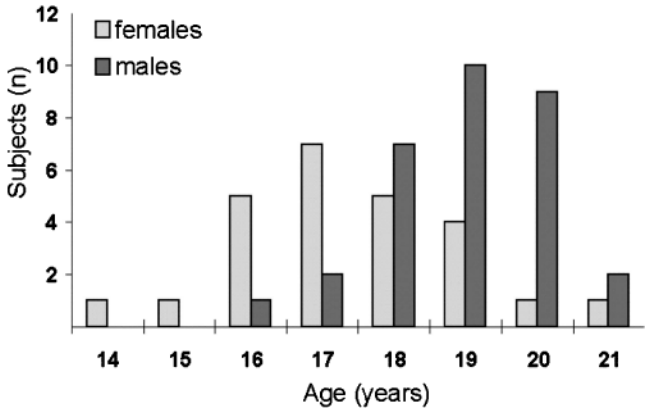

FIGURE 3. Chronological age distribution in 56 subjects at the handwrist stage R-J.

In the head film analysis (without correction for 7% linear enlargement) the following distances were assessed (Figure 4):

Sagittal

- A: Basal length of the skull.
- B: Basal length of the maxilla.
- C: Basal length of the mandible.

Vertical

- D: Basal height of the maxilla.
- E: Dentoalveolar height of the maxilla.
- F: Basal height of the mandible.
- G: Dentoalveolar height of the mandible.

Diagonal

- H: Diagonal length of the skull.

The changes of the cephalometric variables during the periods (1) R-IJ to R-J and (2) R-J to 2 years thereafter were assessed. The linear measurements were performed with a ruler to the nearest 0.5 mm.

In the head film analysis, sources of errors exist in the definition of the reference points and lines, in the tracing procedure, and in the measurement of the distances and their changes. For the assessment of the total method error (ME), all head films were analyzed twice. The Dahlberg formula[6] was used in the ME calculations:

$$ME = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between 2 measurements of a pair and n is the number of double measurements.

The lowest ME (0.37 mm) for distance measurements was found for the distance A (basal length of the skull) and the highest (1.24 mm) for the distance E (dentoalveolar height of the maxilla). The MEs for the changes of the

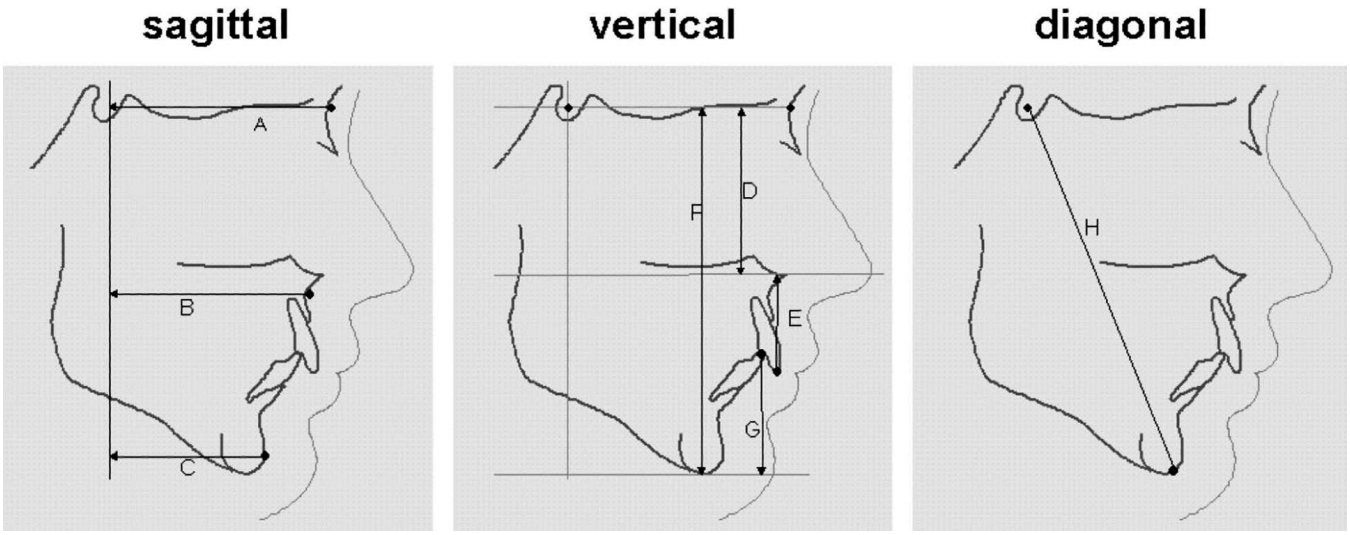

FIGURE 4. Examined cephalometric distances: (A) basal length of the skull, (B) basal length of the maxilla, (C) basal length of the mandible, (D) basal height of the maxilla, (E) dentoalveolar height of the maxilla, (F) basal height of the mandible, (G) dentoalveolar height of the mandible, and (H) diagonal length of the skull.

TABLE 1. Method Error Calculations of Eight Cephalometric Distances

Variables	Method Error	
	Distances (mm)	Changes of Distances (mm)
A: basal length of the skull	0.37	0.31
B: basal length of the maxilla	0.66	0.52
C: basal length of the mandible	0.85	0.52
D: basal height of the maxilla	0.73	0.33
E: dentoalveolar height of the maxilla	1.24	0.46
F: basal height of the mandible	0.50	0.41
G: dentoalveolar height of the mandible	0.98	0.52
H: diagonal length of the skull	0.40	0.38

cephalometric distances varied between 0.31 and 0.52 mm (Table 1).

RESULTS

Period R-IJ (1 year before R-J) to R-J

All results of this period are shown in Figure 5

Sagittal changes. (A) Thirty-two percent of the subjects showed growth changes in the basal length of the skull, (B) 34% in the basal length of the maxilla, and (C) 25% in the basal length of the mandible. Maximum sagittal growth changes were found for the basal length of the mandible with 3.25 mm.

Vertical changes. (D) Five percent of the subjects showed basal growth changes in the maxilla and (F) 13% in the mandible. (E) Nine percent of the subjects showed dentoalveolar growth changes in the maxilla and (G) 16% in the mandible. Maximum dentoalveolar growth changes in the maxilla were 1 mm and in the mandible 2.75 mm (Figure 7).

Diagonal changes. (H) Sixty-four percent of the subjects showed diagonal basal growth changes of the skull. The maximum diagonal growth change was 2.75 mm.

Total changes. The mean value of the maximum of all variable changes was 2 mm. Eighty-six percent of the subjects revealed growth changes of less than 1 mm.

Period R-J to 2 years after R-J

All results of this period are shown in Figure 6

Sagittal changes. (A) Forty-nine percent of the subjects showed growth changes in the basal length of the skull, (B) 25% in the basal length of the maxilla, and (C) 33% in the basal length of the mandible. Maximum sagittal growth changes were found for the basal length of the mandible with 2.5 mm.

Vertical changes. (D) Eight percent of the subjects showed basal growth changes in the maxilla, (F) 19% in the mandible, (E) 20% of the subjects showed dentoalveolar growth changes in the maxilla, and (G) 10% in the mandible. Maximum dentoalveolar growth changes in the maxilla were 1.75 mm, and in the mandible they were 1.25 mm (Figure 7).

Diagonal changes. (H) Seventy-seven percent of the subjects showed diagonal basal growth changes of the skull. The maximum diagonal growth change was 2.75 mm.

Total changes. The mean value of the maximum of all variable changes was 1.6 mm. Eighty-one percent of the subjects revealed growth changes of less than 1 mm.

DISCUSSION

It is a generally accepted fact that the occurrence of a particular handwrist stage is not related to chronological

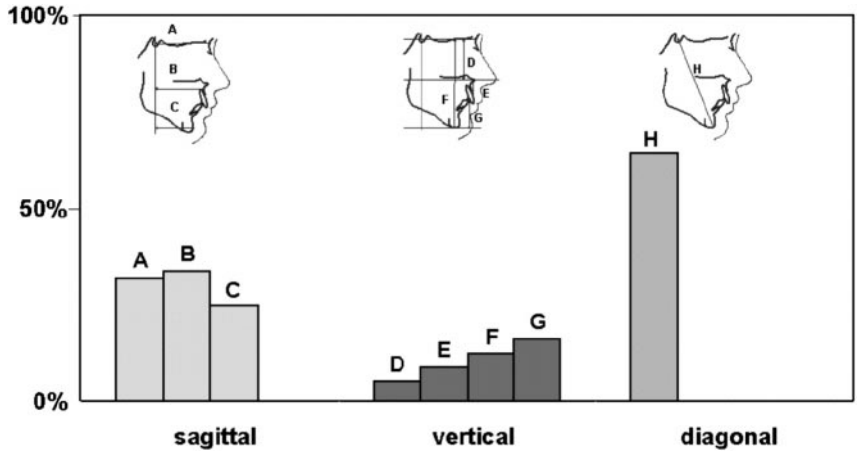

FIGURE 5. Percentage of subjects, who showed growth changes for the variables A to H larger than their respective method errors during the 1-year period R-IJ to R-J.

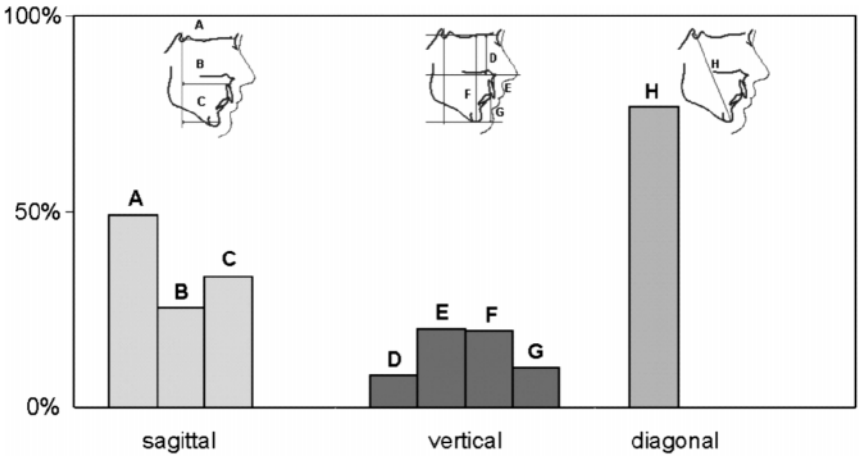

FIGURE 6. Percentage of subjects, who showed growth changes for the variables (A) to (H) larger than their respective method errors during the period R-J to 2 years thereafter.

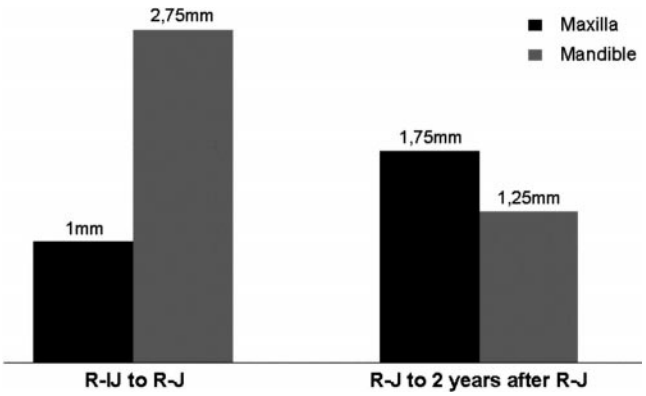

FIGURE 7. Maximum vertical dentoalveolar growth changes in the maxilla and the mandible during the periods R-IJ to R-J and R-J to 2 years after R-J, respectively.

age.[3,7–12] (This was also verified in this study.) Thus, the age distribution of the 56 subjects reaching R-J ranged between 14 and 21 years (Figure 3). Moreover, the handwrist stage R-J occurred earlier in female subjects than in male subjects. Therefore, chronological age cannot be used for the assessment of facial growth termination.

A differentiation between the handwrist stages R-IJ and R-J was not always easy. The difficulty was reduced by comparing the handwrist roentgenograms taken at yearly intervals and by conferring the analyses of the 2 independent examiners. Nevertheless, in some cases it was rather unclear whether radius-union was completed (R-J) or not (R-IJ). In case of uncertainty, the stage was assigned as R-IJ. Thus, it was assured that possible growth changes after R-J in fact took place at this stage and not in R-IJ.

The ME of single-distance measurements varied from 0.37 to 1.24 mm. The lowest ME was found for the basal

length of the skull (A/ME: 0.37 mm) and for the diagonal length of the skull (E/ME: 0.4 mm). This was because these cephalometric distances were related to fixed anatomic structures. When, on the other hand, assessing the basal length of the maxilla (B/ME: 0.66 mm) and of the mandible (C/ME: 0.85 mm) as well as the dentoalreolar height of the maxilla (E/ME: 1.24 mm) and the dentoalveolar height of the mandible (G/ME: 0.98 mm), measurements were performed with the help of constructed lines. When using a constructed line at a length of 100 mm, an inaccuracy in angulation of $\pm 0.5^\circ$ results in a deviation of the measured distance of 1.7 mm [2 (sin $0.5^\circ \times 100$ mm)].

In this study, only growth changes larger than the variable ME were considered. Comparing the 2 periods (R-IJ to R-J and R-J to 2 years after), the frequency of the measured growth changes before and after R-J were, on average, almost equal. However, as expected, the maximum growth change of a particular distance was lower after the occurrence of R-J than before.

Growth changes of less than 1 mm occurred in 86% of the subjects 1 year before R-J and in 81% of the subjects after R-J. Thus, the possibility of a large extent of significant growth persisting after R-J is rather small. In the fields of dentofacial orthopedics and orthognathic surgery, the clinical consequences would be very minor because growth changes after R-J of less than 1 mm are of minor importance. Thus, it can be deduced that the handwrist stage R-J in the average subject is a reliable indicator for ''completed'' facial growth. However, it should be remembered that single individuals may exhibit growth changes up to 2.5 mm.

On the other hand, in the field of tooth implantology it is important to forecast even small vertical dentoalveolar growth changes. Placing a tooth implant before vertical dentoalveolar growth has terminated can lead to a vertical step between the implant and the natural neighboring teeth because of implant ankylosis. Because dentoalveolar growth changes after R-J of up to 1.75 mm in the mandibular incisor region (ME of changes: 0.52 mm) and of up to 1.25 mm in the maxillary incisor region (ME of changes: 0.46 mm) occurred in individual cases, vertical steps of these amounts can cause major esthetic problems. To minimize the risk of an infraocclusion when an early implant is required, an exchangeable temporary supraconstruction could be an appropriate compromise.

CONCLUSIONS

In conclusion, the results of this study revealed that after the occurrence of the handwrist stage R-J, most subjects (81%) revealed growth changes of less than 1 mm. In the fields of dentofacial orthopedics and orthognathic surgery, this amount of growth is of minor clinical importance. However, in the field of tooth implantology, dentoalveolar growth of down to 0.5 mm after the insertion of an implant can cause esthetic and functional problems. Because some individuals revealed growth changes of up to 1.75 mm in the mandibular incisor region and up to 1.25 mm in the maxillary incisor region, it is recommended to wait some years after the occurrence of R-J before placing a tooth implant.

REFERENCES

1. Johanson G, Palmqvist S, Svenson B. Effects of early placement of a single tooth implant: a case report. *Clin Oral Implants Res.* 1994;5:40–51.
2. Thilander B, Ödman J, Jernt T. Single implants in the upper incisor region and their relationship to the adjacent teeth. *Clin Oral Implants Res.* 1999;10:346–355.
3. Greulich W, Pyle S. *Radiographic Atlas of Skeletal Development of the Hand and Wrist.* 2nd ed. Stanford, Calif: Stanford University Press; 1959:1–256.
4. Björk A. Variations in the growth pattern of the human mandible: longitudinal radiographic study by the implant method. *J Dent Res.* 1963;42:400–411.
5. Hägg U, Taranger J. Skeletal stages of the hand and wrist as indicators of the pubertal growth spurt. *Acta Odontol Scand.* 1980;38:187–200.
6. Dahlberg G. *Statistical Methods for Medical and Biological Students.* New York, NY: Interscience Publications; 1940:1–140.
7. Behrents RG. *Growth in the Aging Craniofacial Skeleton. Monograph 17, Craniofacial Growth Series.* Ann Arbor, Mich: Center for Human Growth and Development, The University of Michigan; 1985:1–145.
8. Kaminek M. *Kieferorthopädische Therapie mit festsitzenden Apparaturen.* Leipzig, Germany: Johann Ambrosius Barth; 1980:1–168.
9. Taranger J, Hägg U. The timing and duration of adolescent growth. *Acta Odontol Scand.* 1980;38:57–67.
10. Israel H. Age factor and the pattern of change in craniofacial structures. *Am J Phys Anthhropol.* 1973;39:111–128.
11. Johnson LC. Kinetics of skeletal remodeling. In: *Structural Organisation of the Skeleton: A Symposium.* New York, NY: The National Foundation; 1966.
12. Hrdlicka A. Growth during adult life. *Proc Am Philos Soc.* 1936; 76:847–897.