

Rate of infraposition of reimplanted ankylosed incisors related to age and growth in children and adolescents

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Abstract – In growing individuals, infraposition of a reimplanted, ankylosed tooth may disrupt normal alveolar development and compromise prosthetic treatment. The aims of this study were to analyze the rate of infraposition of ankylosed incisors in growing subjects and to provide guidelines for the timing of extraction. The subjects comprised 30 boys and 12 girls, selected consecutively from patients on annual post-trauma follow-up, and observed for periods ranging from 1 to 10 years. Only patients with one replanted ankylosed maxillary central incisor were included, the homologous teeth with healthy periodontal ligaments serving as controls. Growth intensity was evaluated from analyses of annual body height measurements. The following four periods were established: before the growth spurt, from initial to maximal growth spurt, from maximal growth spurt to the end and after the growth spurt. In 11 patients, cephalograms were taken at diagnosis and at extraction. Progression of infraposition varied individually. Diagnosis before the age of 10 or before the growth spurt was associated with very high risk of severe infraposition. In these cases the ankylosed tooth should be removed within 2–3 years. If ankylosis develops during the growth spurt, the tooth should be monitored regularly, but no intervention is indicated provided the adjacent teeth do not tilt and infraposition is minor or stable. Annual body height measurements, indicating the intensity of skeletal growth, are an aid to assessment. Cephalometric radiographs are important for evaluating the direction of growth of the jaws since there is a difference between horizontal and vertical growers.

Reimplantation of avulsed teeth is frequently complicated by dentoalveolar ankylosis (1, 2). The root of the reimplanted tooth is gradually resorbed and replaced by bone (3). To date, there is no satisfactory therapy for this condition. The ankylosed tooth can be retained until the crown falls off, i.e. when most of the root has been replaced by bone. In children and adolescents, however, ankylosis is often associated with increasing infraposition of the tooth, retarded growth of the alveolar bone and tilting of adjacent

teeth (4, 5). To avoid such complications, an ankylosed tooth should be removed before the changes become so pronounced that they compromise prosthetic treatment. A method for removing such a tooth has been described earlier (4, 6). Although the findings warrant the conclusion that in growing individuals ankylosed teeth should be removed by this method, to date there are no guidelines available as to the appropriate timing of the treatment. Earlier studies have established a relationship between

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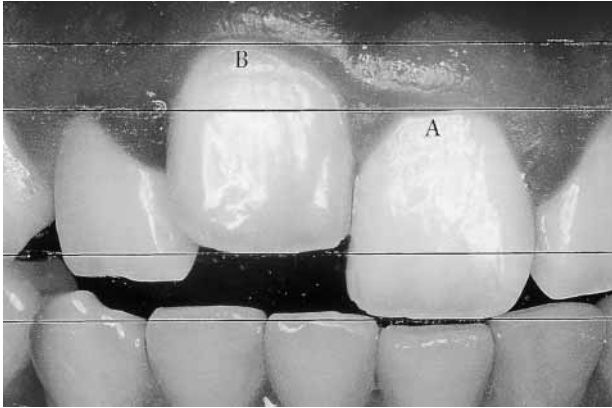


Fig. 1. Measurement of infraposition. Infraposition of the ankylosed tooth was measured in the cervical margin region to the nearest 0.1 mm. Point A of the cervical/marginal line, perpendicular to the long axis of the crown of the homologous tooth, was transferred to the tooth in infraposition. The distance from this point to the corresponding point of the tooth in infraposition (B) was measured.

infraposition of reimplanted, ankylosed teeth and the age of the patient at the time of injury (5, 7, 8). The infraposition is due to local arrest of growth of the dentoalveolar bone and the severity depends on the stage of development of both the occlusion and facial growth (9). Thus monitoring facial growth is an important aspect of evaluation of the prognosis of an ankylosed tooth.

The aims of the present study were twofold: firstly, to analyze the relationship between the rate of infraposition and age at the time of injury, growth intensity and facial growth, and, secondly, to establish guidelines for the appropriate timing of removal of the ankylosed tooth.

Subjects and methods

The subjects comprised 30 boys and 12 girls, selected consecutively from patients under routine post-trauma follow-up at the Department of Pediatric Dentistry, Eastmaninstitutet in Stockholm. Only patients with one replanted ankylosed maxillary central



Fig. 2. A. An 8-year-old girl with an ankylosed maxillary left incisor. The open bite is due to a sucking habit. B. Three years later, the open bite is reduced. The left lateral incisor has tilted mesially due to eruption of the adjacent canine. The ankylosed incisor is in severe infraposition, index score 3 (Fig. 3).

incisor were included. The age at time of trauma varied from 6.5 to 15 years (mean 10.1 years, SD 2.1). The subjects were stratified according to age: Group I <10 years (n=24), Group II 10–12 years (n=10), and Group III ≥12 years (n=8). When ankylosis was diagnosed, on the basis of percussion and mobility tests and/or radiography, the occlusion was documented using plaster casts and intraoral photography, and body height was registered. Intraoral radiographs, photographs and body height measurements were repeated every 6 months until the tooth was

Table 1. Development of infraposition in relation to age group at time of injury (I <10 years, II 10–12 years and III ≥12 years)

Age groups in years	Infraposition in mm*			Index of infraposition severity (0–4)**					
	No. of subjects	Mean	SD	No. of subjects	Index 0	Index 1	Index 2	Index 3	Index 4
I 6.5–9.9	20	3.4	1.5	24	0	4	4	12	4
II 10.0–11.9	9	2.6	0.7	10	0	5	1	4	0
III 12.0–15.6	8	1.4	1.2	8	1	4	0	3	0
Total	37	2.8	1.5	42	1	13	5	19	4

* Measured in the cervical margin region (Fig. 1).

** Index (Fig. 3).

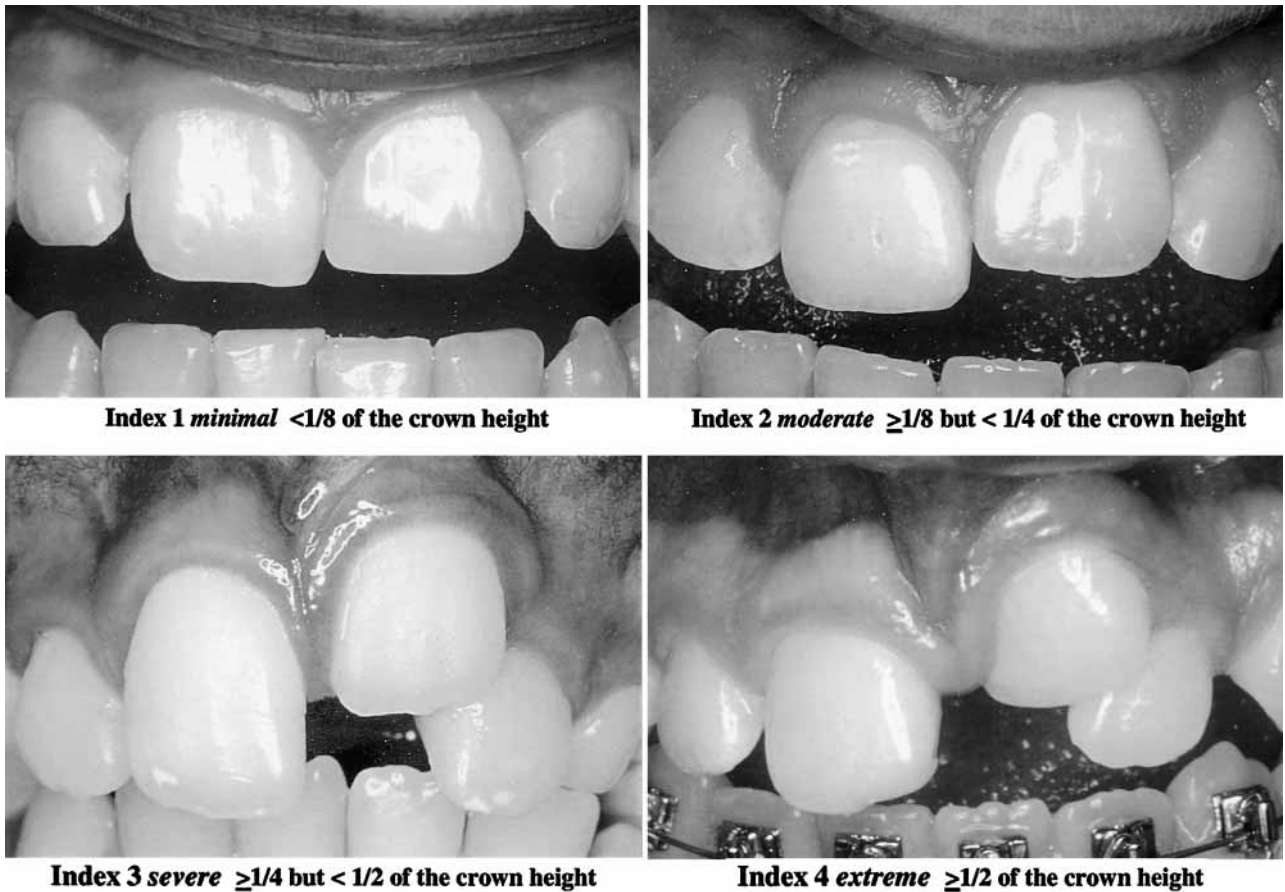


Fig. 3. Index for infraposition of ankylosed incisors. The homologous maxillary incisors with healthy periodontal ligaments are used as reference teeth. A. Index 1. Minimal, <math><1/8</math> of the crown height. B. Index 2. Moderate, $\geq 1/8$ but $< 1/4$ of the crown height. C. Index 3. Severe, $\geq 1/4$ but $< 1/2$ of the crown height. D. Index 4. Extreme, $\geq 1/2$ of the crown height.

extracted. Impressions for plaster casts were taken annually. In 11 subjects, cephalometric radiographs were taken at diagnosis and at extraction. The follow-up periods varied from 1 to 10 years and lasted on average 3.5 years (SD 1.8, median 3.1 years).

Measurements

On the plaster casts, progression of infraposition was measured to the nearest 0.01 mm, using digital calipers. The homologous teeth with healthy periodontal

Table 2. Infraposition in relation to growth intensity during the observation period after injury

Growth intensity*	Infraposition in mm*			Index of infraposition severity (0–4)**					
	No. of subjects	Mean	SD	No. of subjects	Index 0	Index 1	Index 2	Index 3	Index 4
Period									
I	5	3.6	1.8	7	0	2	1	3	1
II	24	2.8	1.5	27	0	7	2	15	3
III	6	2.5	1.4	6	1	2	0	3	0
IV	2	1.0	1.4	2	0	2	0	0	0
Total	37			42	1	13	3	21	4

* (I) before the growth spurt, (II) from initial to maximal growth spurt, (III) from maximal growth spurt to the end and (IV) after the growth spurt.

** Measured in the cervical margin region (Fig. 1).

*** Index (Fig. 3).

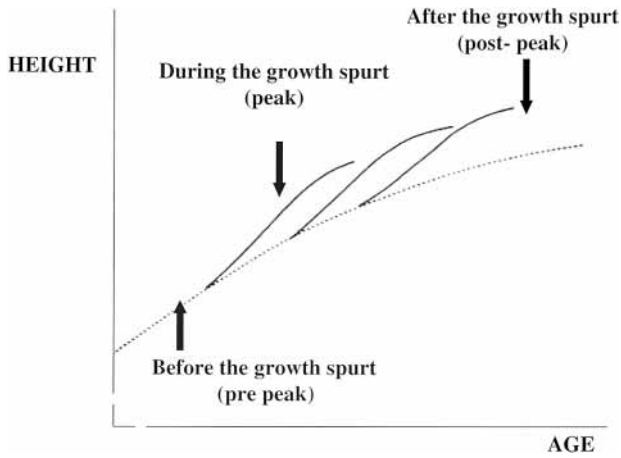


Fig. 4. Growth chart of body height measurements.

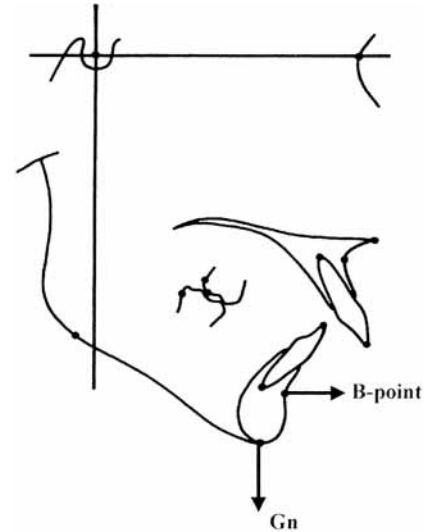


Fig. 5. Reference points used in the cephalometric analysis of the growth direction of the mandible. The B point was used for evaluation of horizontal growth and Gn (Gnathion) for vertical growth.

ligaments served as controls. In many cases, minor crown fractures of both the ankylosed and the homologous teeth had been restored and the incisal area of many of the infrapositioned, ankylosed teeth had been lengthened. To allow inclusion of such cases in the study, the following method of measurement was devised. The homologous unaffected incisor served as a reference tooth. A line was drawn through the most inferior point of the cervical margin (point A) on the

reference crown, perpendicular to the long axis of the crown of the ankylosed tooth. The distance from this line to the most inferior point of the cervical margin on the infrapositioned tooth (point B) was measured (Fig. 1). This measurement corresponded well with

Development of infraposition according to an index 0 to 4 */ in relation to growth intensity and observation time

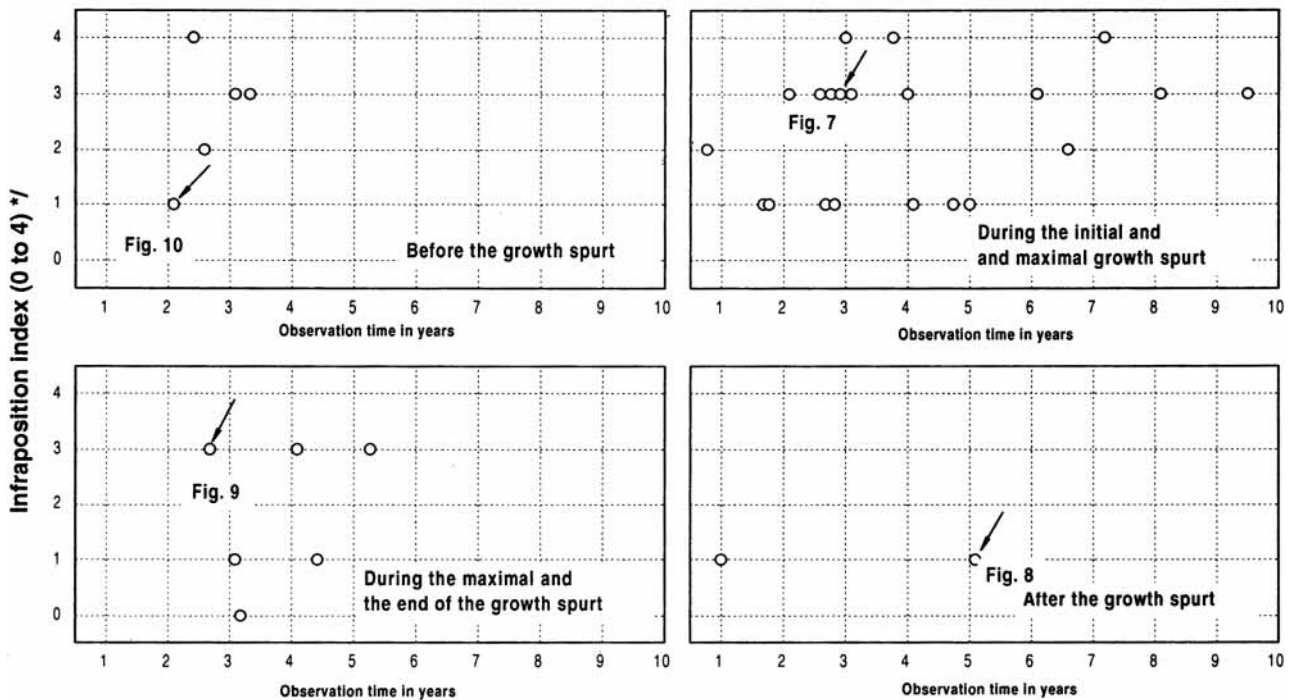


Fig. 6. Relationship between infraposition and growth intensity ($n=42$). Infraposition was evaluated according to the severity index in Fig. 3 and growth intensity, based on annual body height measurements, according to Fig. 4. The cases indicated are presented in Figs. 7–10.

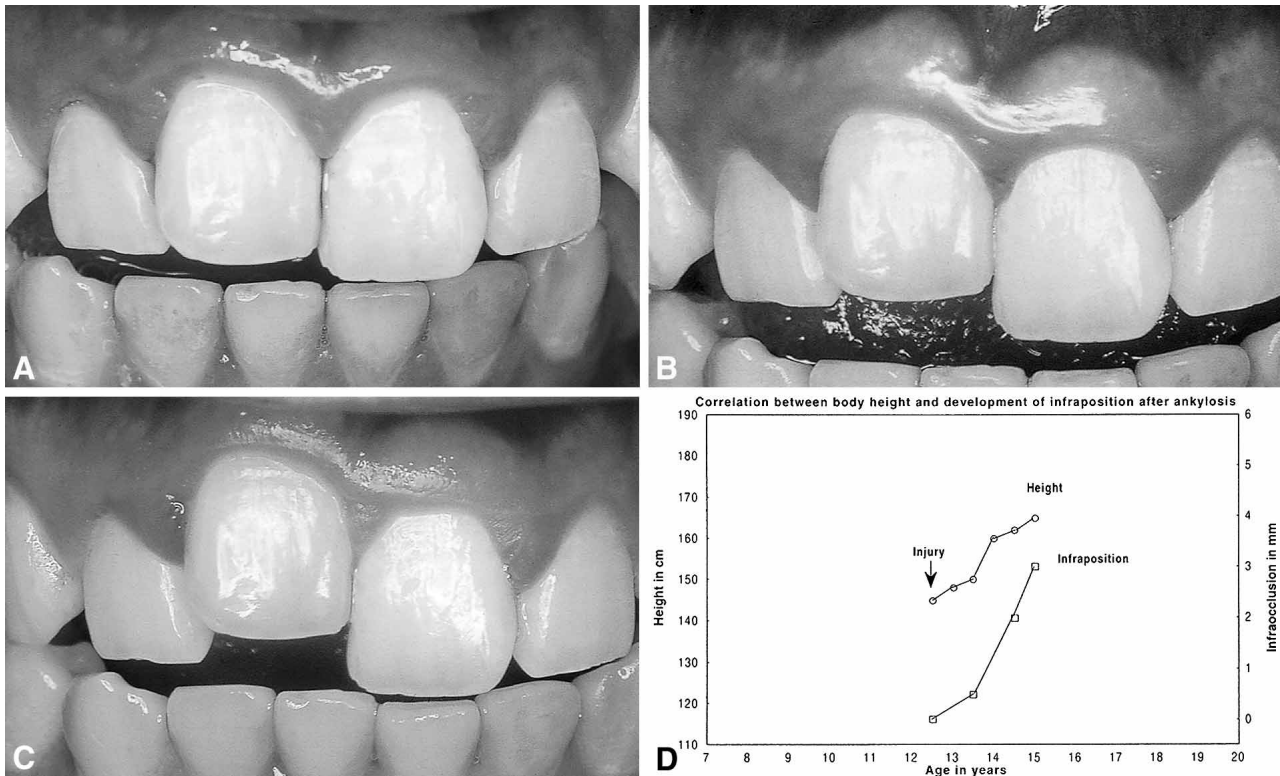


Fig. 7. Relationship between growth intensity and infraposition of an ankylosed central incisor (indicated in Fig. 6). A. The right central incisor was reimplanted in a boy at 12 1/2 years of age. Slight infraposition can be seen after 1 year. B. After 2 years there was a marked increase in infraposition. C. After 3 years, infraposition was severe. D. Annual body height measurements during the observation period showed a pronounced growth spurt, which correlated with the infraposition. Modified from (5).

measurements in the incisal region. Accuracy was assessed in 10 cases in which both the ankylosed and the reference tooth were unaffected by restorations or other disturbing factors. The degree of infraposition was measured as described above at both the incisal edges and at the cervical margins. The average difference was 0.1 mm (SD 0.3 mm).

In five patients, measurement was complicated by sucking habits that had changed the position of the reference tooth and affected the whole alveolar ridge, or by tilting of the reference tooth during the observation period (Fig. 2). To evaluate the progression of infraposition even in these difficult cases, an infraposition severity index was devised. Rating severity of infraposition from minimal to extreme, the index relates infraposition to the crown height of the reference tooth (Fig. 3).

Growth analysis

In Sweden, all children and adolescents undergo regular health assessments at child welfare centers from birth and at school medical centers throughout the school years. Height and weight curves are established. These data were made available for the study and height measurements of the subjects from about

6 years of age and onward were used to evaluate growth intensity.

The annual standing height measurements were plotted on a special chart. The actual growth period during which the patient was observed was assessed using a technique devised by Karlberg et al. 1992 (10) and used in several clinical studies to evaluate growth intensity in young patients (11–13). It was thus possible to assess the timing of the pubertal maximum of standing height, and peak (age at peak \pm 1 year) (Fig. 4).

For evaluation of growth intensity during follow-up of the subjects, four periods were used: before the growth spurt ($n=7$), from initial to maximal growth spurt ($n=27$), from maximal growth spurt to the end ($n=6$) and after the growth spurt ($n=2$).

Analysis of cephalograms

The cephalograms were analyzed with a computer system (14). Thirty-one previously defined reference points (15) were used for schematic illustrations drawn by the computer. The schematic figures were of the same size as the original radiograph, and were used to test the precision of the recordings. The B-point and Gnathion (Gn) were used to describe

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the horizontal and vertical development of the mandible (Fig. 5).

Statistical methods

The chi-square test was used to analyze the variation of infraposition in relation to age and growth intensity ($P < 0.05$). The total error of measuring infraposition with calipers was calculated from double determinations on 10 study casts, randomly selected from the subject material (16). Infraposition was measured at both the incisal edges and the cervical margins. Precision in the incisal area was 0.1 and 0.2 in the gingivocervical region.

The error of measurements on cephalograms, described earlier (15), did not exceed 0.6 mm for any of the measurements.

Results

Infraposition in relation to age (Table 1)

It was possible to measure the degree of infraposition in mm in 37 subjects and to apply the index in all 42. On average, infraposition was most severe in the youngest group (mean 3.4 mm, SD 1.5) and least

severe in the oldest group (1.4 mm, SD 1.4). The difference was significant ($P = 0.002$). In the youngest group, four subjects had a severity index score of 1 and four subjects a score of 2. They were treated by auto-transplantation and thus the follow-up period was very brief. In Group II, subjects aged 10–12 years, the infraposition did not increase as rapidly as in the youngest group. In the oldest group, the rate varied.

Infraposition in relation to growth intensity and observation period (Table 2, Figs. 6–8)

Among the four periods of growth intensity, there were no significant differences in infraposition, measured in mm. Seven subjects had been observed for 2–3 years before their growth spurt: all experienced a rapid increase in infraposition. The two subjects with a severity index of 1 after 2 years were treated by auto-transplantation. During the period from initial to maximal growth spurt, 27 subjects were observed for 1–10 years: there were pronounced variations in the increase of infraposition. In seven subjects (26%) observed for 2–5 years, development of infraposition was minimal, but it was moderate to extreme in the

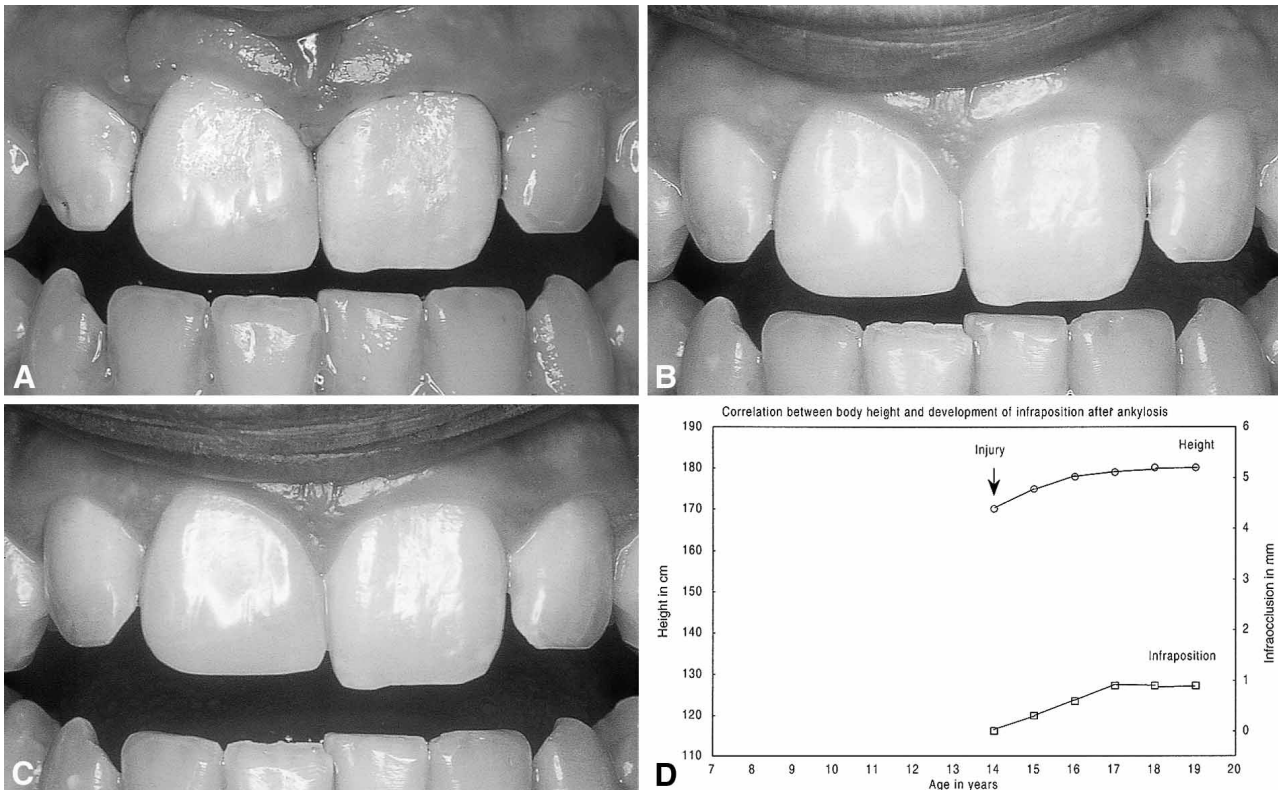


Fig. 8. Relationship between general growth and infraposition of an ankylosed central incisor (indicated in Fig. 6). A. The right central incisor was reimplanted in a boy at 14 years of age. B. Slight infraposition was seen after 1 year. C. At the 4-year control there was only a minimal increase in infraposition. D. Annual body height measurements showed that 2 years after the injury, growth was almost complete. Modified from (5).

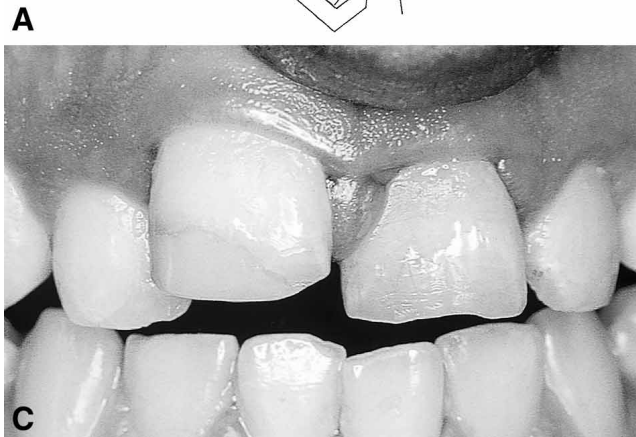
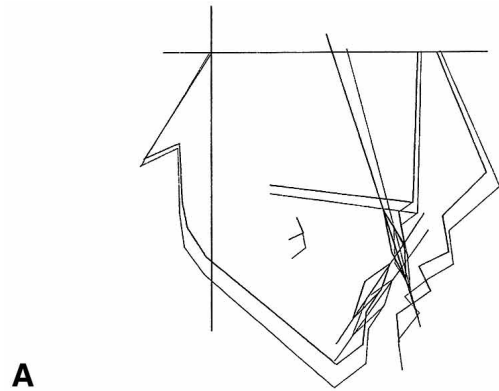


Fig. 9. Ankylosis of the maxillary right incisor was diagnosed in a 14-year-old boy (indicated in Fig. 6). During 2 years of follow-up his body height increased only 6 cm. His face grew in a vertical direction and there was a rapid increase in the infra-position of the ankylosed incisor. A. Schematic illustration of the cephalometric changes of the face from age 14.2 to 15.4 years, showing vertical growth of the mandible. B. At the age of 14 years there was minimal infra-position of the maxillary right incisor. His body height was 170 cm. C. At the age of 16 years. The infra-position of the ankylosed incisor had increased markedly. Note incisal attrition of the maxillary left central incisor. The maxillary right lateral incisor has tilted mesially. His body height was 176 cm.

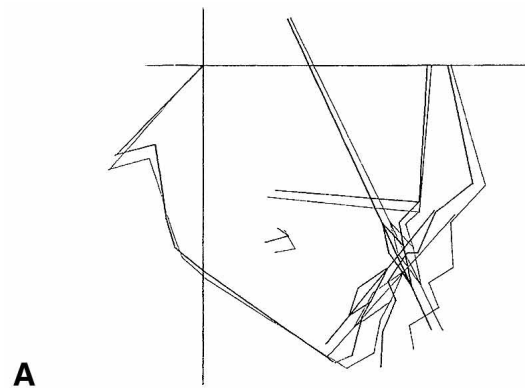


Fig. 10. In an 8-year-old boy (indicated in Fig. 6) the maxillary left incisor was reimplanted. During follow-up over 1.3 years his body height increased 8 cm and only minor infra-position occurred. His face grew in a horizontal direction. A. Schematic illustration of the cephalometric changes of the face from age 8.6 to 9.8 years, showing horizontal growth of the mandible. B. At the age of 8.2 years, 3 months after trauma. Body height 129.5 cm. C. At the age of 9.6 years. Minimal infra-position. Body height 137.5 cm.

remaining 20 subjects (74%). During the next growth period, six subjects were observed for 3–5 years. Variation was also marked in this group: one subject experienced no infraposition, whereas there was minimal development in two subjects and severe development in three. The two subjects observed after the growth spurt exhibited only minimal infraposition.

Infraposition in relation to horizontal and vertical changes of the mandible

All subjects except one exhibited greater vertical than horizontal development of the mandible. One subject experienced vertical development of 9 mm and horizontal development of 2 mm in a 1.3-year period, indicating extreme vertical growth of the mandible. During this period, the infraposition of the ankylosed tooth increased to 3.0 mm (Fig. 9), while his body height increased less than 6 cm. In another subject, the vertical development of the mandible during a 1.3-year period was 4.2 mm and horizontal development 4.9 mm, indicating horizontal growth of the mandible. The infraposition during this period was 1 mm, while his body height increased 8 cm, indicating intensive growth (Fig. 10).

Discussion

It is generally recommended that in growing individuals an ankylosed tooth should be removed before the onset of further complications such as tilting of the adjacent teeth and the development of a defect in the alveolar ridge (4, 5). However, in young patients there are advantages in retaining the tooth for as long as possible as a space maintainer. Thus, the timing of extraction is very important.

Clinically, it has been found that there is severe damage to the alveolar process and the dentition if the infraposition has progressed to half the crown height of the neighbouring teeth. In this material, 28 of the 42 teeth had reached an index score of 2 or more. They should have been extracted earlier. Decoronation is recommended when the severity of infraposition corresponds to an index score of 2.

The present study included only patients with one severely injured tooth, whereas most cases of trauma involve multiple teeth. In many patients, evaluation is further complicated by malocclusion or functional habits such as thumb sucking, which mask the development of infraposition. The study showed that infraposition could be measured at the cervical margin of the tooth, rather than at the incisal edge. A further aid to evaluation was the application of an index of severity of infraposition for reference during follow-up. These measures might facilitate clinical follow-up in future studies.

The progression of infraposition varied individually. When ankylosis was diagnosed before the age of 10, there was a particularly high risk of severe infraposition. After 2 years, most of the ankylosed teeth in this age group had developed pronounced infraposition, with scores on the severity index ≤ 2 . Furthermore, for children in this age group, the condition is likely to be exacerbated during puberty by rapid facial growth. In seven subjects aged 8–9 years, cephalograms showed the eruption pattern of the incisor with the healthy periodontal ligament to be more vertical than horizontal. This vertical development of the dentition might explain the rapid rate of infraposition.

In the subjects over 10 years of age at diagnosis, the rate of infraposition showed greater variation. Twenty-seven subjects were followed from initial to maximal growth spurt: of these, 20 (74%) developed severity index scores of 2 or more. The rate varied individually from less than 1 year to 10 years. In two patients, carefully observed with cephalograms, the increase in infraposition was slow, due to a horizontal growth pattern, whereas in two subjects, a rapid increase was associated with a vertical growth pattern.

In the oldest group, the increase in infraposition was minimal, particularly in subjects observed after the peak of growth.

In conclusion, progression of infraposition varies individually. There is a high risk of severe infraposition when ankylosis is diagnosed before the age of 10 or before the growth spurt. In these cases the ankylosed tooth should be removed within 2–3 years. If ankylosis develops during the growth spurt, the tooth should be monitored regularly: no active treatment is necessary as long as the adjacent teeth do not tilt and the extent of infraposition is minor or stable. Annual body height measurements, indicating the skeletal growth intensity, are an aid to assessment. Cephalometric radiographs are important for evaluating the growth direction of the jaws.

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