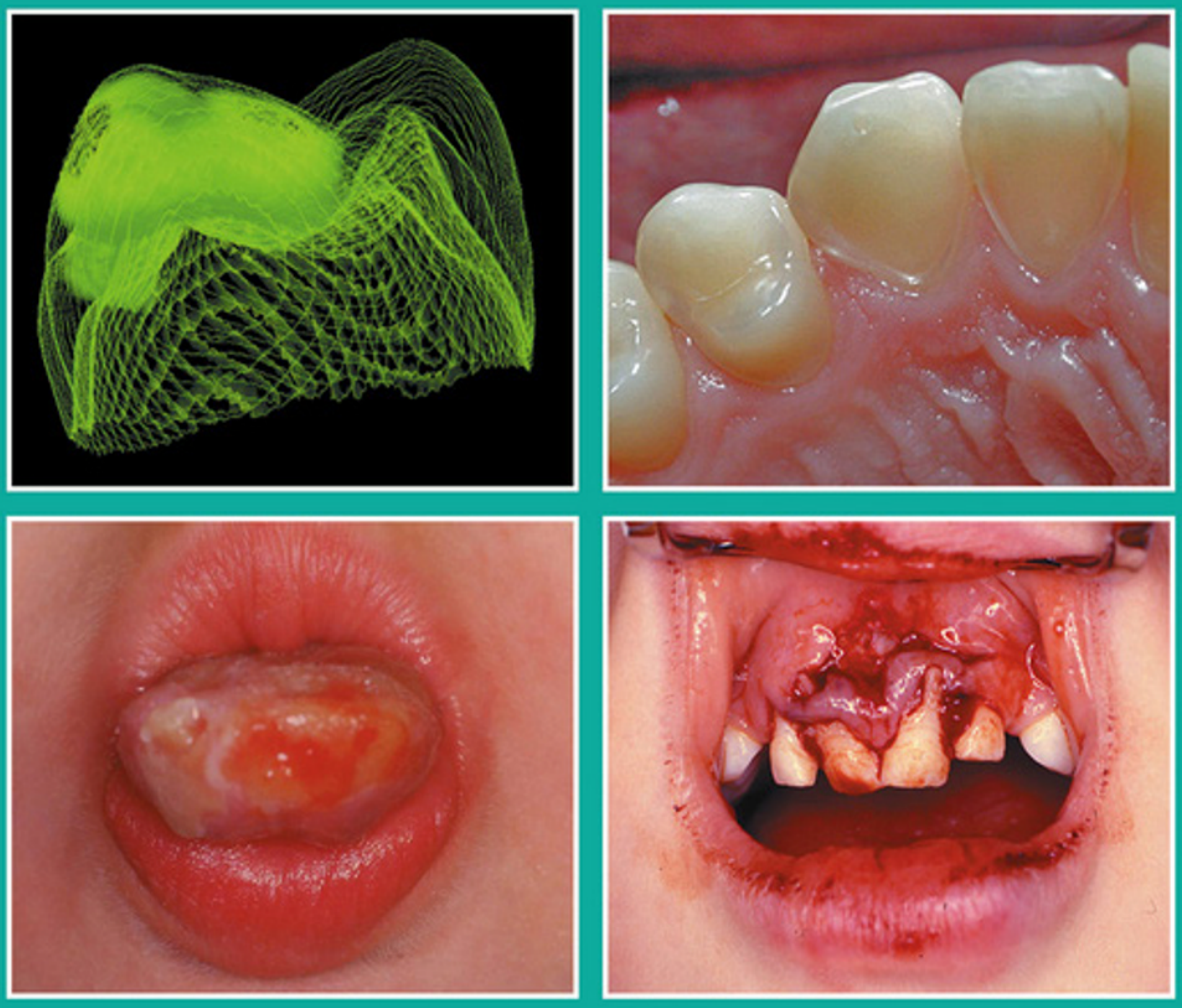
THIRD EDITION

Pediatric Dentistry

A Clinical Approach

EDITED BY
GÖRAN KOCH • SVEN POULSEN • IVAR ESPELID • DORTE HAUBEK



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Pediatric Dentistry

To Anna-Lena Hallonsten

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Registered Office
John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Offices
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
1606 Golden Aspen Drive, Suites 103 and 104, Ames, Iowa 50010, USA

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Library of Congress Cataloging-in-Publication Data

Names: Koch, Göran, editor. | Poulsen, Sven, editor. | Espelid, Ivar, 1951– editor. | Haubek, Dorte, editor.
Title: Pediatric dentistry : a clinical approach / edited by Göran Koch, Sven Poulsen, Ivar Espelid, Dorte Haubek.
Other titles: Pediatric dentistry (Koch)
Description: Third edition. | Chichester, West Sussex, UK ; Ames, Iowa : John Wiley & Sons Inc., 2017. |
Includes bibliographical references and index.
Identifiers: LCCN 2016023611| ISBN 9781118913499 (cloth) | ISBN 9781118913635 (Adobe PDF) |
ISBN 9781118913642 (ePub)
Subjects: | MESH: Pediatric Dentistry | Dental Care for Children–methods
Classification: LCC RK63 | NLM WU 480 | DDC 617.0083–dc23
LC record available at https://lccn.loc.gov/2016023611

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: top left - courtesy of Tobias Fagrell

Set in 9.5/12pt Minion Pro by SPi Global, Pondicherry, India

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Preface to the Second Edition

Pediatric Dentistry: A Clinical Approach was first published in 2001 with the aim of providing a comprehensive review of pediatric dentistry with special emphasis on evidence-based oral health care for the child and adolescent. In this second edition of this textbook, we have built upon the earlier volume by thoroughly updating the text, as well as replacing chapters and adding new ones as necessary.

The sciences behind pediatric dentistry, as well as strategies of clinical approaches, have developed rapidly over the past few decades. These advances have been reflected in the considerable work undertaken by the many clinicians and scientists who have contributed to this textbook.

Pediatric dentistry aims to improve the oral health of children and adolescents through health promotion, prevention and systematic and comprehensive oral care. It is concerned with the expression of, and interventions against, the major dental diseases as well as with a number of dental and oral conditions specific to childhood and adolescence. These comprise all aspects of dental and occlusal developmental disturbances, traumatic injuries to the teeth, periodontal conditions, oral pathological conditions, pain control, dental need and treatment of handicapped and medically compromised children. Pediatric dentistry applies principles from other clinical disciplines, medical and behavioral sciences and adapts them to the special needs of the growing and developing individual from birth through infancy and childhood to adolescent late teens.

Our objective is that this book will serve not only as a basis for undergraduate training in pediatric dentistry but will also be of relevance to postgraduate students and dental practitioners who want to increase their knowledge and skills in order to deliver up-to-date pediatric dental care.

Göran Koch and Sven Poulsen
Editors

Preface to the Third Edition

This third edition of *Pediatric Dentistry: A Clinical Approach* follows up on the two previous editions published in 2001 and 2009. It represents a considerable effort from a large group of highly experienced colleagues within the field of pediatric dentistry and related disciplines.

The present edition is expanded to include new chapters on recently developed essential subjects within the field of pediatric dentistry, i.e., genetics in pediatric dentistry, child abuse and neglected children, and ethics in pediatric dentistry. The previous chapter on pedodontic endodontics has been split into two chapters – one on primary teeth and one on young permanent teeth. Most of the chapters have been thoroughly revised and several new illustrations are included. The concept of evidence-based care has been given more attention.

It is our hope that this edition will also serve the objective stated for the previous editions.

Göran Koch, Sven Poulsen, Ivar Espelid, Dorte Haubek
Editors

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/koch/pediatric_dentistry

The website includes:

- Interactive multiple choice questions

CHAPTER 1

Pediatric Oral Health and Pediatric Dentistry: The Perspectives

Sven Poulsen, Göran Koch, Ivar Espelid, and Dorte Haubek

Children are special

Pediatric dentistry is defined as "the practice, and teaching of and research in comprehensive preventative and therapeutic oral health care of children from birth through adolescence" [1]. The central element in this definition—and that which distinguish it from other clinical fields in dentistry—is *children*, further qualified as individuals *from birth through adolescence.*

In this book, we adopt the United Nations (UN) Convention definition of a child as "every human being below the age of 18 years unless, under the law applicable to the child, majority is attained earlier" [2]. That children are different from adults has not always been recognized. Previously, children were depicted as "small adults" (Figure 1.1), but recent research reflect that health services for children need to consider that children are growing and developing individuals who are dependent on an adult caregiver. This requires oral health professionals with special competencies, so-called *child competency* (Box 1.1).

Today, a satisfactory definition of health needs to include somatic as well as non-somatic dimensions. Consequently, oral health should include not only sound teeth and surrounding oral structures, but also absence of dental fear and anxiety as a prerequisite for good oral health during later periods of life. This is consistent with recent concepts of oral health as a determinant factor for quality of life [3].

Community responsibility: the population perspective

By the end of the nineteenth century, a number of large epidemiologic studies on caries in children carried out in the Nordic countries showed that more than 80% of the children had carious teeth and that only a few per thousand had received any dental treatment. These studies were the major reason why children's dental health was conceived as a problem, requiring public intervention in terms of organized public dental health services for children.

It is interesting to note that the arguments for better oral services for children in the Nordic countries were based on epidemiologic data. Using epidemiologic information to document a health problem is to adopt a population approach rather than an individual clinical approach. This illustrates that in the Nordic countries, organized child dental care has for more than a century been considered a collective responsibility rather than the responsibility of the individual on their own. Formal legislation and regulations concerning child dental care were passed by the parliaments of all Nordic countries several decades ago and dental services, including outreach preventive services, have been developed to serve the whole child population. The epidemiologic starting point of child dental care in the Nordic countries also explains why the child dental services in these countries have collected valuable epidemiologic information to continually monitor the level of disease in the target groups.

The clinical perspective

Pediatric dentistry encompasses all aspects of oral health care for children and adolescents. It is based on basic knowledge from various odontological, medical, and behavioral sciences that are applied to the unique situation of the developing child and young person. Prevention is still the cornerstone of pediatric dentistry. Starting prevention in early childhood makes it possible to maintain sound erupting teeth and keep oral structures healthy. Pediatric dentistry also implies early diagnosis and treatment of the multitude of oral diseases and conditions found in the child's and the adolescent's oral cavity, including caries, periodontal diseases, mineralization disturbances, dental erosion, disturbances in tooth development and tooth eruption, and traumatic injuries in otherwise healthy individuals as well as oral health care of sick and disabled children. The realm of pediatric dentistry is constantly expanding, and now includes such areas as early identification of children suspected to suffer from syndromes, and of children suspected to suffer from child maltreatment. Ethical considerations superimpose all these areas.

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Figure 1.1 Until the eighteenth century, children were considered to be small adults (sort of "miniature grown-ups") as shown in this painting from a medieval church. Note the similarity of the facial features of the adults and the children. Source: Epitaph in Norra Sandsjö parish church, Sweden, of Johan Printzensköld and Anna Hård af Segerstad and their five children.

Box 1.1 Professionals should recognize that children are not "small adults" and that special competency (child competency) is needed, when meeting children

Children are different from adults in a number of ways:

- children are individuals in growth and development
  - physical
  - psychological
  - social
  - cognitive
  - emotional
- oral health, including attitudes and behavior relating to oral health, is formed during childhood and adolescence
- children's situation is different from the situation of adults:
  - they are in the care of and dependent on adults
  - they are not able to foresee consequences of their own decisions and behavior.

Child competency is:

- a specific insight into the dental and oral health for the child and adolescent
- an ability to communicate effectively with children, adolescents, and their parents
- a positive professional attitude towards children, adolescents, and their parents.

The quest for evidence-based interventions—preventive, diagnostic or rehabilitative—is urgent in pediatric dentistry as well as in all other fields of dentistry, and recent research has identified the need for more high-quality research in a number of the domains comprising pediatric dentistry [4]. It is important that diagnosis, risk assessment, prevention, treatment, and follow-up of children are based on scientific evidence, when available. Translation of evidence into clinical guidelines will thus help to secure quality of dental care for all children. The burden of dental disease is not equally distributed and it is a goal to diminish the inequality. Health technology assessment (HTA) bodies in many countries have provided useful guidelines about important topics in pediatric dentistry. In Scandinavia, the Swedish Council on Health Technology Assessment (SBU) has produced relevant guidelines for pediatric dentistry.

Education in pediatric dentistry: the perspectives

The undergraduate education and training in pediatric dentistry in the Nordic countries today is well balanced and aims to give the student sufficient knowledge and competence to deliver basic dental care to preschool children, school children, and adolescents. During the last decades the undergraduate curriculum has increased the emphasis on prevention and behavioral and social sciences.

The need for postgraduate courses and training was recognized early. To provide dental care to complicated cases, often with special needs and in a multidisciplinary team, requires specialized knowledge and child competence as obtained in a specialist education in pediatric dentistry. The European Academy of Paediatric Dentistry presented guidelines for a specialist education in pediatric dentistry in 1995 [5]. The education is a 3-year full-time course given at universities and institutes preceded by at least 2 years' practice as a general practitioner. This program has been adopted by most educational centers in Europe during the last decades.

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CHAPTER 2

Growth and Pubertal Development

Anders Juul, Sven Kreiborg, and Katharina M. Main

The evaluation of growth charts and pubertal development in children and adolescents is an important tool for any clinician in the assessment of health status. Optimal thriving and height attainment in accordance with family potential can only be achieved in an environment providing optimal socioeconomic conditions, health care, and psychosocial support. Thus, failure to thrive or to grow may be the first indication of an underlying problem that may need attention. In turn, treatment of children may need to consider the specific growth and developmental windows in order not to disturb this delicate balance.

Measurement of growth in different phases of life

The current concept of prenatal and postnatal growth suggests that there are distinct growth phases, which should be considered separately.

Prenatal growth

Prenatal growth is divided into three trimesters (by convention). The first trimester is characterized by organogenesis and tissue differentiation, whereas the second and third trimesters are characterized by rapid growth and maturation of the fetus. Fetal growth can be assessed by serial ultrasonography in the second and third trimesters. Abdominal circumference, head circumference, and femoral length of the fetus can be determined, and from these parameters fetal weight can be estimated using different algorithms [1]. The fetal weight estimate should be related to normative data. Some reference curves for fetal growth are based on children born prematurely [2], and hence such curves tend to underestimate normal fetal weights from healthy pregnancies. Alternatively, reference curves based on ultrasound studies of normal healthy infants exist [1] and should preferably be used. Based on the changes in fetal weight estimates over time, the fetus can be considered as having a normal fetal growth rate, or alternatively as experiencing intrauterine growth restriction (IUGR) [3]. Children born at term (gestational age 37–42 weeks) are considered mature. Children born before 37 weeks of gestation are premature, and children born after 42 weeks of gestation are postmature. At birth, weight and length can be measured and compared to normative data correcting for gestational age at birth. Based on these comparisons, a newborn child can be classified as either appropriate for gestational age (AGA), small for gestational age (SGA), or large for gestational age (LGA).

IUGR fetuses will often end up being SGA at birth, but not necessarily so. Thus, IUGR infants may end up lighter than their genetic potential but remain within normal ranges (i.e., AGA). Therefore, IUGR and SGA are not synonymous entities, although they are often referred to as such in the literature (Figure 2.1). Height velocity *in utero* is higher than at any time later in life, leading to an average birth length of 50–52 cm and birth weight of 3.5–3.6 kg after 37–42 weeks of gestation. It is therefore not surprising that growth disturbances during this phase may have long-lasting effects on growth and health later in life. Whereas the first trimester is dominated by tissue differentiation and organ formation, the second and especially third trimesters show a rapid gain first in length and then in weight. Fetal and placental endocrinology is highly complex and hormones such as insulin, leptin, placental growth hormone, insulin-like growth factor (IGF)-2, and thyroid hormone are only some of the many growth factors involved in the regulation of fetal growth.

Postnatal growth

Postnatally, height can be determined by measuring length in the supine position in the first 2–3 years of life. After 2–3 years of age standing height can be measured, preferably using a wall-mounted stadiometer. Height is determined without shoes,

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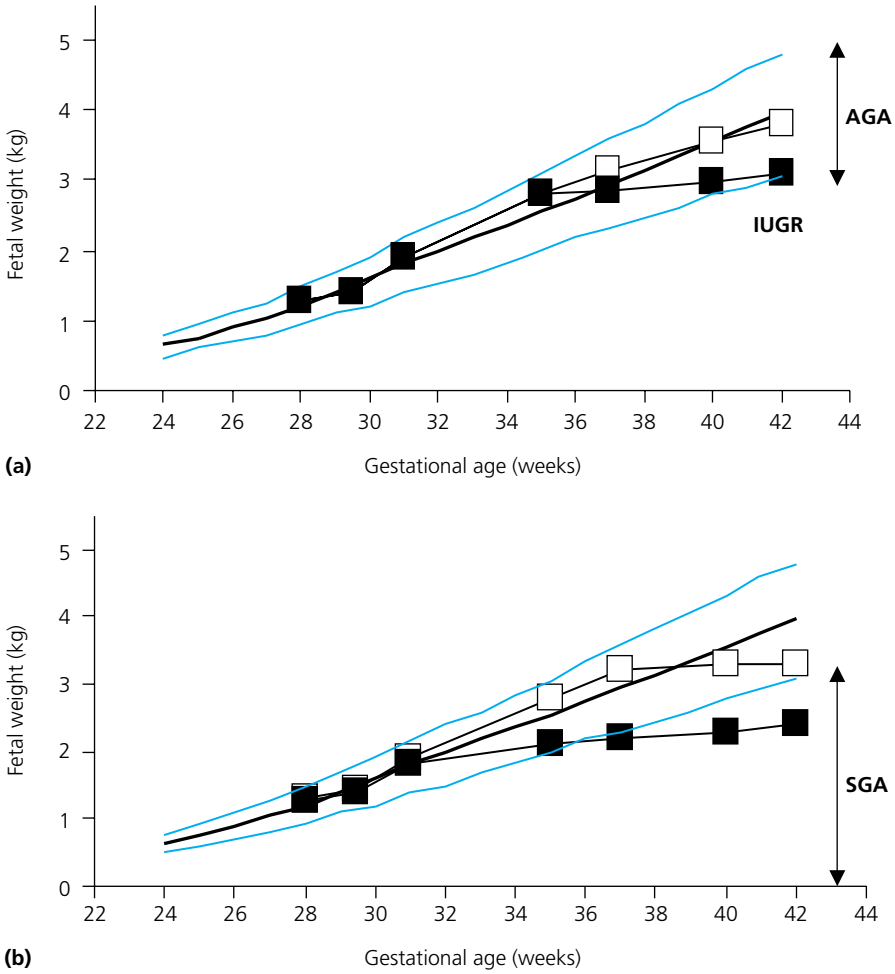


Figure 2.1 Reference ranges for fetal weight according to gestational age during pregnancy denoted by the blue lines (10th, 50th, and 90th percentiles) (8). Panel (a) shows examples of children with normal birth weights at term; a normally growing fetus ending with a birth weight which is appropriate for gestational age (AGA) and (■) a fetus with third trimester intrauterine growth restriction (IUGR) ending with a birth weight below the genetic potential but within normal limits (AGA). Panel (b) shows examples of fetuses with intrauterine growth retardation (IUGR) ending up AGA (□) or SGA (■).

shoulders towards the wall, arms hanging down, and the face straight forward (Figure 2.2). The eyes should be horizontally aligned with the external ear opening. The means of three measurements are recorded. The stadiometer should be calibrated on a daily basis.

Importantly, the body proportions (such as head circumference, facial appearance, sitting height, and arm span) may be helpful in the differential diagnosis of growth disorders (Figure 2.1). This can simply be done by assessing the sitting height with subsequent calculation of the sitting height to standing height ratio. This enables quantification of whether or not a growth failure is proportional or disproportional (such as in hypochondroplasia). Reference ranges for this ratio exist [4].

Changes in height can be separated into infant, childhood, and pubertal growth phases according to the infancy–childhood–puberty (ICP) model described by Karlberg [5]. The majority of children will follow the distinct growth patterns of these phases.

Infancy

After a brief initial weight loss of up to 10% of the birth weight, growth during the first months postnatally follows to a large extent fetal growth rate during the third trimester with 30 g/day and 3.5 cm/month. After that a rapid decline in growth rate occurs, in both weight and height. However, this period still represents a major growth phase during the lifetime with a three-fold increase in weight over 6 months. Very little is known about the regulatory factors of growth during this period of life, but nutrition and living conditions play a major role. In 2006, the World Health Organization (WHO) published a new growth chart reference for infancy based on breastfed infants from different countries and ethnic origins living under optimal socioeconomic conditions. This chart did not find significant differences in growth patterns between these children, which indicates that genetic differences may first become evident later in life [6].

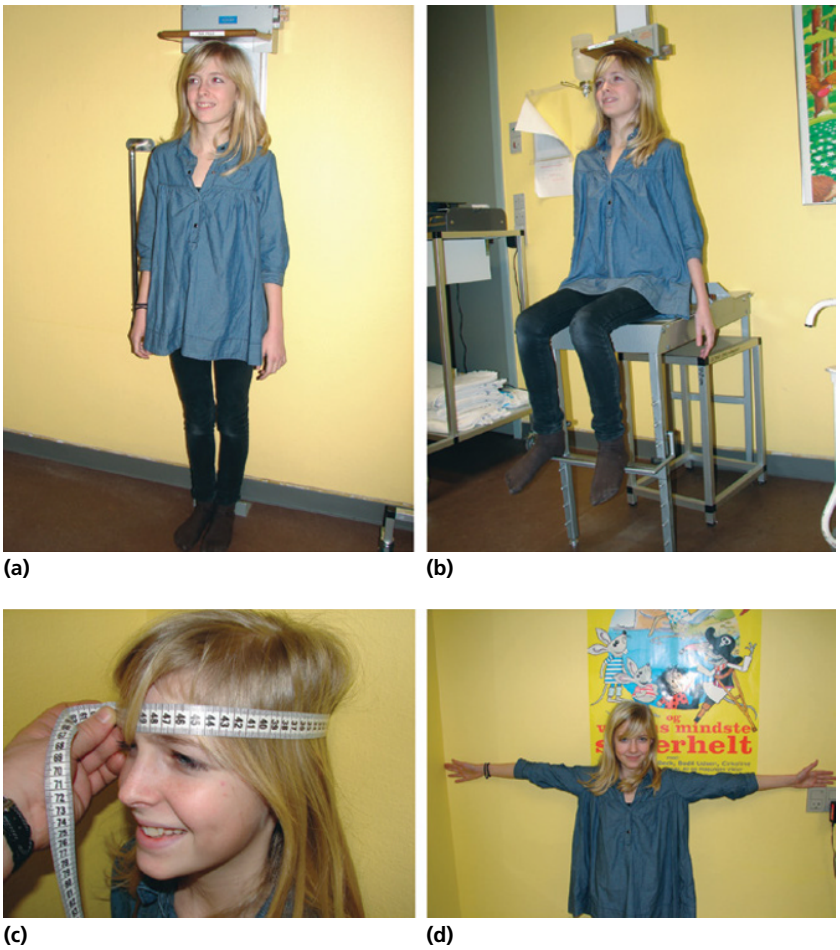


Figure 2.2 Standing height determined by a wall-mounted stadiometer (a). Height is recorded as the mean of three measurements. Sitting height is determined by a specifically designed chair (b). Head circumference is determined using a measuring tape (c). Arm span is determined by measuring the distance from fingertips to fingertips (d).

Childhood

In this phase growth is relatively constant, with a gradual decline in growth velocity over time. From 2 to 4 years children grow approximately 7 cm and 2 kg/year. Beyond 5–6 years of age this rate has decreased to approximately 5 cm/year. This growth phase is highly dependent on growth and thyroid hormones.

Puberty

During the pubertal growth spurt, which typically stretches over 4–5 years, total height gain is on average 20–25 cm for girls and 25–30 cm for boys with large interindividual variations. There is some tendency that early maturers obtain a higher peak height velocity compared to late maturers (Figure 2.3). Sex steroids increase the pulsatile growth hormone secretion, which in turn increases IGF-1. Weight gain is highly individual and may occur both before and after peak height velocity.

Final height has increased over the past century in developed countries due to major improvements of socioeconomic status and health care, a phenomenon which is now predominantly observed in developing countries. However, earlier onset of pubertal development and increased prevalence of childhood obesity has influenced the trajectory of childhood growth within the last one or two generations, and recently, new Danish reference charts for height, weight, and body mass index have been established [7].

In girls, the onset of the growth spurt is early and may even precede the development of secondary sexual characteristics in some. Typically, breast buds appear before pubic hair at 10–11 years of age, but occasionally this succession may be reversed [1]. Both breast development and pubic hair attainment are graded into five stages (B1–B5 and PH1–PH5) according to Tanner and Whitehouse [8]. The first menstruation, menarche, is a sign of adult-level estradiol production and follicle maturation and occurs late during the growth spurt at approximately 13 years of age. Height attainment after menarche is small, with 4–8 cm over 1.5–2 years.

In boys, the pubertal growth spurt occurs relatively late during development. Puberty commences with enlargement of testis size from 3 to 4 mL at 11–12 years of age, and this very first sign of pubertal onset is usually not noticed by the boy or even less so by the parents. Pubertal development in boys is graded into five

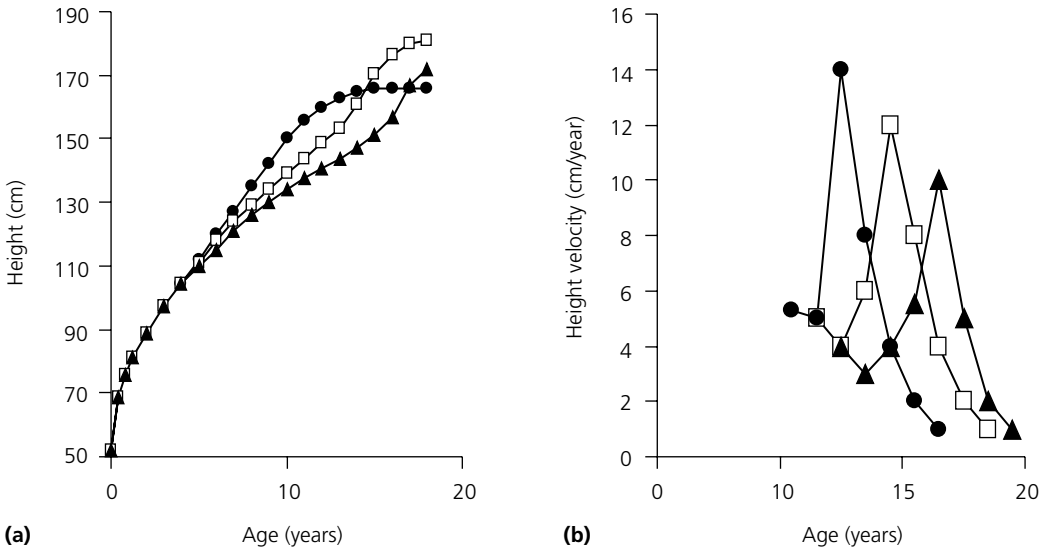


Figure 2.3 (a) Three examples for height curves and (b) height velocity curves from children with early puberty (●), normally timed puberty (□) and delayed puberty (▲). Note that final height is almost the same (a) and that peak height velocity is higher in earlier puberty (b).

genital stages (G1–G5) according to Tanner and Whitehouse [8]. Testis growth continues and within 6–12 months pubic hair can be seen. Testicular volume can be determined by the use of an orchidometer to which the size of the testes is compared. Maximum height velocity often occurs at a testis size of 10–12 mL at around 14 years of age, at the time when the voice breaks and facial hair appearance occurs. Thus, boys are already relatively virilized at the time of the adolescent growth spurt [9]. In mid-puberty, many boys develop physiological gynecomastia, which usually disappears within 6–12 months.

The onset of puberty is approximately a year earlier in girls than boys, which consequently results in earlier growth arrest in girls than boys (14–15 versus 16–17 years of age). The timing of puberty may also differ by 1–2 years according to ethnicity and nationality. Over the past couple of decades a decline in the age of onset of puberty has been observed in many countries [10,11] suggesting that environmental factors and modern lifestyle may affect maturation in addition to hereditary factors.

Growing pains

A significant number of children and adolescents intermittently experience pains, localized to the shins or legs when going to bed after a physically active day. The etiology of this phenomenon is unknown, but local warmth, gentle massage, and mild pain medication, if the child is in real discomfort, can normally ameliorate the problem, which resolves spontaneously.

Evaluation of growth charts

Growth evaluation should be based on observations over time by applying longitudinal measurements of height and weight on an age- and gender-specific growth chart. These charts are

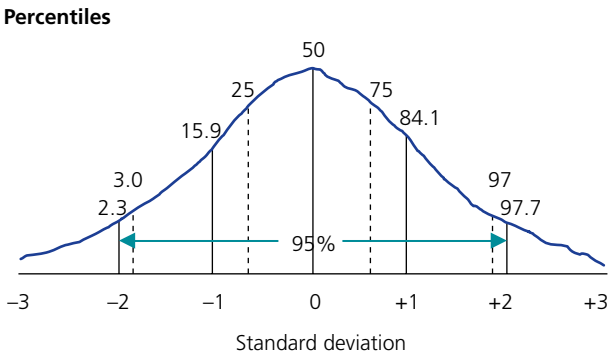


Figure 2.4 Normal (Gaussian) distribution of heights illustrating the 95% reference interval by percentiles or standard deviations (SDs).

available for many populations and also for a variety of growth disorders and syndromes. Due to the secular trend in height, country-specific reference ranges should be constructed at regular intervals [12]. Repetitive measures of growth will result in a trajectory of growth, which then can be evaluated against family potential (parental stature, growth of siblings). As some children show considerable seasonal variation in growth, follow-up periods of 6–12 months may be necessary. In children approaching puberty, pubertal staging [8] will additionally be necessary for adequate assessment.

Growth charts are usually based on cross-sectional data from children and adolescents, covering 95% of the population (±2 standard deviations). Charts may depict centiles or standard deviation lines. Per definition, 2.5% of the population will be below or above the outer limits (Figure 2.4). In contrast, height velocity curves are based on longitudinal follow-up studies of healthy children (Figure 2.5).

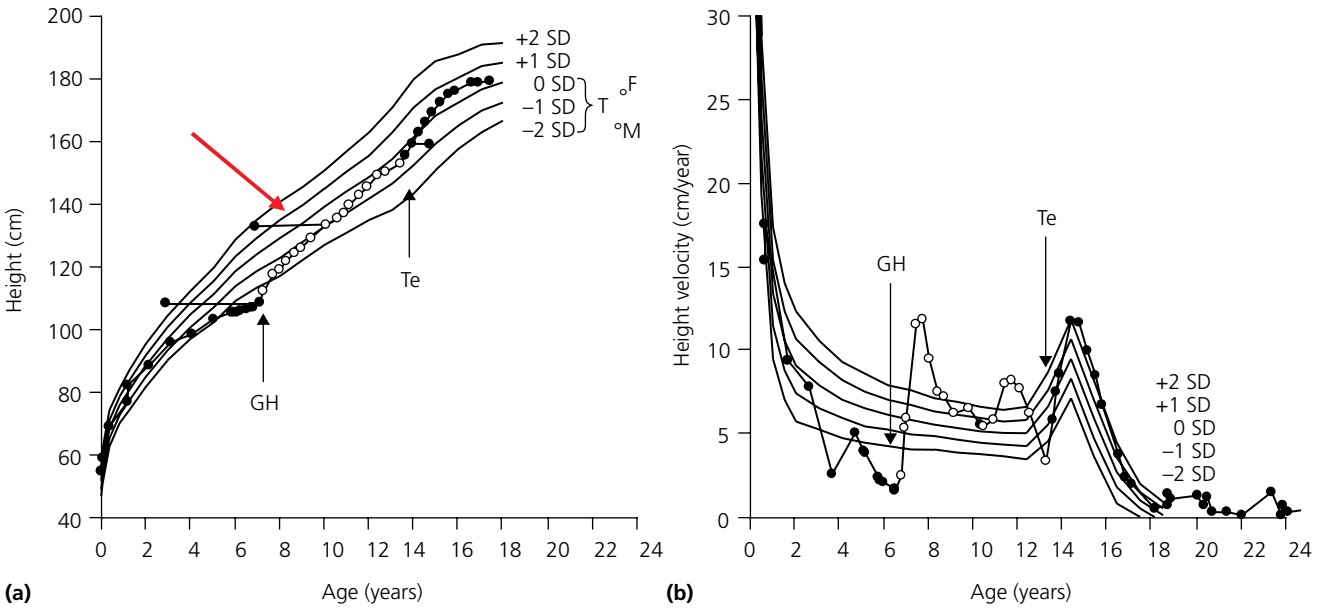


Figure 2.5 Normal height curve (a) based on healthy children. Lines denote mean ±1 standard deviation (SD) and ±2SD. One individual patient is depicted on the curve (●) before and after operation for a pituitary tumor (craniopharyngeoma) resulting in growth hormone deficiency. A typical deceleration is seen prior to diagnosis. Horizontal lines (red arrow) denote bone age. Following operation the child suffers from pituitary insufficiency and is substituted with L-thyroxine, hydrocortisone growth hormone, (GH) (arrow), and testosterone (Te) (arrow). This results in a final height well within target height. T = target height range, F = father's, and M = mother's height expressed as SDs. (b) Normal height velocity curve based on Tanner's longitudinal study of healthy children. The same child (●) is depicted on this curve illustrating the marked growth acceleration following GH therapy, as well as the acceleration when puberty is initiated.

Box 2.1 Calculation of family growth potential (equal to target height or genetic height potential)

Girls

[Maternal height (cm) + paternal height (cm)]/2 – 6.5 cm

Boys

[Maternal height (cm) + paternal height (cm)]/2 + 6.5 cm

To allow for growth variation within a family, the target height range is calculated as midparental height ± 6.5 cm for both genders.

Potential pitfalls of this approach are: (a) the parents differ considerably in height centiles and (b) one of the parents is not of normal stature.

In the evaluation, both the position within the growth chart in relation to the parental potential and the trend of the individual growth curve are important. Deviations from the expected may represent two separate pathologic conditions. In populations with a significant secular trend in height attainment due to recently improved socioeconomic conditions, the growth of siblings in comparison to the patient may be helpful as well. The simplest method to determine the family growth potential is based on calculation of midparental height (Box 2.1).

During childhood, most children will follow their trajectory of growth, which ideally should follow the family potential. There are, however, two phases in life where this trajectory may not be followed without necessarily representing pathology: (a) during the first 2 years of life, children may "catch up" or "slow down" depending on their intrauterine growth and size at birth, a phenomenon also called regression towards the mean; and (b) during puberty, early maturation will lead to a growth spurt above average (vice versa for late maturation) and the individual child will therefore almost always deviate upwards (or downwards) compared to the mean on the growth chart (due to the cross-sectional design of the growth charts). In general, tall children have a tendency to enter puberty early, short children to enter puberty later.

Acute diseases during childhood and adolescence will often only result in a temporary weight loss with rapid catch-up after recovery. In contrast, height attainment will often get compromised in long-term or serious illness. These children may show considerable catch-up growth after recovery, if their bone age allows further growth potential. Thus, growth deceleration is seen commonly in the year(s) prior to diagnosis of severe chronic disease (e.g., brain tumors or malignancies) which is often first noticed in retrospect.

Detailed evaluation of growth includes bone age determination and final height predictions.

Bone age determination

Linear growth continues until the fusion of the ossification centers. Thus, determination of bone maturation may help to assess the growth potential in an individual, as many disorders of growth are associated with either delayed or accelerated bone age. Bone age is mostly measured with a radiograph of the left hand and wrist and a comparison of the epiphyseal growth plates with age- and gender-specific references (Figure 2.6). Two main systems are used clinically: (a) the Greulich–Pyle method [13] and (b) the Tanner–Whitehouse (TW) method [14].

Computer-based automated bone age determination programs [15] are increasingly used as they provide rapid and accurate determination of bone age and consequently final height prediction by applying parental height, current height, weight, age at menarche, and secular trend.

Final height prediction

Both methods of bone age determination (Greulich–Pyle and TW methods) can be employed in prediction models (Bayley–Pinneau and TW method, respectively) for final height [14,16], with a broad margin of error. Both methods are based on studies of healthy children who were followed up until final height, in whom bone ages were determined at various ages. Heights at each bone age were assigned a certain percentage of the final height, e.g., a 13-year-old boy with a bone age of 14 years is assumed to have reached approximately 90% of his final height according to the Bayley–Pinneau tables, and his current height can then be transformed into a final height estimate. Pitfalls in this approach are (a) the normal biological variation of bone age in comparison to chronologic age which is ±1 year and (b) the fact that prediction models are based on normally growing children and may therefore both underestimate and overestimate final height in pathologic conditions.

Dental age determination

Dental age or dental maturity may be assessed in different ways. The simplest method is to record the teeth erupted and compare to normative data. A more precise method is to judge the development of the teeth from radiographs. Haavikko [17] has given normative data for individual permanent teeth, while Demirjian [18] has developed a scoring system based on assessment of all lower left permanent teeth (except the third molar) from an orthopantomogram. Demirjian's method has gained general recognition as the most precise. In general, the correlation between dental age and bone age is, however, relatively low (Figure 2.7).

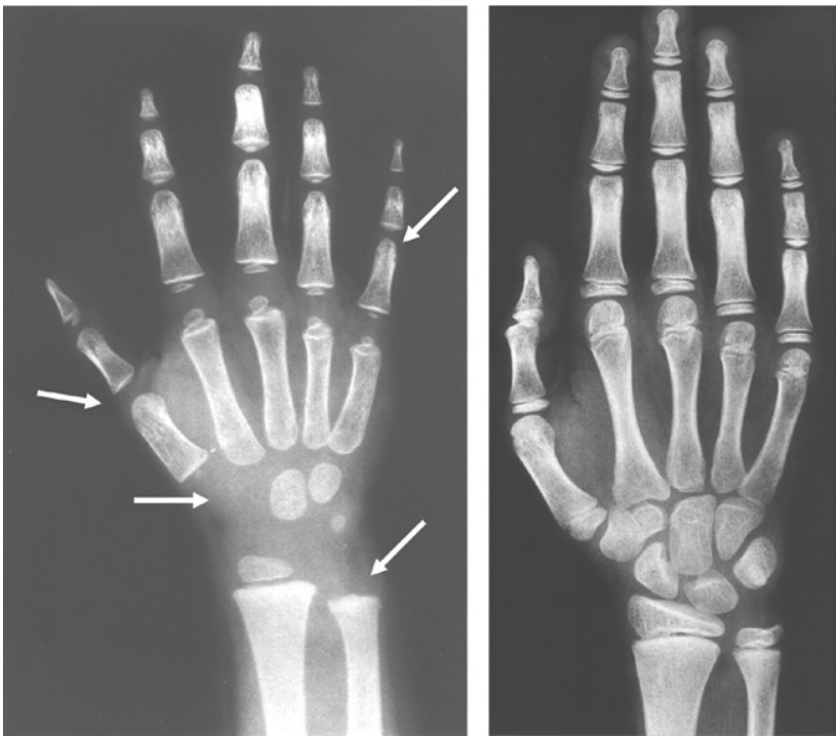
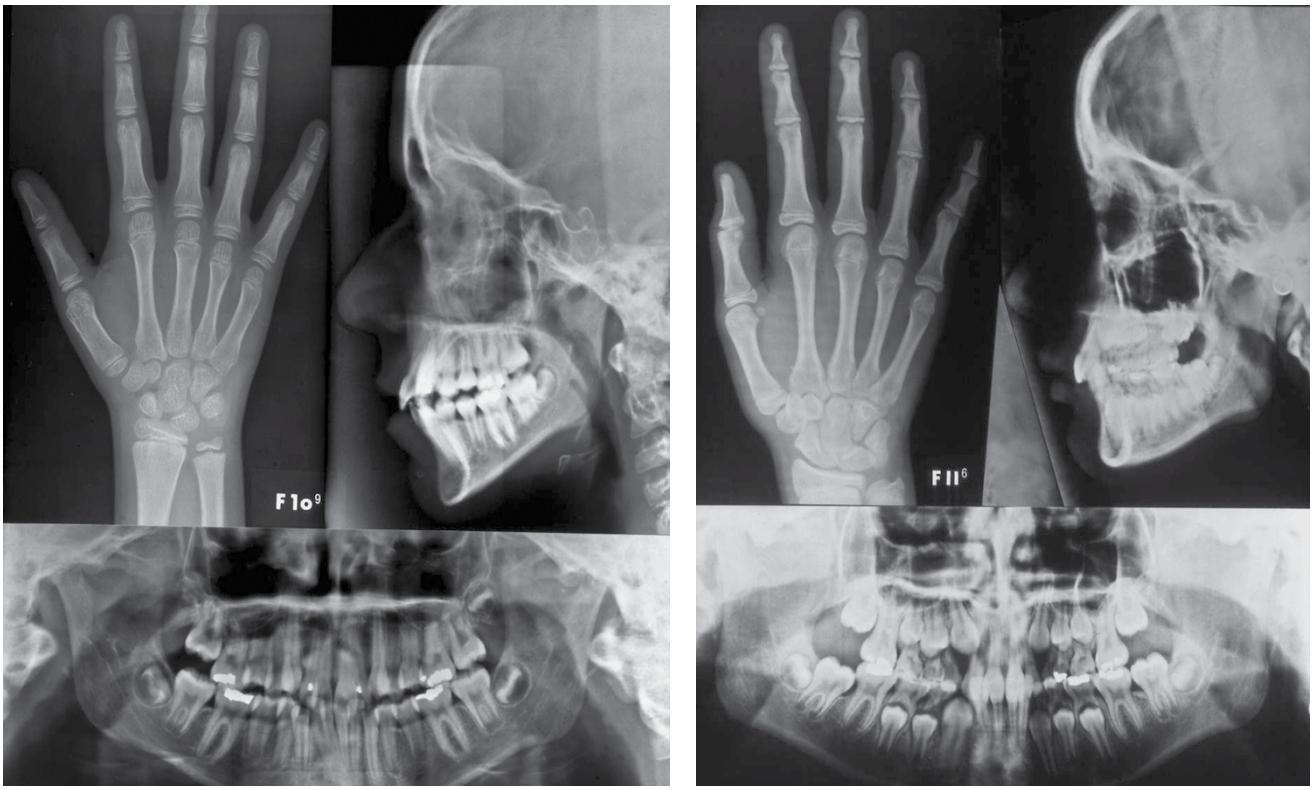


Figure 2.6 Two radiographs of the left hands of two healthy children. Note that the mineralization of the small bones has not yet occurred in the younger child (left).



(a) (b)

Figure 2.7 Illustrative examples showing low correlation between bone age and dental age. (a) A healthy girl, aged 10 years 9 months, with advanced dental maturity (nearly complete permanent dentition: DS4, M1) compared to the skeletal maturity (prepubertal hand–wrist radiograph). (b) A healthy girl, aged 11 years 6 months, with delayed dental maturity (early mixed dentition: DS2, M1) compared to the skeletal maturity (postpubertal hand–wrist radiograph).

Disorders of growth and puberty

Intrauterine growth restriction

Many adverse conditions can lead to impairment of intrauterine growth and development. Infections, medications, environmental chemicals, exposure to tobacco, maternal diseases, and uteroplacental insufficiency may cause early or late growth restriction. A fetus may follow a growth trajectory below normal throughout pregnancy and be born SGA, or growth restriction may have its onset during the third trimester and lead to IUGR.

Over the past few decades research has revealed that antenatal and early postnatal growth patterns may have health consequences in adult life, which may be caused by fetal programming to accommodate adverse conditions. Links have been established to cardiovascular disorders, dyslipidemia, diabetes mellitus, pubertal timing, and reproductive function. The majority of children born SGA or IUGR (80–85%) will show spontaneous catch-up growth after birth, typically within the first 2–3 years of life. Thus, the remaining 10–15% of IUGR/SGA children do not show catch-up growth and remain short in childhood and end up as short adults. These children respond well to treatment with biosynthetic growth hormone. Silver–Russell syndrome is associated with prenatal as well as postnatal growth failure, and children typically respond with significant improvement of final height despite the fact that they generally have no evidence of growth hormone deficiency.

Postnatal growth failure

Today, being of short stature is less well accepted by many societies than being tall. Therefore, many children are presented in the clinic (Figure 2.8). In the majority of cases a growth curve evaluation will reveal that the child is within its family potential. A typical growth curve of a child with familial short stature is shown in Figure 2.8(a). These children are typically growing at a normal growth rate and thus following their growth trajectory. These families need reassurance, as there is today no convincing treatment schedule available that will reliably and significantly increase final height. If, however, the child's position on the growth curve does not correspond to the familial potential or the growth trajectory deviates downwards due to low growth velocity, the child should be investigated further. Many chronic and systemic diseases (e.g., asthma, sleep apnea, malabsorption, and metabolic diseases) and systemic steroid treatment may lead to growth disorders. In rare cases even large doses of inhaled steroids may have a growth inhibitory effect (Figure 2.8f).

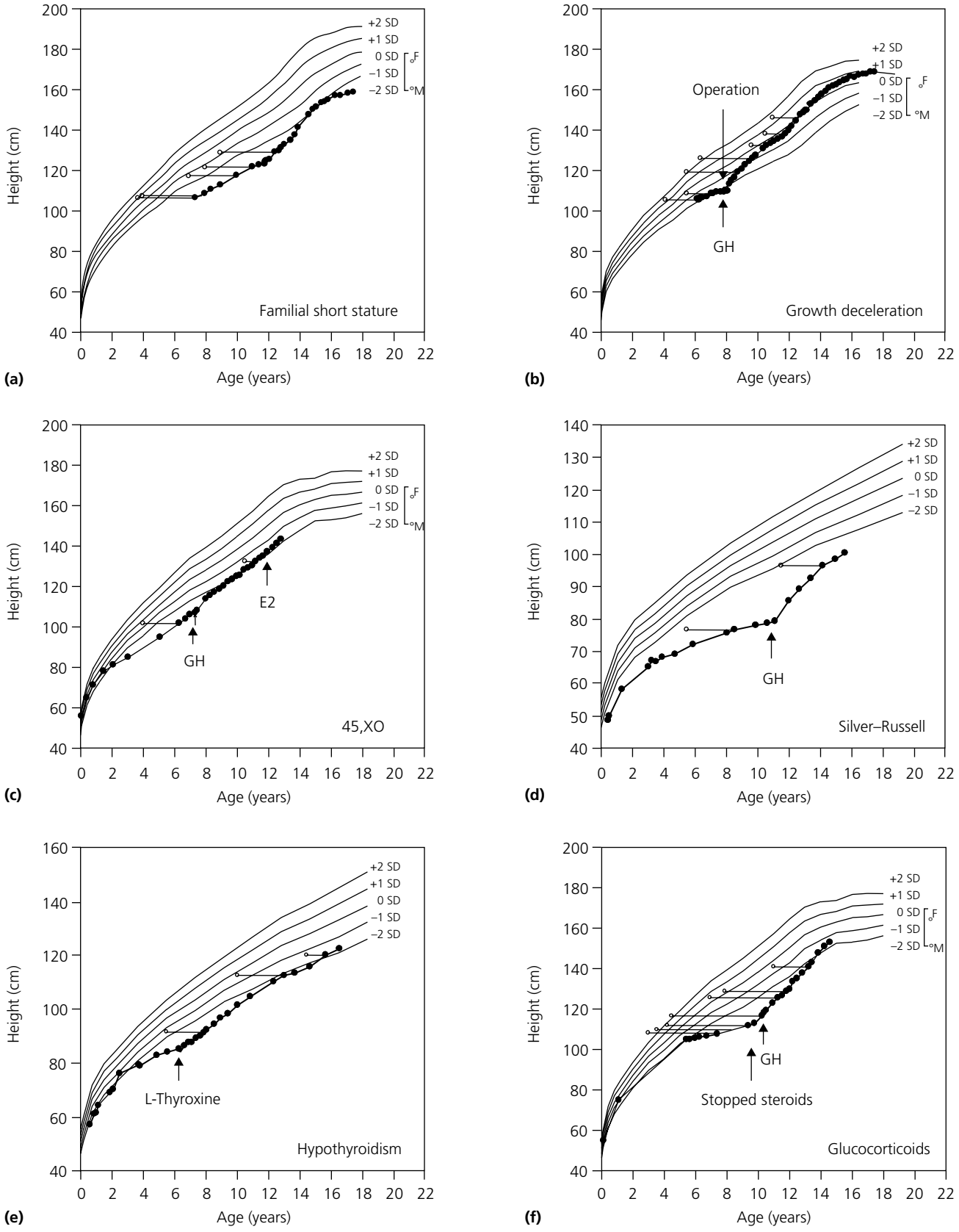


Figure 2.8 Illustrative growth curves of children with growth failure. (a) A child with familial short stature who has a sub-normal predicted adult height in accordance with the short genetic height potential and retarded bone age. (b) A child with growth deceleration due to the development of a benign brain tumor, which was diagnosed and operated upon. Following the operation, growth hormone (GH) therapy was started and a normal final height was obtained. (c) A girl with Turner syndrome diagnosed in late childhood because of growth failure and a height at diagnosis below genetic height potential. Growth hormone treatment results in growth acceleration, and at age 12 years puberty induction was initiated by low-dose estradiol treatment. (d) Prenatal and postnatal growth failure in a girl diagnosed with Silver–Russell syndrome before and after initiation of growth hormone therapy which results in marked catch-up growth. (e) A girl with deceleration of growth from 2 to 3 years of age concomitantly with constipation. She was diagnosed with acquired hypothyroidism and substituted with L-thyroxine which normalized growth. (f) Marked stunting of growth from 5 years of age and delayed bone age in a girl who was erroneously treated with high-dose inhalation steroids despite the fact that she no longer had asthma. Cessation of therapy accompanied by growth hormone therapy resulted in marked catch-up growth.

Table 2.1 Short-limbed conditions and adult height (cm)

Condition	Adult height (cm)
Achondroplasia	106–142
Hypochondroplasia	132–147
Diastrophic dysplasia	86–122
Pseudoachondroplasia	80–130
Metaphyseal dysplasia	
McKusick type	105–145
Schmid type	130–160
Chondrodysplasia punctata	130–160
Chondroectodermal dysplasia	106–153
Acromesomelic dysplasia	97–123
Pyknodysostosis	130–150

Hormonal insufficiencies such as growth hormone deficiency (Figure 2.8b) or hypothyroidism (Figure 2.8e) and Cushing syndrome typically present with stunting of growth. Likewise, chromosomal aberrations such as Turner syndrome in girls (45,X) (Figure 2.8c), genetic syndromes such as Silver–Russell syndrome (Figure 2.8d) or Noonan syndrome are well-known etiologies for postnatal growth failure. Also severe neglect or abuse may induce growth retardation (psychosocial dwarfism).

Importantly, skeletal dysplasias can cause severe stunting of growth. In this case, body proportions are skewed as in the typical case of achondroplasia. Achondroplasia is the most frequent form of short-limb dwarfism. Affected individuals exhibit short stature caused by rhizomelic shortening of the limbs, characteristic facies with frontal bossing and midface hypoplasia, exaggerated lumbar lordosis, limitation of elbow extension, genu varum, and trident hand. Achondroplasia is caused by mutation in the fibroblast growth factor receptor-3 gene (*FGFR-3*). There is some evidence to suggest that a minor fraction of the milder forms of skeletal dysplasias (hypochondroplasia) may also be due to *FGFR-3* mutations. A large number of different skeletal dysplasias can be classified according to clinical and radiologic criteria (Table 2.1).

Tall stature and growth acceleration

Tall stature is today socially more accepted, and some studies indicate that tall people may have higher social success and better job prospects. However, for some individuals, extreme tall stature may still present a major disadvantage and give numerous practical problems (Figure 2.9).

Most cases are familial (Figure 2.9f), but rare diseases may also be the underlying cause. Supernumerary sex chromosomes, such as Klinefelter syndrome (47,XXY) (Figure 2.9a), the most common sex chromosome abnormality (1:660 newborns), triple X syndrome (47,XXX), and double Y syndrome (47,XYY) (Figure 2.9b) are all characterized by increased growth compared to the reference population, as well as compared to their genetic target. Endocrine disorders, such as gigantism (growth hormone hypersecretion because of pituitary tumor) (Figure 2.9c), are extremely rare, but should be excluded. Other genetic conditions such as Marfan syndrome (long limbs with narrow hands and long slender fingers, and arm span greater than height), Soto syndrome (prominent forehead, large ears and mandibles, and coarse facial features) and homocysteinuria may be found among patients referred because of tall stature.

Tall stature must be distinguished from conditions with temporary growth acceleration that do not lead to increased final height, such as obesity (Figure 2.9d) in childhood, hyperthyroidism, and early sexual maturation (Figure 2.9e). These children will deviate upwards on their growth chart, but their accelerated bone maturation will at the same time lead to premature fusion of the growth plates.

If the estimated final height is unacceptable to the child and family, gender-specific treatment with sex hormones to accelerate closure of the epiphyseal plates is an available option, which, however, requires careful discussion with the families about potential risks and benefits. This can be done either by induction of early pubertal maturation or by addition of sex hormone during spontaneous puberty to shorten the pubertal growth spurt. In addition, operative epiphysiodesis of growth plates around the knees is an established treatment option for tall stature.

Early puberty

Early pubertal maturation is much more frequently seen in girls than in boys. There are indications that true precocious puberty before the age of 8 years in girls and before the age of 9 years in boys is becoming more frequent in many populations. Foreign adopted children seem to be at greatest risk. There also appears to be a genetic component, as some families present with early puberty over several generations. In girls, early puberty often presents as an idiopathic premature activation of the hypothalamus–pituitary axis and is rarely caused by diseases. Conditions such as intracranial tumors, hydrocephalus, autonomous sex hormone production (gonadal tumors), and disorders of steroid biosynthesis such as congenital adrenal hyperplasia need to be excluded, especially in boys. It is possible to postpone further pubertal development until a more appropriate age by treatment with long-acting gonadotropin agonists. This treatment can be useful for children who have difficulties in coping with the psychological effects of early maturation or in very short children, in whom predicted final height is extremely low. Paradoxically, these children are usually referred at a time of pubertal growth acceleration, and therefore present with a height in excess of their peers. Parents are usually unaware of the fact that they may end up being very short (Figure 2.9e).

Late puberty

Late puberty is much more frequently seen in boys than in girls as an extreme of the natural gender dimorphism. In most cases, it is a simple delay of maturation without any underlying pathology. Family history may reveal inheritance from one or both parents as a constitutional delay of growth in puberty. These children usually present with short stature compared to their age-matched friends, lack of secondary sexual characteristics, a growth curve that shows deviation downwards with time, and delayed bone age.

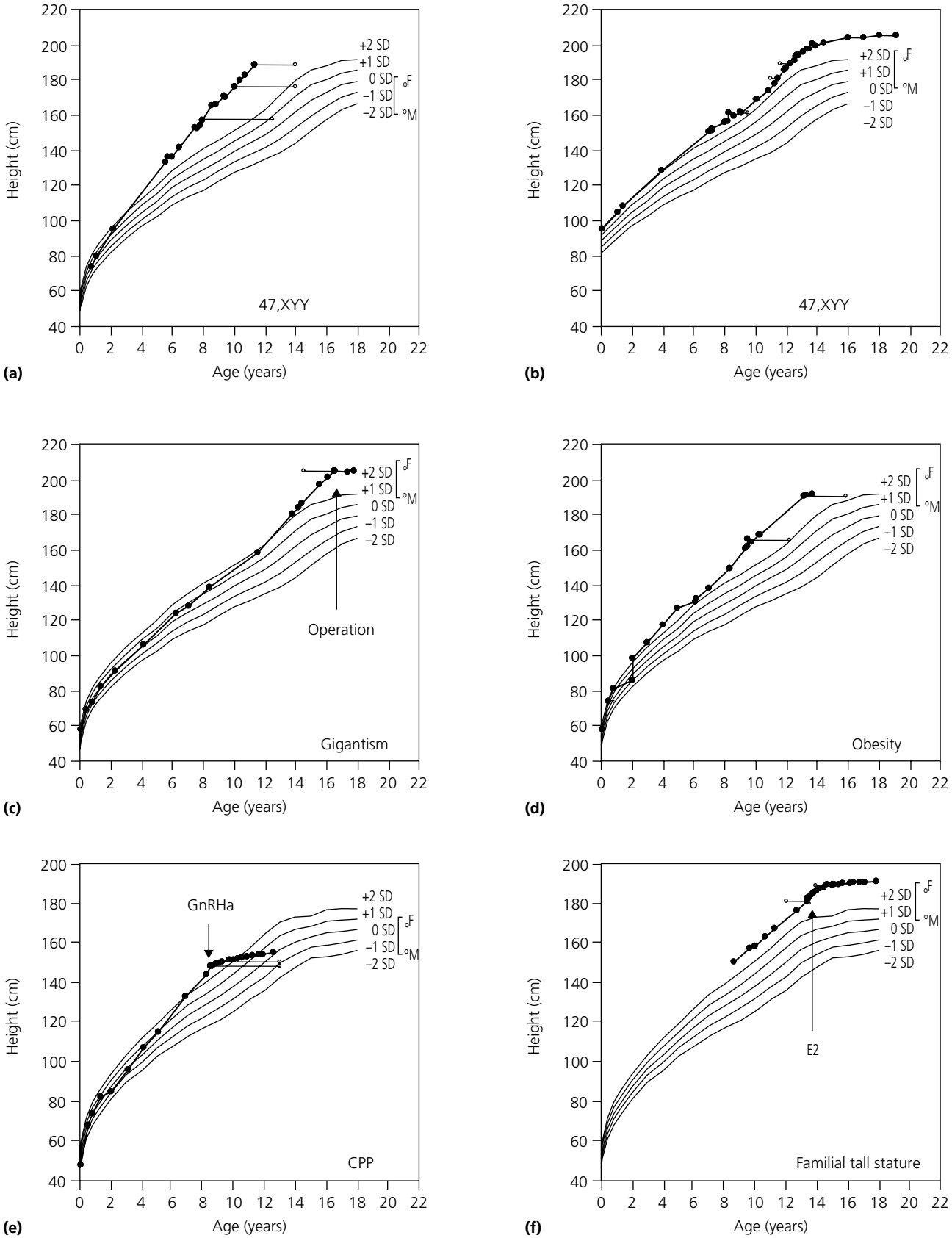


Figure 2.9 Illustrative growth curves of children with tall stature and growth acceleration. (a) A boy with marked growth acceleration from early childhood who was diagnosed with Klinefelter syndrome (47,XXY). He will end up above his target height despite advanced bone age. (b) A boy with growth acceleration from early childhood who was diagnosed with double Y syndrome (47,XYY) who will end up with increased final height. (c) A boy with growth acceleration from 10 to 12 years of age who was diagnosed with gigantism and operated on for his growth hormone-producing pituitary adenoma. (d) A boy with growth acceleration and who was obese (simple obesity) who will end up with a final height within his target range, probably because of his advanced bone age. (e) Increased growth in a girl who presented with precocious puberty (regular menstruation at the age of 9 years), and markedly advanced bone age. She will end up with a final height at the lower end of her target range. (f) A girl with familial tall stature and delayed puberty who was treated with high-dose estrogen to accelerate epiphyseal fusion. Despite this, she reached a final height above target range.

In rare cases, delayed puberty is caused by endocrine disorders such as gonadotropin or pituitary insufficiency or developmental disorders of the gonads. Excessive sporting activities and eating disorders can also cause significant delay in physical maturation. In girls, delayed puberty may be caused by a chromosomal disorder, such as Turner syndrome (45,X).

If no pathology is found, simple reassurance may be the only treatment necessary. Delayed puberty itself does not lead to short final height. If puberty is delayed beyond acceptable limits for the child, treatment with low-dose sex hormones for 6–12 months may help to "kickstart" the process.

Disorders with deviations in dental maturity

Many children with postnatal growth failure also show delay in dental maturity, e.g., growth hormone deficiency. Likewise most patients with Soto syndrome show advanced dental maturity. Thus, the dentist should be aware of the oral manifestations of general diseases and, thereby, contribute to early diagnosis (see Chapter 23).

Conclusion

Prenatal and postnatal growth reflects the general health status of an individual. Growth charts are easy to obtain, noninvasive, and cheap. Many countries offer health services that allow the longitudinal follow-up of height and weight attainment, together with an evaluation of puberty progression in teenage years. Pathologic growth charts and a bone age that deviates significantly from chronologic age can be the first indicators of a serious underlying condition that needs attention. Thus, knowledge about normal and abnormal growth patterns in children and adolescents is necessary for all medical personnel that are involved in their health care. In addition, the pediatric dentist should be aware of the fact that marked deviations in dental maturity could be part of a general growth problem.

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CHAPTER 3

Child and Adolescent Psychological Development

Anders G. Broberg and Gunilla Klingberg

Evidence has been accumulated over the past few decades to show that if dentists have a basic knowledge of children's cognitive and socioemotional development, then they will be much better prepared for difficult situations that may emerge. The aim of this chapter is to provide the reader with an overview of the essentials of developmental psychology. It will describe those aspects of normal development that are most useful for dentists treating "typical" children of different ages. We use the term children for the age range 0–12 years, and the term adolescents for children between 13 and 18. For the 0–12 range we make a further division into infancy (0–1), toddlerhood (2–3), preschool years (4–5), and middle childhood (6–12).

The chapter starts with an overview of how to conceptualize psychological development, then follows more focused aspects relating to cognitive, emotional, and social development in preschoolers, school-aged children, and adolescents. Finally, we present those aspects of the field of *developmental psychopathology* that we find most useful to pediatric dentistry.

Perspectives on psychological development

Long before developmental psychologists began to use scientific methods to study age-related changes, philosophers proposed explanations of development based on everyday observations. Many of their questions and assertions about the nature of human development continue to be central to modern-day developmental science.

The argument about nature versus nurture is one of the oldest and most central theoretical issues within both psychology and philosophy. Progress in both neuroscience, especially molecular biology, and developmental psychopathology since the millennium shift has however led to a new stance, where neuroscientists and developmental psychologists share a common interest in nature *and* nurture rather than nature or nurture. In the section "Developmental psychopathology" we will return to current ways of addressing this issue.

A biopsychosocial approach

Human life is produced by the interaction and modification of three major systems: biological, psychological, and social. It is the integration of these systems that leads to a complex, dynamic portrait of human thought and behavior.

The *biological system* is made up of all the processes necessary for the psychological functioning of the organism. Biological processes develop and change as a consequence of genetically guided maturation, environmental resources, exposure to environmental toxins, encounters with accidents and diseases, and lifestyle patterns of behavior.

The *psychological system* consists of mental processes central to a person's ability to make meaning of experiences and take action. Emotion, motivation, memory, perception, problem solving, language, symbolic abilities, and our orientation to the future, all require the use of psychological processes. The psychological system provides the resources for processing information and navigating reality.

The *social system* is composed of processes through which a person becomes integrated into society. Societal influences include family organization; social support; culture; social roles; ethnic and subcultural influences; patterns of economic prosperity or poverty; and exposure to racism, sexism, and other forms of discrimination, to name only a few. The impact of the social system on psychological development results largely from interpersonal relationships, often relationships with significant others.

The biopsychosocial approach seeks to understand the internal experiences that are the product of interactions among biological, psychological, and social processes. Changes in one of the systems generally bring about changes in the others. At each period of life, children and adolescents spend much of

Pediatric Dentistry: A Clinical Approach, Third Edition. Edited by Göran Koch, Sven Poulsen, Ivar Espelid, and Dorte Haubek.

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their time mastering a unique group of *developmental tasks* that are essential for social adaptation. Solutions of developmental tasks will set children on different developmental trajectories with consequences for how future tasks will be solved. The importance of introducing time as a powerful ingredient in the interaction between the biological, psychological, and social systems has called for a new concept, the *transactional model of child development*.

Meaning is created out of efforts to interpret and integrate the experiences of the biological, psychological, and social systems. A primary focus of this meaning-making is the search for identity. Children and adolescents establish categories that define who they are connected to or not, who they care or do not care about, and who they admire or reject or deny.

With this broad introduction to developmental science as the psychologist sees it, we now turn to more narrow aspects of child and adolescent development.

Aspects of psychological development

Child development is most often described using either a variable- or a person-based approach. A variable-based approach divides child development into components: cognitive, emotional, social, etc., and describes the development of each component through childhood and adolescence. The person-based approach describes what is typical for a child of a certain age, whether preschooler, school-aged child, or adolescent, using a number of components simultaneously. Both approaches have their advantages and disadvantages and the choice is more a matter of taste. No matter what, a child's development is not divided into tidy packages labeled "physical development," "social development," and "language development" but is instead a coherent, integrated process. Nevertheless we will start by taking a look at particular processes and end with a more holistic approach.

Cognitive development

Cognition is the process of organizing and making meaning out of experience. Cognitive developmental theory focuses specifically on how knowing emerges and is transformed into logical, systematic capacities for reasoning and problem solving. Perhaps the most widely known and influential of the modern cognitive theorists is Jean Piaget [1]. Recent interest in the social framework within which cognition develops has been stimulated by the work of Lev Vygotsky [2].

Cognitive development according to Jean Piaget

According to Piaget (1896–1980), every organism strives to achieve equilibrium: a balance of organized structures (motor, sensory, or cognitive). When structures are in equilibrium they provide effective ways of interacting with the environment. Equilibrium is achieved through adaptation; a process of gradually modifying existing ways of organizing knowledge in order to take into account changes and discrepancies between what is known and what is being experienced. Adaptation is a two-part process in which continuity and change interact. *Assimilation*, the tendency to interpret new experiences in terms of existing mental structures (schemas), contributes to the continuity of knowing, and it is balanced by *accommodation*, the tendency to modify familiar schemas in order to account for new dimensions of the object or event that are revealed through experience.

Piaget described cognitive development in terms of four stages, each of which is characterized by a unique capacity for organizing and interpreting information. At each new stage competencies of the earlier stages are not lost but are integrated into a qualitatively new approach to thinking and knowing.

The first stage, *sensorimotor intelligence*, is characterized by the formation of increasingly complex sensory and motor schemas that allow infants to organize and exercise control over their environment.

During the second stage, *preoperational thought*, children develop the tools for representing schemas symbolically through language, imitation, imagery, symbolic play, and symbolic drawing. Knowledge is, however, still very much tied to the child's perceptions.

During the third stage, *concrete operational thought*, children begin to appreciate the logical necessity of certain causal relationships. They can manipulate categories, classification systems, and hierarchies in groups. They are more successful at solving problems that are clearly tied to physical reality than at generating hypotheses about purely philosophical or abstract concepts.

The final stage of cognitive development according to Piaget is *formal operational thought*. This level of thinking permits a person to conceptualize many simultaneously interacting variables. It allows for the creation of systems of laws, or rules that can be used for problem solving. Formal operational thought reflects the quality of intelligence on which science and philosophy are built.

Piaget's theory has had an enormous influence on our understanding of cognition and the way we think about the reasoning capacities of children and adolescents. Some of this can be summarized as follows.

- Cognition has its base in the biological capacities of the human infant: knowledge is derived from action. Knowledge is constructed rather than passively absorbed.
- Discrepancies between existing schemas and contemporary experience promote cognitive development. Encounters with all types of novelty, especially experiences that are moderately distinct rather than widely different from what is already known, are important for advancing new ideas and new ways of organizing thought.
- Preschoolers and school-aged children (not to mention infants and toddlers) think in different ways, and the ways they think are different from the ways (older) adolescents and adults think. This does not mean that their thinking is unorganized or illogical, but the same principles of logic

that typically govern adult thought do not govern the thinking of young children.
- Children can approach problems using many of the principles that are fundamental to scientific reasoning. They can also begin to reason about their reasoning (e.g., explain how they arrived at a specific conclusion), but it takes formal operational thought to grasp and make use of meta-cognition (i.e., thinking about thinking) in its more eloquent aspects.

Appearance and reality

The child's movement away from egocentrism during the preschool years seems to be part of a much broader change in his or her understanding of appearance and reality. Flavell [3] has studied this in a variety of ways. In one procedure the experimenter shows a child a sponge that has been painted to resemble a rock. After the child has felt the sponge/rock and has answered questions about what it looks like and what it "really" is, a researcher might ask something like this:

> "John [one of the child's playmates] hasn't touched this, he hasn't squeezed it. If John just sees it over here like this, what will he think it is? Will he think it is a rock or will he think it is a sponge?"
>
> "A sponge" says 3-year-old Minnie, who thinks that the playmate will believe the object is a sponge, because she herself knows it is a sponge.
>
> "A rock" says 4-year-old Ken, who realizes that, because John hasn't felt the sponge, he will have a false belief that it is a rock.

Investigators have also asked whether the child can grasp the *false belief principle*. Individuals who understand the false belief principle can look at a problem or situation from another person's point of view in order to discern what kind of information can cause that person to believe something that is not true. A number of developmentalists have examined a theoretical notion known as *theory of mind*, or *mentalization*, a set of concepts that explain other people's ideas, beliefs, desires, and behavior [3]. Adults and adolescents have a much more fully developed theory of mind than have children. However, research also suggests that young children's degree of sophistication is greater than either Piaget or casual observers of children would expect, and that there are big individual differences with regard to when and how children's mentalizing abilities develop.

Children's development of a theory of mind shows that cognitive development is a relational process. The child learns to conceptualize the world around him or her by communicating with others. That cognitive development is an interpersonal endeavor is the hallmark of Vygotsky's theory.

Cognitive development according to Vygotsky

The Russian psychologist Lev Vygotsky (1896–1934) argued that development can only be understood within a social framework. New levels of understanding begin at an interpersonal level as two individuals, initially an infant and an adult, coordinate their interactions. Further, Vygotsky claimed that cognitive development can only be understood in the context of culture, and that high-level mental functions begin in external activity that is gradually reconstructed and internalized. He gave the example of pointing.

Initially, an infant will reach toward an object that is out of reach, stretching the hand in the direction of the object and making grasping movements with the fingers. As soon as the caregiver recognizes that the child wants the object and is able to satisfy the child's request, the child begins to modify the reaching and grasping movement into a socially meaningful gesture—pointing. The individual grasping has become an interpersonal communication gesture, and the child has internalized an understanding of the special relationship between the desired goal, the caregiver as mediator, and pointing as a meaningful sign.

According to Vygotsky, a child's learning of new cognitive skills is guided by an adult (or a more skilled child, such as an older sibling) who models and structures the child's learning experience; a process later called *scaffolding*. Vygotsky [2] offered the concept of the *zone of proximal development*, which is the discrepancy between how difficult a problem (e.g., in math) a child can solve on his or her own relative to solving a problem under adult guidance or in collaboration with capable peers. Learning within the zone of proximal development sets into motion the reorganization and internalization of existing developmental competencies, which then become synthesized at a new, higher intra-mental level.

Several specific implications of Vygotsky's work can be inferred [4], of which at least three are of relevance for understanding child development in relation to dentistry, as follows.
- The mental structures and functioning of people raised in a specific culture will be different from those of people raised in other cultures. In contrast to Piaget, who viewed the emergence of logical thought as largely a universal process, Vygotsky considered the nature of reasoning and problem solving as culturally created.
- Individuals can promote their own cognitive development by seeking interactions with others who can help draw them to higher levels of functioning within their zone of proximal development.
- Teachers, whether formal or informal (like parents or dental personnel), must navigate their "lessons" so that they can scaffold the child's learning within his or her zone of proximal development.

Adaptation, according to Piaget, or learning, according to Vygotsky, is effective only when the input is new (i.e., different from existing knowledge) but related enough to existing knowledge (i.e., within the zone of proximal development) to permit accommodation rather than assimilation (Piaget) and the building of more elaborate mental structures (Vygotsky) (Box 3.1).

Language development

Somewhere between 16 and 24 months, after an early period of very slow word learning (12–18 months typically), most children begin to add new words rapidly, as if they have figured out that things have names. For the majority of children, the

Box 3.1

Children's understanding of the concept of pain and the need for local anesthesia varies considerably with age and cognitive development. First of all, both are abstract phenomena. The preschool child's connotations to pain could be punishment or guilt. He or she does not understand the physical background of the pain. Also, local anesthesia is hard to grasp and the child is not capable of deciding whether to have an injection or not. Even if a preschool child receives good and age-appropriate information about these concepts and then declines local anesthesia when asked, he or she is not able to understand the cause and effect if feeling pain during treatment. While an adult would reason "I have to blame myself for experiencing pain as I did not want the local," the child understands this differently. He or she will probably just blame the dentist for hurting him or her. Because of this, it is obligatory when treating young patients that the dentist makes sure treatment is as free from pain as possible, and to use local anesthesia on proper indications. Since dental treatment implies some level of stress, the child needs to master more advanced reasoning to fully understand pain and how to prevent it during dental treatment. Therefore, as a rule of thumb, the decision whether to have local anesthesia or not should only be left to teenagers. It is not until adolescence, and being able to think at the level of formal operations, that the child can take full responsibility for pain if declining an injection.

Box 3.2

Peter, 7 years old, is having fissure sealants placed on his first permanent molars. This is the first real treatment for Peter and he is a bit cautious. At the previous appointment the dentist told him what was going to happen today and also promised to show everything step by step as the treatment progresses. The first tooth is fixed satisfactorily. And when the dental team is about to isolate the second tooth with cotton roles Peter says to himself: "Lie still and open wide, this will not take long."

naming explosion is not a steady, gradual process; instead, a vocabulary spurt begins once the child has acquired about 50 words. Noun learning precedes verb learning because infants lack the ability to associate words consistently with actions until about 18 months of age. During the preschool years, children continue to add words at a remarkable speed. At age 2½, the average vocabulary is about 600 words, about a quarter of which are verbs [5], and most children at this age are equipped with a language capacity that also enables them to begin to communicate verbally with unfamiliar adults, provided that (a) the adult adapts his or her way of speaking to the child's level of cognitive understanding, and (b) the emotional contact is such that the child feels free to talk. By age 5 or 6, total vocabulary has risen to perhaps 15,000 words—an astonishing increase of 10 words per day. The momentous shift in the way children approach new words happens around the age of 3 years. Understanding the categorical nature of words helps children develop what we might think of as mental "slots" for new words. Once the slots are in place, children seem to organize automatically the linguistic input they receive from parents, teachers, peers, books, television programs, and other sources to extract new words and fill the slots as quickly as possible.

Even though most children are reasonably fluent in their first language by the age of 3 or 4 years, there are still many refinements to be made. Soon after young children have figured out inflections and basic sentence forms, such as negation and questions, they begin to create remarkably complex sentences, using conjunctions such as *and* and *but* to combine two ideas or using embedded clauses. During middle childhood, children become skilled at managing the finer points of grammar, such as understanding various ways of saying something about the past (I went, I was going, I have gone, I had gone, I had been going, etc.).

Children use language not only for communication with others, but also for "internal purposes"—to help control or monitor their own behavior. Such *private speech*, which may consist of fragmentary sentences, muttering, or instructions to the self, is detectable from the earliest use of words and sentences (Box 3.2).

Emotional development

Emotions, for example, fear, sadness, anger, and joy, are part of a complex set of interconnected feelings, thoughts, and behaviors. Plutchik [6] conceptualized emotions as part of a feedback system; a stimulus, which could be an internal experience, such as pain, or an external stimulus, such as a looming object, is perceived and given some meaning. The meaning is associated with a feeling and with its accompanying physiological state. These combine to create an impulse for action that, if expressed, is observed in behavior. Two aspects of emotions that are of special interest for this chapter are temperament and emotional regulation.

Temperament

Temperament is a theoretical construct that refers to relatively stable characteristics of response to the environment and patterns of self-regulation [7]. Theorists have offered different views about the specific features of temperament and what accounts for the stability of these features. However, they all tend to agree that a primary feature of temperament is the child's positive or negative reaction to environmental events, and that the stability of this reaction leads to a patterned reaction by others [8].

As early as the 1950s Thomas and co-workers [9] studied temperament and were able to classify infants into three temperamental groupings: *easy, slow to warm up*, and *difficult*. Roughly 35% of the sample could not be classified into any of these categories (Table 3.1).

Later work on temperament identified activity level, sociability, and negative emotionality as traits with a substantial genetic influence [10]. Kagan and co-workers [11] have identified *behavioral inhibition* as a relatively stable temperamental trait, which has been shown to be a vulnerability factor for the development of shyness and anxiety problems later in childhood.

Rothbart and Posner [12] have identified three broad temperamental factors in 3- to 7-year-old children: surgency/extraversion, negative affectivity, and effortful control. *Surgency* is primarily defined by positive emotionality and approach (including sensation-seeking, activity level, impulsivity, smiling and laughter, and low shyness). *Negative affectivity* involves shyness, discomfort, fear, anger/frustration, sadness, and low soothability. *Effortful control* is defined by high inhibitory control, attentional focusing, low-intensity (non-risk-taking) pleasure, and perceptual sensitivity.

To summarize, it makes sense to think of temperament as two basic processes:

- *Reactivity*—how easily aroused the child is, either positively or negatively. Both the very inhibited and the very impulsive child are highly reactive to environmental stimuli although his or her reactions have different origins in the brain and take very different forms.
- *Control*—how able the child is to handle his or her activated nervous system.

Both aspects of temperament are important in the dental situation, which for some children is packed with fear-eliciting stimuli from which one wants to escape, and for others with a number of exciting things one wants to explore. In both cases it will be difficult for the child to sit still and follow instructions. Temperament is closely linked to the concept of emotion regulation to which we turn in a moment. Let us, however, conclude with the aspect of stability in childhood temperament.

Although temperament shows consistency over the period of infancy and toddlerhood, it is in no way written in stone. Temperament is in fact only modestly stable over longer periods of time—the level of stability depending on culture, measurement techniques, and methods of analysis. Temperamental characteristics are modified as they come into contact with socialization pressures at home and at school, as well as with new capacities to regulate behavior. Whether it is temperament itself (in terms of a biological propensity) that changes, or if the child simply learns to "hide" or "suppress" aspects of his or her temperament that are not culturally sanctioned, is a question of debate.

Tim is a typical example of shyness in a young child and how this can manifest during a dental visit (Box 3.3). Other examples

Table 3.1 Different types of early temperaments

Type	Description	Percentage of sample
Easy	Positive mood, regular body functions, low to moderate intensity of reaction, adaptability, positive approach rather than withdrawal from new situations	40
Slow to warm up	Low activity level, tendency to withdraw on first exposure to new stimuli, slow to adapt, somewhat negative in mood, low intensity of reactions to situations	15
Difficult	Irregular body functions, unusually intense reactions, tendency to withdraw from new situations, slow to adapt to change, generally negative mood	10

Adapted from Thomas *et al*. 1970 [9].

Box 3.3

Tim is a 3-year-old boy visiting the dentist for the first time. He is very cautious and does not respond with eye contact nor does he answer questions. He refuses to sit in the dental chair and to let the dentist have a look at his teeth. Tim has a sister who is 2 years older and who is also a patient at the clinic. She acted very much the same way when she was 3, but after careful introduction she now cooperates well. Both Tim and his sister spend their days at a day-care center. They function well in their peer groups, and play and have fun with friends, but have difficulties making new acquaintances. They are shy when meeting new people and it takes them quite a while to feel at ease in novel situations. In this case it is recommended that the dental team identifies the shyness and decides to use the first appointment to establish a good rapport and relationship with Tim and the accompanying parent. Tim is a child who needs extra time in order to feel at ease. If he is met with understanding and empathy combined with stepwise introduction to the dental examination, and to all new dental treatment in the future, he will most likely cooperate well.

of temperament are active, speedy children who jump into the chair right away, and are eager to have their teeth checked. These children are very restless and seem to have very little time for conversation, which is why it is difficult to get through with information or instructions. There are also children who get upset very easily when feeling uncomfortable, for example, when the dentist uses the water suction. But if just given some extra attention, these children are often able to feel a lot more at ease and to cooperate well.

Emotion regulation

Emotion regulation refers to a variety of processes that allow infants to control the intensity of their emotional state and reduce feelings of distress. These abilities, which mature over the first 2 years of life, have important implications for a child's successful social participation in preschool and later in childhood [13]. One of the most important elements in the earliest development of emotion regulation is the way caregivers assist infants in managing strong feelings. Caregivers can provide direct support when they observe that a child is distressed: cuddling, hugging, rocking, or swaddling like a baby. They may offer food or a pacifier to the baby, or nurse him or her as a means of comfort. Through words and actions, the caregiver may help the child interpret the source of the stress, or suggest ways to reduce the stress.

There is a dramatic development during the infancy and toddler periods in terms of the acquisition and display of emotion regulation skills and abilities: the relatively passive and reactive infant becomes a child capable of self-initiated behaviors that serve regulatory functions [14]. Because the lack of adaptive emotion regulation skills may contribute to adjustment difficulties characterized by undercontrolled (i.e., acting-out) or over-controlled (i.e., inhibited) emotion expressions, failure to acquire these skills may lead to difficulties in areas such as social competence and school adjustment. Children who have difficulty managing emotion in a flexible, constructive way may be less successful in negotiating peer relationships, or in managing academic challenges. Thus, the acquisition of adaptive emotion regulation skills and strategies is considered a critical achievement of early childhood [15,16]. Moreover these skills may be linked in important ways to other dimensions of self-control or self-regulation that are also developing during early childhood (Box 3.4).

Developmental tasks

So far we have discussed different facets of child development as if they were separable. In reality they are not, and this section will introduce the principal concept used today to describe and understand child development and competency more broadly: *developmental tasks* [17].

How do we know that a child is developing OK? There is a set of criteria common across many parents, communities, cultures, and measures that reflect major tasks of adaptation spanning development and the key criteria by which adjustment in society is assessed. Table 3.2 indicates psychosocial tasks of childhood and adolescence commonly found in textbooks on child development.

Box 3.4

Dental treatment usually follows a well-known path, and most extractions of teeth are uneventful. However, from time to time things happen. The dentist may have just started to extract a tooth when suddenly the crown fractures and the dentist needs to do a small surgical treatment. Even though equally well informed in advance about the treatment procedure, children handle these new and unexpected situations differently. Some will just accept this as a matter of fact and cope well with what has to be done. Others can get very upset and the dentist will have to pay a lot of attention to the patient, comforting, informing, and so on, before treatment can be continued. In some cases it might even be impossible to proceed with the treatment right away or without use of sedation.

Table 3.2 Examples of developmental tasks

Age period	Task
Infancy to preschool	Attachment to caregiver(s) Language Differentiation of self from environment Self-control and compliance
Middle childhood	School adjustment (attendance, appropriate conduct) Academic achievement (e.g., learning to read, do arithmetic) Getting along with peers (acceptance, making friends) Rule-governed conduct (following rules of society for moral behavior and social conduct)
Adolescence	Successful transition to secondary schooling Academic achievement (learning skills needed for higher education or work) Involvement in extracurricular activities (e.g., sports, clubs) Forming close friendships within and across gender Forming a cohesive sense of self; identity

Adapted from Masten & Coatsworth 1998 [17].

These developmental tasks reflect several broad domains of competence in the environment and, within each domain, a developmental progression. One fundamental domain is *conduct* (how well one follows the rules). Early in childhood, children are

expected to begin controlling their behavior and complying with parental directives. Later, as they enter school, they are expected to learn and follow the rules for classroom conduct and refrain from striking out at people in a disagreement. By adolescence, they are expected to follow the rules of schools, home, and society without direct supervision. By middle childhood, *academic achievement* is an important domain of success for children in many societies; it continues to be important in adolescence, with the quality of expected performance continually rising. *Getting along with other children* becomes a salient domain by middle childhood, initially in terms of peer acceptance and later in terms of developing friendships and romantic relationships. Within the individual, the *self-domain* is the most common task arena, first in the form of differentiating one's self from the environment and later in terms of identity and autonomy.

Developmental tasks reflect both universal human phenomena in development, such as attachment to caregivers and language, as well as more culturally or historically specific tasks. School achievement, for example, is salient in many cultures, but not in all. Individual identity as a task may have more prominence in cultures that emphasize individualism and autonomy compared to those that emphasize community and belonging.

Deciding whether a child is competent can be difficult when a child lives in a cultural or community context that differs markedly from the larger society in which the community or ethnic group is embedded. Children may for example live in highly dangerous inner-city neighborhoods where survival could depend on behavior viewed as inappropriate in mainstream society.

Rapidly expanding knowledge about early child development indicates the importance of the early childhood years as a foundation for later competence. The early development of motor skills, language, self-confidence, play, and problem-solving abilities, for example, are highly relevant for understanding competence in the school years. Underlying these capabilities is a developing brain. Recent studies of humans and other species have made it clear that the brain is profoundly responsive to experience.

Motivational systems are also central to human competence. Babies are delighted by exercising new-found skills, like blowing bubbles, making sounds, or dropping food from the highchair, whereas older children find pleasure in activities like singing nonsense songs, making jokes, solving puzzles, or riding a bike. There is a *mastery motivation* system inherent in our species, which is readily observable in the inclination of young children to actively engage with the environment and to experience pleasure (feelings of efficacy) from effective interactions. It is clear that children's beliefs about their own success affect their behavior.

Man is a social animal

Without others we do not develop the different skills that make us into human beings. Personal relationships are central to children's and adolescents' ability to tackle developmental tasks and challenges. Some of these relationships are more important than others. Attachment relations come first [18], and they set the stage for later relations to siblings, peers, adults outside the immediate family, etc.

Attachment theory

Although extremely vulnerable and dependent, newborn babies arrive in the world equipped with a sophisticated array of inbuilt behaviors designed to maximize their survival. Two of these behaviors, and the systems that underpin them, are the *attachment* and *exploratory* behavior systems. Like the offspring of other nomadic mammals, human babies need to learn not *where* to flee in times of danger but to *whom*. The exploratory and the attachment systems work like communicating vessels; when one is active the other is downregulated. When the child feels safe and knows that his attachment figure is available, the child's exploratory system is turned up, and the child is free to interact with the world around him and to incorporate new aspects of the world around him. When the toddler or preschooler encounters something that is experienced as threatening the attachment system is immediately activated; exploration halts and the child instead focuses on reuniting with her attachment figure as soon as possible [19]. Over the first years of life most children learn to use their parent or parents as a *secure base* from which to explore the surrounding environment, and as a *safe haven* to return to in times of stress or danger.

The older children get, the more capable will they be in handling mildly stressful situations on their own. It is, however, important to keep in mind that this does not mean that attachment becomes less important as the child grows older, it simply means that the attachment system is less often activated. However, when activated it is just as stressful for older children or adolescents not to have their attachment needs met properly as it is for young children.

Depending largely on the characteristics of the caregiving environment, children vary in their capacity to use the parent as a secure base or safe haven. Technically this is referred to as children developing different attachment patterns (secure, avoidant, resistant, disorganized) [20,21]. The caregiving experiences children have with their attachment figures will be stored in the brain as mental representations, schemas or, as they are called in attachment theory, *internal working models* of the child interacting with important others. These internal working models carry within them important information with regard to the caregiver (as trustworthy and reliable or as unpredictable or, even worse, as dangerous) as well as the children themselves (as worthy of love and respect, as one who has to rely on themselves, as helpless, or in the worst scenario as someone used to being scoffed at or mocked).

The reason why internal working models are important for this chapter is that they are used as "filters." Later encounters with adults outside the immediate family will be experienced through the "lens" of these early working models. Remember Piaget's concepts of assimilation and accommodation. Children

Box 3.5

Typically children are cautious during their first dental visit and parents handle this in different ways. Many parents encourage their child to get acquainted with the novel situation by letting the child answer the questions from the dental team when possible; they praise the child's behavior, and make comforting comments. These parents function as a secure base from which the child makes expeditions. Other parents are quite the opposite. They answer all questions without giving the child even a chance, or they may literary cling to the child thereby restricting the possibility of the child being able to explore the dental operatory. Sometimes these different interaction patterns can already be observed when the child is in the waiting room. Some children are allowed to play freely, while others are more supervised, and sometimes even physically restrained, by their parents.

use their existing knowledge of social encounters (based to a high degree on their interaction with attachment figures) to predict how unknown people will interact with them, *and* how they should interact with these people. The more negative caregiving experiences the child has had, the more likely he or she is to treat nice strangers as if they were mean and unreliable. For similar reasons, encounters with medical personnel with unfortunate endings prime the child in a negative way (Box 3.5).

Social ecology

Since the 1970s there has been a strong push to widen the scope from the parent–child dyad to the family at large as well as to the child and his or her family in the context of the wider social network. Urie Bronfenbrenner [22] was one of the key people in launching this area of research. He emphasized that a child grows up in a complex social environment (a *social ecology*) with a distinct cast of characters: sibling(s), parent(s), grandparents, day-care workers, teachers, peers, etc. And this cast is in turn embedded within a larger social context. The parents may or may not have jobs, jobs that they may like or dislike. Day-care environments vary greatly in terms of organization and quality, the family's social support system (grandparents, neighbors, friends) may be thin and fragile or it can be dense and reliable. Depending on the family's financial and social situation they may live in a well-to-do suburb, or in an inner-city or suburban area stricken by ethnic violence and crime, or anywhere in between.

Box 3.6

Ashif is a 6-year-old boy from an immigrant background who lives in a suburban area. He arrived as a refugee 2 years ago together with his mother, father, and two elder sisters. The family had to travel for quite a while and under hardship to get here but they now have a permit to stay. The parents have great difficulties understanding and speaking the language. The dentist expects to find a deteriorated oral health as she has seen before in many young patients with a background similar to that of Ashif. But the dental examination reveals healthy teeth and gums. Talking to Ashif and his accompanying parent she finds out that the family is very competent and motivated regarding oral hygiene and diet, and that they have very healthy habits.

One of the most important aspects of Bronfenbrenner's research was his discussion of what he called *social addresses*. Social addresses are, for example, low socioeconomic status, working-class family, alcoholic parent, immigrant family. Much early research in clinical psychology and child and adolescent psychiatry had shown that psychological ill-health is much more common in children living in families with "negative" social addresses. But, as Bronfenbrenner repeatedly stressed, a child's psychological health is not influenced by the social address in itself. Most children in poor or immigrant families develop just as good psychological health as children from more well-to-do families. It is only when the social address impinges on the parent's care-giving capacity that we expect psychological consequences to follow. Thus, as Bronfenbrenner has warned us, the social address is only statistically, *not* causally, related to the psychological outcome (e.g., psychological health). The clinician should always have this in mind, trying the best he or she can to treat each new patient or parent as an individual and not as a representative of a social group (Box 3.6).

A holistic description of children of different ages

Let us end the description of normal development by trying to put the different pieces together. For the reader who wants to know more about children's psychological development there are a number of good textbooks in developmental psychology. The following holistic sketch of children of different ages is based on Helen Bee and Denise Boyd's *The developing child* [23].

The preschool years (3–5 years)

The main theme of the preschool period is that the child is making a slow, but immensely important shift in balance with regard to how much and in which situations he or she depends

on others, especially parents. The toddler, and later the preschooler, moves around easily, can communicate more (and more clearly), and has a growing sense of himself or herself as a separate person with specific qualities. He or she also has the beginning of cognitive and social skills that allow him or her to interact more fully and successfully with playmates. In these years, the child's thinking is decentering, to use Piaget's term: the child shifts from using himself or herself as the sole frame of reference and becomes less tied to physical appearances.

Among toddlers, new-found skills and new independence are often not accompanied by much impulse control. Two-year-olds in general are pretty good at doing, but they are terrible at *not* doing. If frustrated, they tend to hit things, and wail, scream, or shout. A large part of the conflict parents experience with children of this age arises because the parent must limit the child, not only for the child's own safety, but also to help teach the child emotional self-regulation. The preschool years also stand out as the period in which the seeds of the child's social skills and personality are sown (Box 3.7).

Box 3.7

Joe is 4 years old and has just had a little sister. During weekdays he is at home with his mother, and usually sees children of his own age a couple of times every week. He likes playing with his friends, rides a three-wheeler and wants to have a two-wheel bike for his birthday. Becoming a big brother has been revolutionary; lots of jealousy and adjustment difficulties, but at the same time Joe is also very proud of his sister. In order to maintain his security and position with his mother he sometimes clings to her or wants to sit on her lap. During the dental visit he talks a lot and frequently asks for the names of the instruments and wants to know precisely what each is used for. He enjoys having his teeth checked, and cooperates well. His teeth can be examined and polished without any problems.

The attachment process that began in infancy continues to be formative, because it helps to shape the child's internal working model of social relationships. However, in the years from 2 to 6 the early model is continuously updated, for some children consolidated, for others revised and established more firmly. The resultant interaction patterns tend to persist into elementary school and beyond. The 3-, 4-, or 5-year-old child who develops the ability to share, to read others' cues well, to respond positively to others, and to control aggression and impulsiveness is likely to be a socially successful, popular 8-year-old [24]. In contrast, the noncompliant, hostile preschooler is far more likely to become an unpopular, aggressive schoolchild [25].

The elementary school years (6–12 years)

Some kind of transition into middle childhood is noted in most cultures. There seems to be widespread recognition that a 6-year-old child is somehow qualitatively different from a 4- to 5-year-old child: more responsible, and more able to understand complex ideas. The fact that schooling begins at this age in many cultures seems to reflect an implicit or explicit recognition of this fundamental shift. Cognitively, the child now understands, for example, conservation problems (that the amount of liquid is the same whether in a narrow and high container or in a wide and low one). More generally, the child seems to be captured less by appearance, and instead focuses more on the underlying reality (i.e., pays less attention to surface properties of objects and more to underlying continuities and patterns). This can be seen not only in children's understanding of physical objects but also in their understanding of relationships and of themselves. In terms of self-concept, a global judgment of self-worth first emerges at about the age of 7 or 8 years. In most cultures gender segregation becomes the rule, especially in individual friendships, by age 6 or 7 years.

There seem to be two aspects of developmental processes at work in the elementary school years:

- *Cognitive influences*. Of the developmental shifts seen during middle childhood, the cognitive seem the most central, comprising a necessary condition for the alterations in relationships and in the self-scheme that also occur during this period. Similarly, the quality of a child's relationships with peers and parents seems to rest in part on a basic cognitive understanding of reciprocity and perspective taking. The child now understands that others read him or her as much as he or she reads them.
- *Peer group influences*. A great deal of a child's experiences at this age comes from social interactions with peers. Social relationships present the child with a unique set of demands, both cognitive and interactive, and have unique consequences for the child's social and emotional functioning. It is during the elementary school years, for example, that patterns of peer rejection or acceptance are consolidated, with reverberations through adolescence (and into adult life) (Box 3.8).

Box 3.8

Sarah is 11 years old and spends most of her time with friends. When not together they still keep in contact using social media or texting to one another. She is doing all right in school, and is well aware of how her friends and classmates perform in different subjects. When seeing the dentist she is very talkative and eager to behave as she believes is expected of her. She has had a filling or two at a previous visit without any problems. Sarah has a deep cavity in a lower first molar. The filling therapy is carried out under local anesthesia without any problem and is much quicker than expected. As there is plenty of time left, the dentist suggests placing fissure sealants on two second upper molars that have just erupted. Sarah agrees to this. It turns out to be tricky to achieve good isolation for placing the sealants and suddenly Sarah is all in tears. In this case Sarah has already had a filling done, which was probably quite stressful. The filling was decided and agreed on beforehand, and was what Sarah had prepared herself for when she showed up. Sarah is typical of a child who wants to be a good patient, but not yet fully capable of saying no when the dentist suggests additional therapy even though she is not up to it. Apparently this was just too much for Sarah to handle. The dentist should not have suggested the sealant therapy. Instead the dentist should have stuck to the original agreement even though there was spare time for additional treatment.

Adolescence (13–18 years)

Early adolescence, almost by definition, is a time of transition, of significant change in virtually every aspect of the child's functioning. Late adolescence is more a time of consolidation, when the teenager establishes a cohesive new identity, with clearer goals and commitments. Early adolescence is a time dominated by assimilation whereas late adolescence is primarily a time of accommodation, to use Piaget's terminology. The 12- or 13-year-old is assimilating an enormous number of new physical, social, and intellectual experiences. While all this absorption is going on, but before the experiences have been digested, the child is in a more or less continuous state of disequilibrium. Old patterns, old schemes no longer work very well, but new ones have not yet been established. It is during this early period that the peer group is so centrally important. Ultimately, the 16-, 17-, or 18-year-old begins to make the necessary accommodation, pulls the threads together, and establishes a new identity, new patterns of social relationships, new goals, and roles.

In some ways, the early years of adolescence have a lot in common with the toddler years. Many go through a period of negativism or sulkiness—from the parents' points of view strikingly similar to a 2-year-old—right at the beginning of the pubertal changes. Many of the conflicts with parents center on issues of independence: to come and go when they please, listen to music they prefer (at maximum volume), and wear the clothing and hair style that are currently "in." As is true for the negativism of 2-year-olds, it is easy to overstate the depth and/or breadth of the conflict between young teenagers and their parents. For the great majority there is no turmoil, but simply a temporary increase in the frequency of disagreements or disputes.

Drawing a parallel between young adolescents and toddlers also makes sense in that both age groups face the task of establishing a separate identity. Toddlers must begin to separate themselves from the relationship with their primary caregivers to make room for other important relationships (with other adults and with peers). Young adolescents must separate themselves from the identity as a child and begin to renegotiate their attachment relationships with the primary caregivers based on the fact that they will soon be adults too (Box 3.9).

Late adolescence is more like the preschool years, major changes have been weathered, and a new balance has been achieved. The physical upheavals of puberty are mostly complete, the family system has accommodated to allow the teenager more independence and freedom, and the beginnings of a new identity have been created. The task of forming emotionally intimate partnerships is a key task of late adolescence. How the society at large functions, in terms of welcoming the older adolescent into a meaningful community, is of great importance. If separating from the family of origin is not coupled with a new sense of belonging, not only in a peer group but also in the culture at large, adolescents will be left with a sense of betrayal and of rootlessness.

Caspi and Moffitt [26] made the more general point that any major life crisis or transition, including adolescence, has the effect of accentuating earlier personality or behavioral patterns rather than creating new ones. As one example, Caspi and Moffitt point out that girls who experience very early puberty have higher rates of psychological problems, on average, than do those who experience puberty at a more average age. Closer analysis, however, reveals that it is only the early-maturing girls who already had social problems before puberty, whose pubertal experience and adolescence are more negative. Not only do we "carry ourselves with us" as we move through the roles and demands of late adolescence and adult life, but existing patterns may be most highly visible when we are under stress.

With this we conclude our description of "typical" development, and now end the chapter with an introduction into how most developmentalists currently conceptualize deviant development.

Box 3.9

Mary is 14 years old and in blooming adolescence. She frequently misses her dental appointments, and is sometimes quite rude to the dental staff. Mary used to have good oral health, but during the past couple of years she has developed several new cavities and her oral hygiene is poor. She has been assessed as a risk patient for oral disease and been on a recall system where she sees a dental hygienist every 4–6 months. This has not helped very much and when new radiographs are taken they disclose four new cavities needing conservative therapy and seven new incipient lesions. The dentist is concerned about Mary's well-being, but when asked about her health Mary is not very cooperative. The dentist loses patience and says he will have to contact her parents. When hearing this, Mary gets up and leaves the clinic without saying a word.

Mary wants to be both a child and a grown-up. Her behavior with missed appointments and rudeness indicates that she might be going through a stormy period of adolescence. It is often difficult to handle these patients in a good way. On the one hand the dentist is responsible for her dental care and the teenager is still legally under the care and supervision of her parents. Bringing the parents into the discussion, however, makes Mary feel patronized and looked upon as a young child. Allowing time for communication, and acknowledging the fact that oral hygiene and dental appointments are not among her top 10 priorities may help. It is important to show that you trust the patient, but also to make clear that you expect her to take responsibility for oral hygiene and to behave acceptably. Trying to reach an agreement with the adolescent so that she is involved in the decision, rather than told what to do, may help. It is suggested that parents are consulted only if this strategy fails.

Developmental psychopathology: development gone awry

Our knowledge about psychological deviance has been enormously enhanced by an approach called *developmental psychopathology*, launched in the 1970s and 1980s by Norman Garmezy, Michael Rutter, Alan Sroufe, and others. It differs from traditional child and adolescent psychiatry (with its phenomenological psychiatric diagnoses) in several important ways. First of all psychopathology is conceptualized as normal development gone awry. Normal and abnormal development are both conceptualized as emerging from the same basic processes rather than being qualitatively different [27]. Dental phobia is from this perspective quantitatively, not qualitatively, different from less severe forms of dental fear and anxiety.

Not only is a child's developmental status at any point in time seen as a result of an ongoing interaction between different biopsychosocial factors. Time itself is also an important aspect. Early caregiving experiences (as discussed earlier in the section on attachment) result in internal working models that the child carries with him or her to day-care, for example. The child's interaction with his or her care providers and peers is thus affected by his or her earlier experiences with parents. In developmental psychopathology, the effect of earlier experiences is conceptualized as a result of a series of transactions between the child and his or her immediate environment. To every new transaction the child carries the result of previous transactions, that is, how well he or she has resolved earlier developmental tasks, and how supporting the environment has been in helping with these accomplishments.

The biopsychosocial model

One outgrowth of the transactional model has been a growing acceptance of the viewpoint that neurobiological development and experience are mutually influencing. It has, for example, been demonstrated that just as gene expression alters social behavior, so do social experiences also exert actions on the brain by feedback to modify gene expression (epigenetics) and brain structure, function, and organization. There is suggestive evidence that adverse early experiences inhibit structural plasticity via a hypersensitivity to glucocorticoids and impair the ability of the hippocampus to respond adaptively to stress in later childhood, adolescence, and adulthood. Furthermore, it has been shown that alterations in gene expression induced by learning and by social and psychological experiences produce changes in patterns of neuronal and synaptic connections and, thus, in the function of nerve cells. Such modifications not only exert a prominent role in initiating and maintaining the behavioral changes, but also contribute to the biological basis of individuality, as well as to individuals being differentially affected by similar experiences [28].

The development of psychopathology is discussed not in terms of singular causes (whether environmental or genetic) but as the probabilistic development of abnormal development due to the cumulative effect of different vulnerability and risk factors. The concept of "vulnerability" is most often used to describe inborn (e.g., an inhibited or overactive temperament) or early acquired aspects of the child (e.g., disorganized attachment), while the term "risk factor" is more often used to describe aspects of the environment that are known to be associated with increased probability of developing psychopathology (e.g., various "social addresses"). Most research in developmental psychopathology shows that it is the number of vulnerability and risk factors, rather than any single factor, that will lead to a deviant outcome.