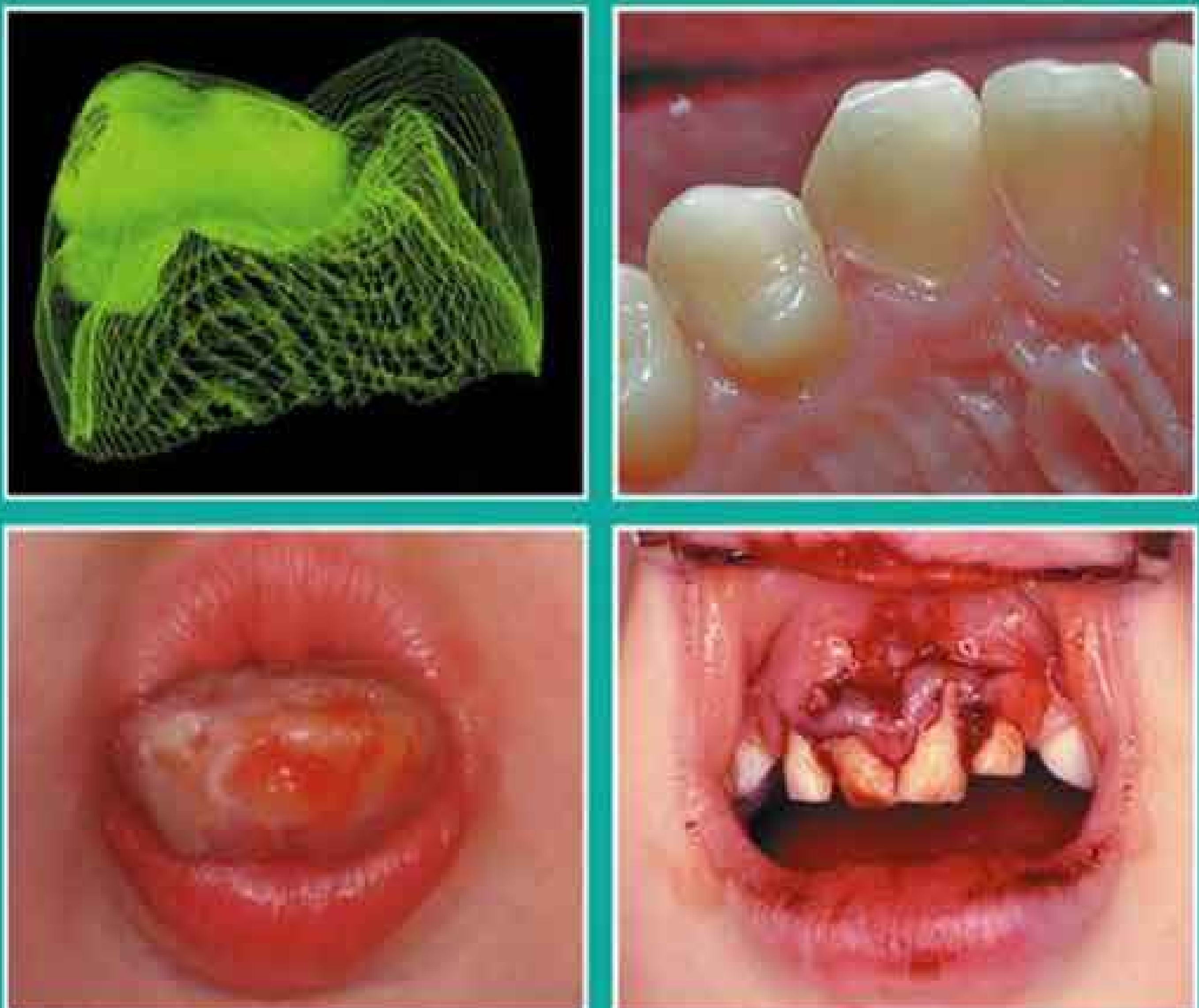
THIRD EDITION

Pediatric Dentistry

A Clinical Approach

EDITED BY

GÖRAN KOCH • SVEN POULSEN • IVAR ESPELID • DORTE HAUBEK



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About the Editors

Göran Koch
Department of Pediatric Dentistry
The Institute for Postgraduate Dental Education
Jönköping
Sweden

Sven Poulsen
Section for Paediatric Dentistry
Department of Dentistry and Oral Health
Aarhus University
Aarhus
Denmark

Ivar Espelid
Department of Paediatric Dentistry and Behavioral Science
Institute of Clinical Dentistry
University of Oslo
Oslo
Norway

Dorte Haubek
Section for Paediatric Dentistry
Department of Dentistry and Oral Health
Aarhus University
Aarhus
Denmark

Contributors

Anita Alm
Department of Pediatric Dentistry
Skaraborg Hospital
Skövde
Sweden
and
Department of Preventive and Community Dentistry
Public Dental Health Service
Västra Götaland Region
Göteborg
Sweden

Jens O. Andreasen
Department of Oral and Maxillofacial Surgery
Copenhagen University Hospital (Rigshospitalet)
Copenhagen
Denmark

Inga B. Arnadottir
Faculty of Odontology
School of Health Sciences
University of Iceland
Reykjavik
Iceland

Kristina Arnrup
Department of Pediatric Dentistry
Postgraduate Dental Education Centre
Public Dental Service
Örebro
Sweden
and
Faculty of Medicine and Health
School of Health Sciences
Örebro University
Örebro
Sweden

Anders G. Broberg
Department of Psychology
University of Gothenburg
Göteborg
Sweden

Göran Dahllöf
Division of Pediatric Dentistry
Department of Dental Medicine
Karolinska Institutet
Huddinge
Sweden

Monty S. Duggal
Department of Paediatric Dentistry
School of Dentistry
University of Leeds
Leeds
UK

Hans Gjørup
Center for Oral Health in Rare Diseases
Department of Maxillofacial Surgery
Aarhus University Hospital
Aarhus
Denmark

Margaret Grindefjord
Department of Pediatric Dentistry
Eastman Institute
Public Dental Service
Stockholm
Sweden
and
Division of Pediatric Dentistry
Department of Dental Medicine
Karolinska Institutet
Huddinge
Sweden

Gro Haukali
Municipal Child Dental Service of Aarhus
Aarhus
Denmark

Martti Helkimo
Department of Stomatognathic Physiology
The Institute for Postgraduate Dental Education
Jönköping
Sweden

Hanne Hintze
Section of Oral Radiology
School of Dentistry
Faculty of Health and Medical Sciences
University of Copenhagen
Copenhagen
Denmark
and
Specialist Clinic of Oral Surgery and Radiology
Aarhus
Denmark

Pernille Endrup Jacobsen
Department of Specialized Oral Health Care
Viborg Regional Hospital
Central Jutland
Denmark

Birgitta Jälevik
Department of Pediatric Dentistry
The Sahlgrenska Academy
University of Gothenburg
Göteborg
Sweden

Simon Storgård Jensen
Department of Oral and Maxillofacial Surgery
Copenhagen University Hospital (Rigshospitalet)
Copenhagen
Denmark

Ann-Katrin Johansson
Department of Clinical Dentistry
Faculty of Medicine and Dentistry
University of Bergen
Bergen
Norway

Annika Julihn
Division of Pediatric Dentistry
Department of Dental Medicine
Karolinska Institutet
Huddinge
Sweden
and
Specialist Clinic of Pediatric Dentistry, Göteborg
Public Dental Service in Västra Götaland
Göteborg
Sweden

Anders Juul
Department of Growth and Reproduction
Copenhagen University Hospital (Rigshospitalet)
Copenhagen
Denmark

Gunilla Klingberg
Department of Pediatric Dentistry
Faculty of Odontology
Malmö University
Malmö
Sweden

Sven Kreiborg
Department of Odontology
Pediatric Dentistry and Clinical Genetics
Faculty of Health and Medical Sciences
University of Copenhagen
Copenhagen
Denmark

Jüri Kurol
Formerly of Department of Orthodontics
The Sahlgrenska Academy
University of Gothenburg
Göteborg
Sweden

Therese Kvist
Division of Pediatric Dentistry
Department of Dental Medicine
Karolinska Institutet
Huddinge
Sweden

Eva Fejerskov Lauridsen
Department of Pediatric Dentistry and Clinical Genetics
School of Dentistry
Faculty of Health and Medical Sciences
University of Copenhagen
Copenhagen
Denmark

Stefan Lundeberg
Department of Pediatric Anesthesia
Operating Services and Intensive Care
Astrid Lindgren Children's Hospital
Karolinska University Hospital
Stockholm
Sweden

Tomas Magnusson
School of Health and Welfare
Jönköping University
Jönköping
Sweden

Katharina M. Main
Department of Growth and Reproduction
Copenhagen University Hospital (Rigshospitalet)
Copenhagen
Denmark

Luc Martens
Department of Paediatric Dentistry and Special Care
University of Ghent
Ghent
Belgium

Bengt Mohlin
Department of Orthodontics
The Sahlgrenska Academy
University of Gothenburg
Göteborg
Sweden

Hani Nazzal
Department of Paediatric Dentistry
School of Dentistry
University of Leeds
Leeds
UK

Johanna Norderyd
National Oral Disability Centre for Rare Disorders
The Institute for Postgraduate Dental Education
Jönköping
Sweden
and
School of Health and Welfare
Jönköping University
Jönköping
Sweden

June Nunn
Public and Child Dental Health
School of Dental Science
Trinity College Dublin
Dublin
Ireland

Birthe Høgsbro Østergaard
Section for Paediatric Dentistry
Department of Dentistry
Health
Aarhus University
Aarhus
Denmark

Maria Ransjö
Department of Orthodontics
The Sahlgrenska Academy
University of Gothenburg
Göteborg
Sweden

Anne Rønneberg
Department of Paediatric Dentistry and Behavioural Science
Institute of Clinical Dentistry
University of Oslo
Oslo
Norway

Bengt Sjödin
Department of Periodontology
Postgraduate Dental Education Centre
Örebro
Sweden

Marit Slåttelid Skeie
Department of Pedodontic Dentistry
Institute of Clinical Odontology
The Faculty of Medicine and Dentistry
University of Bergen
Bergen
Norway

Flemming Skovby
Division of Clinical Genetics
Department of Pediatrics
Zealand University Hospital
Roskilde
Denmark

Christina Stecksén-Blicks
Pediatric Dentistry
Department of Odontology
Faculty of Medicine
Umeå University
Umeå
Sweden

Irma Thesleff
Developmental Biology Research Program
Institute of Biotechnology
University of Helsinki
Helsinki
Finland

Svante Twetman
Department of Odontology, Section for Cariology and Endodontics
Faculty of Health and Medical Sciences
University of Copenhagen
Copenhagen
Denmark

Birgitte Uldum
Municipal Dental Service for Children and Adolescents
City of Copenhagen
Copenhagen
Denmark

Lill-Kari Wendt
Centre for Oral Health
School of Health Sciences and Welfare
Jönköping University
Jönköping
Sweden

Anna Westerlund
Department of Orthodontics
The Sahlgrenska Academy
University of Gothenburg
Göteborg
Sweden

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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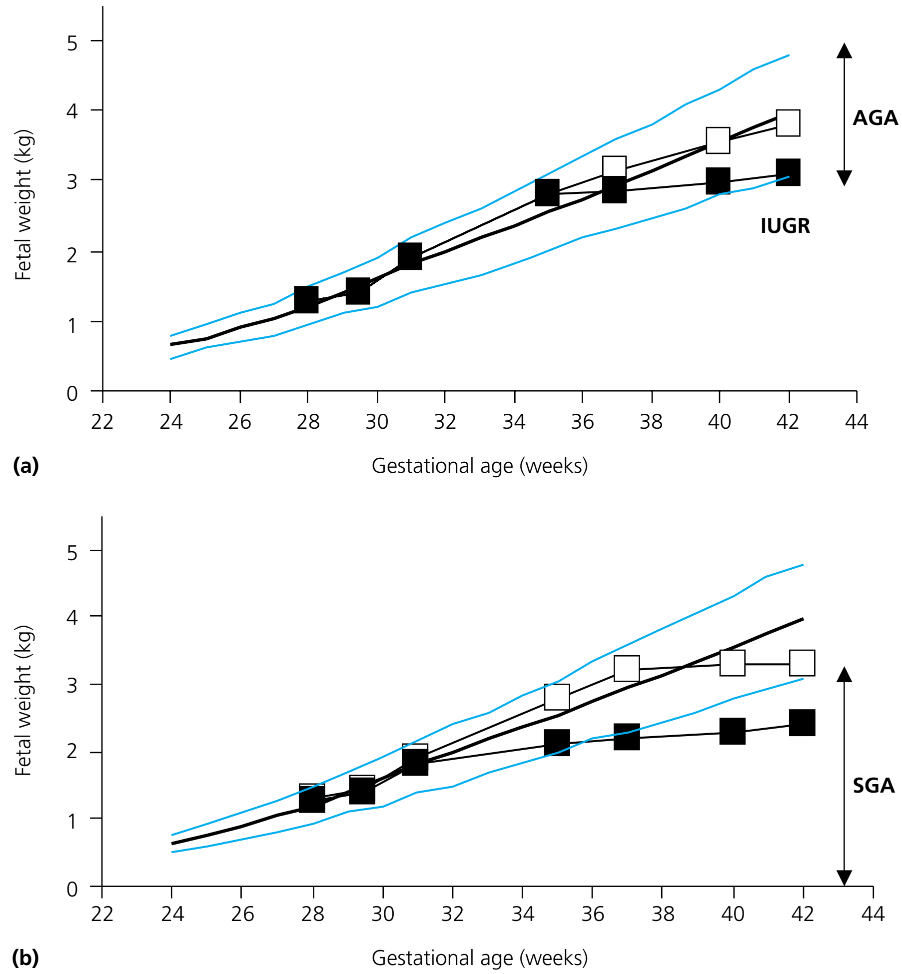

Figure 2.1 Reference ranges for fetal weight according to gestational age during pregnancy denoted by the blue lines (10th, 50th, and 90th percentiles) (8). Panel (a) shows examples of children with normal birth weights at term; a normally growing fetus ending with a birth weight which is appropriate 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].

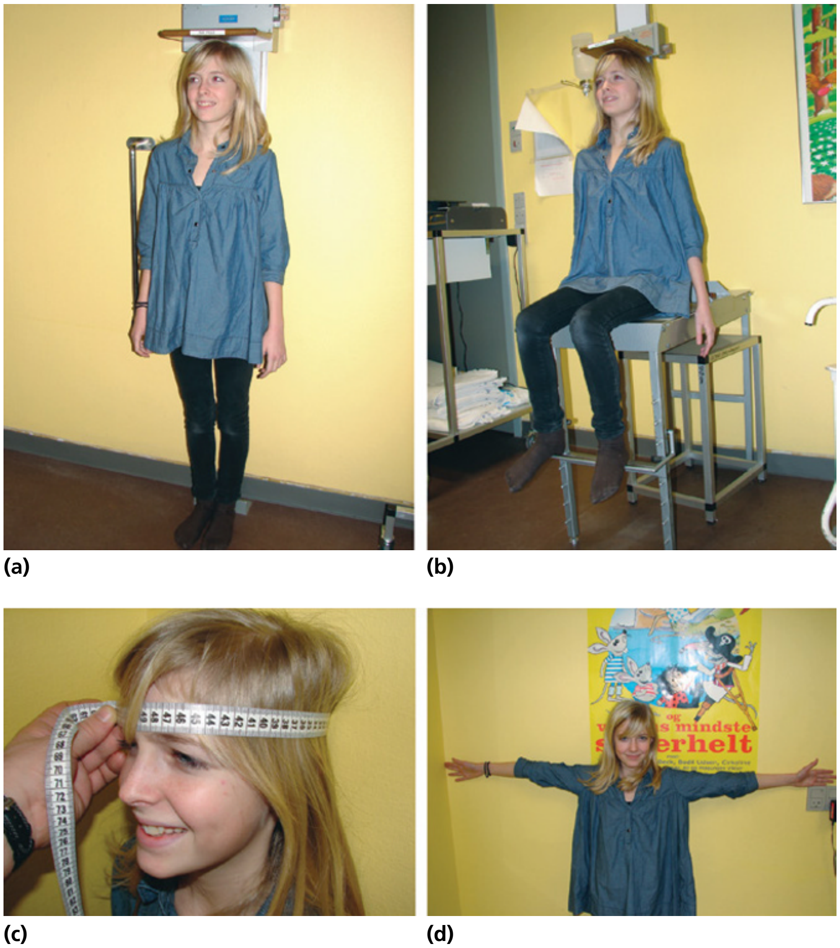

Figure 2.2 Standing height determined by a wall-mounted stadiometer (a). Height is recorded as the mean of three measurements. Sitting height is determined by a specifically designed chair (b). Head circumference is determined using a measuring tape (c). Arm span is determined by measuring the distance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

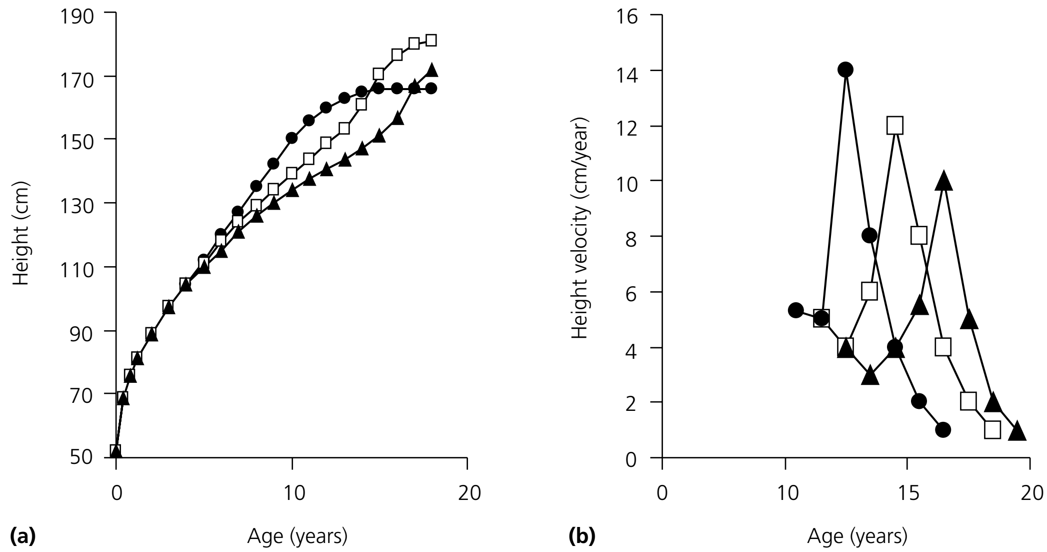

Figure 2.3 (a) Three examples for height curves and (b) height velocity curves from children with early puberty (●), normally timed puberty (□) and delayed puberty (▲). Note that final height is almost the same (a) and that peak height velocity is higher in earlier puberty (b).

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

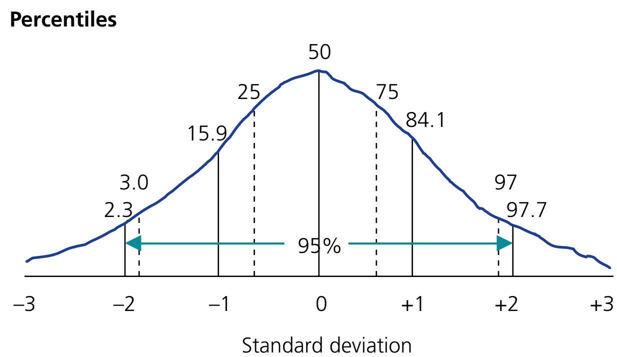

Figure 2.4 Normal (Gaussian) distribution of heights illustrating the 95% reference interval by percentiles or standard deviations (SDs).

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).

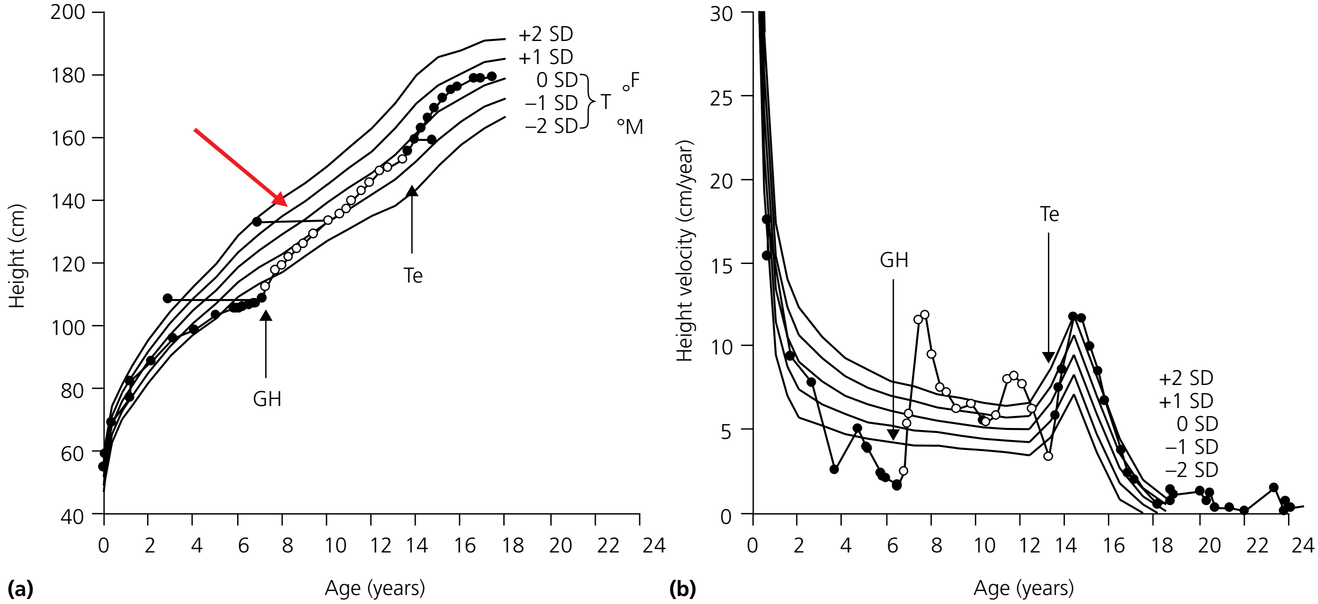

Figure 2.5 Normal height curve (a) based on healthy children. Lines denote mean ±1 standard deviation (SD) and ±2SD. One individual patient is depicted on the curve (●) before and after operation for a pituitary tumor (craniopharyngeoma) resulting in growth hormone deficiency. A typical deceleration 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).

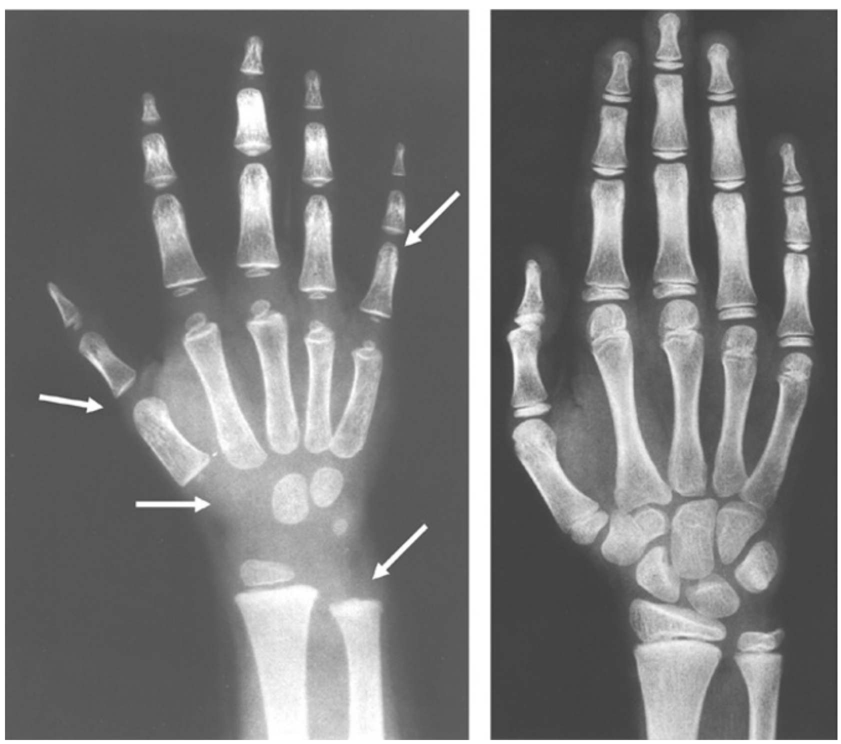

Figure 2.6 Two radiographs of the left hands of two healthy children. Note that the mineralization of the small bones has not yet occurred in the younger child (left).