OPTIMIZING ORTHOGNATHIC SURGERY

Diagnosis • Planning • Procedures

KONRAD WANGERIN
CAROLINE FEDDER (EDS)

QUINTESSENCE PUBLISHING

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In memoriam

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Kiel Connection

Foreword

The editors represent two generations of maxillofacial surgeons, both specializing in orthognathic surgery, who operated together for nearly 5 years. For Konrad Wangerin, these were the last 5 years of his 35-year career, and for Caroline Fedder, the first 5 years after residency. The surgical experience of the older surgeon, who was instrumental in the development of maxillary jaw distraction methods, and the precise now mainly digital treatment planning of the younger surgeon complement each other across the generations.

The chapters with precise photographic documentation, a systematically detailed clinical examination form, and the surgical planning chapter include all steps of a complete case documentation. They also answer the question of when it is appropriate to operate on the mandible first and when to operate on the maxilla first in a maxillomandibular osteotomy.

All surgical methods of orthognathic surgery, including distractions and their indications, are listed. These explanations demonstrate the extensive surgical experience of the author team through an unfiltered presentation of risks, complications, error prevention, limitations of successful method application, and alternatives. A well-considered strategy of complex, multi-stage interdisciplinary treatments – who does what, and when, whether in one stage or two stages, often with orthodontic or dental support – is derived from the illustrated complex case descriptions.

Conventional surgical planning has been gradually replaced by digital 3D surgical planning for years. The increasing complexity of cases has led to more detailed digital planning. It all began with Thomas Lambrecht, who described 3D Styrodur Modeling

Technology based on CT and MRI scans in his monograph in 1995, published by Quintessenz Verlag, and even explained examples from orthognathic surgery. Like the editors and the author of this foreword, he was also part of the “Kiel Connection.”

The current application of this digital 3D planning technique helps the younger generation of surgeons to identify operative challenges and risks during surgical planning, while the older generation had to rely on long-term practical experience. With this 3D planning technique, what used to be solely dysgnathic surgery has evolved into functional and esthetic facial surgery. Modern, complex plastic surgical treatment concepts aimed at improving overall facial esthetics are presented in Volume 1, as well as additional esthetic procedures on the facial soft tissue.

Volume 1 will be complemented by a second volume, in which the interdisciplinary nature of complex treatments will be described in an exciting manner. These include long-term results of 10 to 20 years or more – such long-term results are rare in recent literature. We must not lose sight of the fact that with our surgical outcomes, we are not only sending our patients into a short post-observation period but into the rest of their lives. We have a long-term responsibility for important functions and esthetics, and we should take it seriously. Volumes 1 and 2 are important guides in this regard.

Rolf Ewers, Vienna

Preface

The present book explains the current principles of orthognathic surgery: recognize, evaluate, and act. It contains, described in a practical manner, all the details of photographic diagnostics, conventional surgical planning, and surgical simulations with the production of surgical splints. Exemplary clinical cases explain the entire treatment procedures.

Not only are all common dysgnathic surgical methods explained with indications, advantages and disadvantages, limitations, and potential errors using clinical examples, but also the necessary accompanying procedures in neighboring regions such as the midface, nose, and neck, which have often been overlooked in the past.

Different distraction methods are also successfully integrated into orthognathic surgery as a necessary step for the staged treatment of complex cases. Illustrated examples explain the complexity of the treatment. The function of the temporomandibular joint and the nasopharyngeal airway are not forgotten. A case involving accelerated orthodontic treatment that takes advantage of the postoperative RAP (regional acceleratory phenomenon) effect is also described.

Anesthetic peculiarities that arise from the intraoperative close proximity of both areas of work are presented. Critical phases of surgery are facilitated by extremely precise anesthesiologic support.

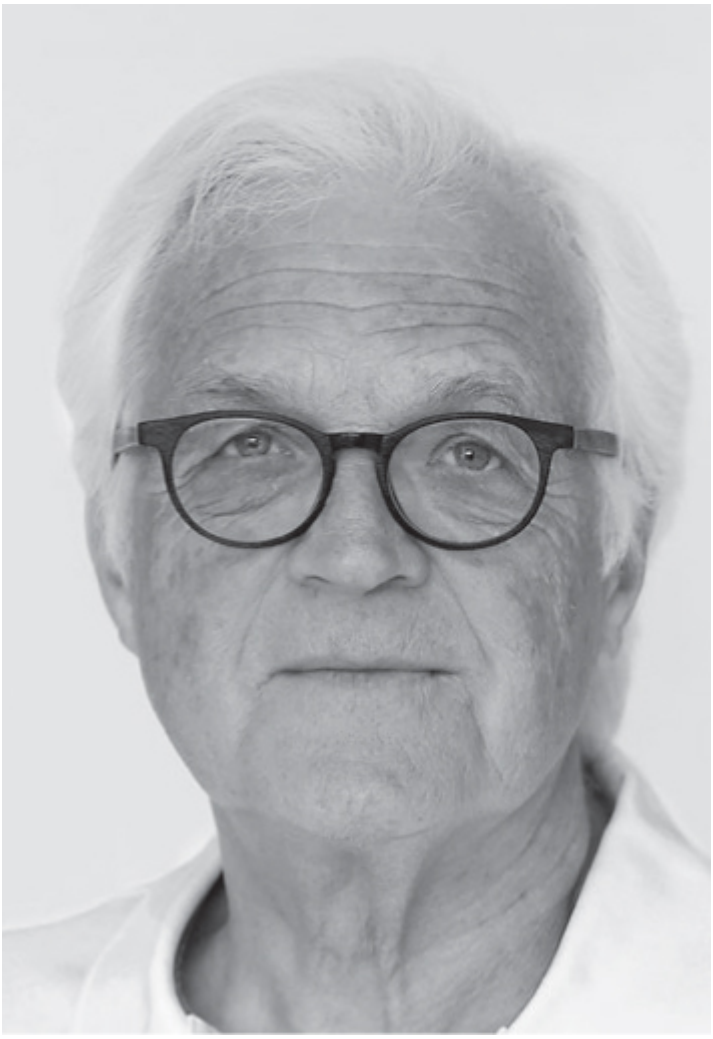
While the correction of malocclusion has been the goal of orthognathic surgery in past decades, today it is the normalization of the facial skeleton and the shaping of a harmonious face with esthetic contours. Several chapters deal with modern plastic surgical treatment concepts and demonstrate impressive esthetic results.

Today, the development of 3D modeling technology has advanced to the point where it can routinely be applied to the surgical planning of even complex dysgnathic corrections. Using a case example, all steps of this phenomenal and forward-looking surgical planning technique are systematically presented. The reverse planning approach, which leads to the prefabrication of individual osteosynthesis plates for the maxilla based on virtual surgical planning on the 3D CT model, which, when used intraoperatively, replace the previous reliance on surgical splints, is also demonstrated. Both developments have the potential to predict the surgical changes in the facial profile, including facial contours. The future goal is to present the patient with their virtual new face preoperatively, which can likely be achieved through surgical changes to the facial skeleton and correction of the malocclusion. However, this foresight is limited by the facial soft tissues and the individual's facial expressions, which cannot yet be digitally captured or altered, either preoperatively or postoperatively.

Konrad Wangerin, Stuttgart
Caroline Fedder, Göppingen

June 2023

Editors



Konrad Wangerin,

Prof Dr Dr Dr hc

Konrad Wangerin studied medicine and dentistry at the Universities of Münster and Cologne, Germany, and in Munich, Germany, at the

Technical University and Ludwig Maximilians University.

His specialization in Maxillofacial Surgery followed from 1979 to1982 at the Ludwig Maximilians University of Munich and at the Christian-Albrecht University of Kiel, Germany. Afterwards he became Senior Registrar and finished his PhD 1988 in Kiel.

In 1990 he moved to the Department of Plastic, Maxillofacial, and Reconstructive Surgery at Marienhospital Stuttgart, Germany, became Chief Surgeon in 1991, and in 1994 was appointed as Adjunct Professor of the Medical Faculty of the University of Kiel and Medical Director at the Marienhospital.

By 1994 he had operated the first intraoral mandibular distraction worldwide and invented several intraoral distractors for the mandible and maxilla, gaining huge experience in distraction work and lecturing and operating around the world.

In 2002 he was awarded an Honorary Degree from the Technical University of Cluj-Napoca, Romania.

After his retirement in 2011, he continued as Senior Director in the medius Clinic Ostfildern-Ruit, and since 2014 he has worked in the private office for maxillofacial and oral surgery together with Dr Roman Beniashvili, at Schorndorf, near Stuttgart, Germany.

Caroline Fedder,

Dr med

Caroline Fedder studied medicine and dentistry at the Medizinische Hochschule Hannover, Germany, and University of Wales College of Medicine, United Kingdom, from 1996 and completed her thesis (Dr med) 2005 in Hannover. She started her medical specialization in maxillofacial surgery in the private Stadtparkpraxis in Hannover, continued at the University Hospital Zürich, Switzerland, and finished 2010 at Katharinenhospital, Stuttgart, Germany.

She met chairman Konrad Wangerin at the Marienhospital Stuttgart, where she joined his department and began her additional

specialization in Orthognathic Surgery.

In 2014 she became Senior Registrar at the medius Clinic Ostfildern-Ruit, and in 2019 gained the specialization Plastic Operations. In the same year she co-founded the clinic for maxillofacial and plastic facial surgery of the Alb-Fils Clinics Göppingen, Germany, and became leading Senior Registrar. Dr Fedder regularly lectures on orthognathic surgery, especially in interdisciplinary symposia with orthodontists, and dedicates her time to facilitating open access to knowledge and high-quality training for surgeons in orthognathic surgery.

Acknowledgments

Konrad Wangerin

This book would not have been possible without the help and collaboration of many colleagues, staff members, friends, and, above all, our patients. I would like to express my thanks to all those who allowed me to depict individual treatment steps or results visually.

I extend a heartfelt thank you to Kathleen Weber and Christian Lange. They have accompanied me for many years, providing unlimited time and all the strength of their organizational skills and computer knowledge. Their support has been tremendous.

Without my longtime friend and orthodontic buddy, Dr Christopher-George Hepburn from Ludwigsburg, Germany, the photographic foundation of this book would not have been achievable. We owe our decades-long trustful interdisciplinary collaboration in two such different fields as orthodontics and maxillofacial surgery, both conservative and surgical, to his father, Dr Christian Hepburn, who passed away in April of this year at the age of 90. Both have played a significant role in many combined complex treatment plans, and Christopher is a co-editor of Volume 2, in which we present our complex treatment cases and long-term results. The two employees of the orthodontic practice, Claudia Brunsch and Carmen Saub, also deserve grateful mention.

I also thank my senior physician and later successor at the clinic, Dr Dr Dr Winfried Kretschmer, with whom I have successfully collaborated for over 20 years, as well as our friends Prof Dr Mihaela and Prof Dr Grigore Baciut from Cluj-Napoca in Romania. Special thanks go to our visiting physician, Hytham Al Rabadi MD

from Amman, Jordan, my practice partner Dr Roman Beniashvili from Schorndorf, Germany, along with Dr Bastian Kern from Waiblingen, Dr Claudia Schrempf from Stuttgart, Germany, Dr Hartwig Paulo from Gelsenkirchen, Germany, Dr Hans-Jörg Becker and his wife Uschi Becker from Zurich, Switzerland, and my friend Dr Bernhard Fuchs from Leonberg, Germany,

I was delighted that Caroline Fedder agreed to work on this project, and thank her for her diligence and precision.

Thanks also to the Ruiter/Göppingen team, including Nadine Kramer, Jessica Coimbra Marques, Claudia Geiger, Jessica Stahlbaum, and Vanessa Wolfer. Thanks also to Judit and Sanjeewa Perera from Ludwigsburg, and their involvement in the facial deformities support association..

Thanks to Andreas Reinhardt from Kiel, Germany, for the wonderful drawings, thanks to ZTM Horst-Dieter Kraus from Stuttgart, and thanks also to the medical-technical advice and support from Barbara Schneider, Kristine Schröder, Joachim Schmid, Andreas Burger, and Adalbert Frech from Tuttlingen, Germany.

And finally, the last thank you goes to the most important people in my life, my family, Andrea, Adrian, and Gregor. Thank you for your understanding and patience.

Caroline Fedder

First and foremost, a big thank you to all the patients who allowed me to use their photos, radiographs, and treatment records, without which the compilation of such a comprehensive and hopefully informative textbook would never have been possible. Many descriptions become even clearer with the exemplary images – we learn from what we see. A special thanks at this point goes to the patient whose case I was allowed to present in detail in the surgical planning chapter.

Furthermore, I would like to thank my long-standing team, now located in the Alb-Fils clinics in Göppingen after three relocations,

who have supported me beyond their working hours in taking photos, selecting radiographs/photos, and, in some cases, serving as models. Kathleen Weber, Vanessa Wolfer, Jessica Coimbra-Marques, Jessica Stahlbaum, Nadine Kramer, Claudia Geiger, Ina Schmitt, and Adela Sabau deserve special mention. They were always ready to implement the next crazy task without hesitation. My team carries me through each working day with the knowledge of fulfilling a meaningful task that is also enjoyable. Teaching and seeing my young colleagues grow professionally is a great gift.

Heartfelt thanks also to Ingo Röthele, who patiently and devotedly carried out the technically and time-consuming professional photo documentation of conventional planning. The model operation was carried out by Jan Ternes – our long-standing dental technician – who has become a master at achieving the desired target occlusion quietly and diligently, always finding a solution based on his, like ours, extensive experience of 3D printing.

I would like to thank my dear colleague and good friend Bergen Pak for countless joyful professional discussions at the highest level, which have always helped me progress, and for his unconditional friendship.

I also want to thank my family, who have supported me throughout this extensive project and shown understanding for the many hours I spent at my desk.

Last but not least, I thank Konrad for the incredible fortune of hiring me as a young specialist and teaching me so much about orthognathic surgery. Your self-critical and inquisitive nature from the very beginning – always asking “Could I/we have planned it even better to achieve an even better result?” – was electrifying and groundbreaking for me from the first moment. Your enthusiasm for orthognathic surgery has always been contagious. You have never settled for what you have already achieved but always sought further development, new projects, new ideas, new energy. Thank you so much for the unique opportunity to plan and write this book. I hope I can pass on this enthusiasm to the next generation of maxillofacial surgeons.

Shared knowledge is double knowledge.

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Contents

PART A

1

Guidelines for photographic documentation of dentofacial malformations

Caroline Fedder

1.1 General

This chapter summarizes the guidelines for the photographic documentation of dentofacial malformations. To ensure that no impressions of the cheek retractor are visible in the subsequent photos, it is advisable to take the facial photos first, followed by the intraoral photos.

1.2 Facial photography

1.2.1 Equipment

In order to enable measurement on the photos after printing, the patient and the photographer must be positioned at the correct distance in order to obtain a true-to-scale printout on DIN A4 (Fig 1-1).

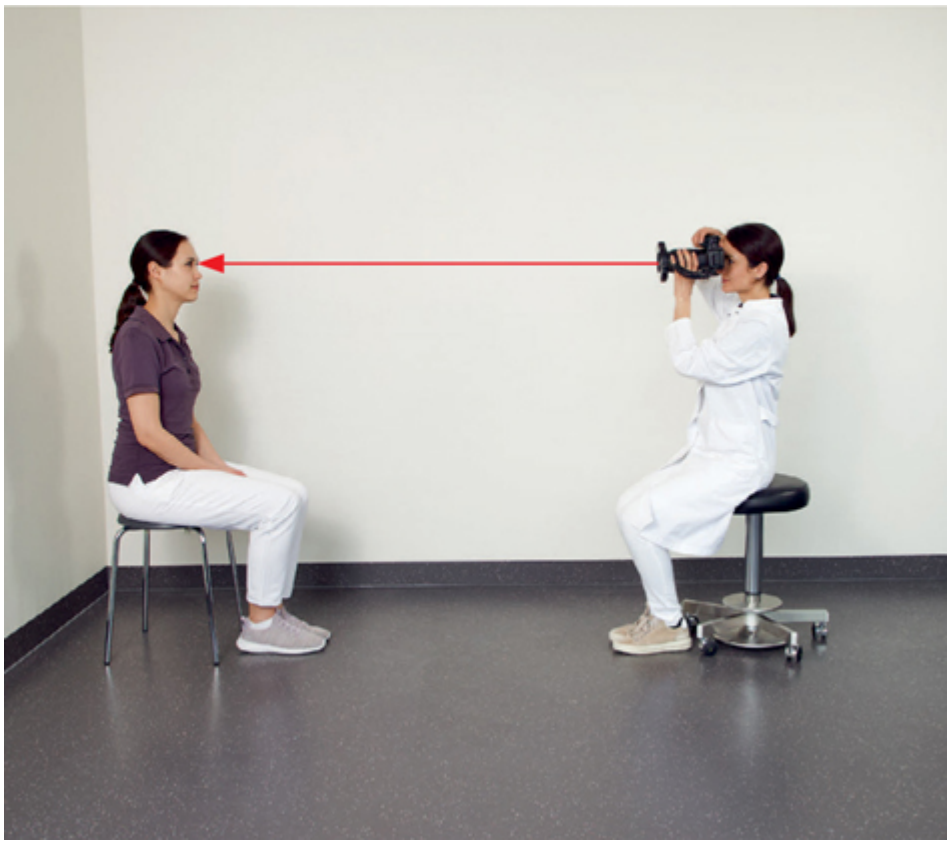

Fig 1-1 Positioning of the camera at the same height as the eyes of the patient.

Markings on the floor for the patient's and the photographer's chairs ensure that the photographer is always at the same defined distance from the patient. If necessary, markings can be placed for standardized rotations (90/45 degrees) of the patient on the floor and/or on the wall.

A solid color background should be used.

1.2.2 Camera / photographer

The camera should be positioned on a tripod, or photo-grapher positioned on a chair with castors adjustable in height using the feet. This allows the camera to be held at the level of the patient's head (Fig 1-2), and the photographer's hands to remain on the camera.

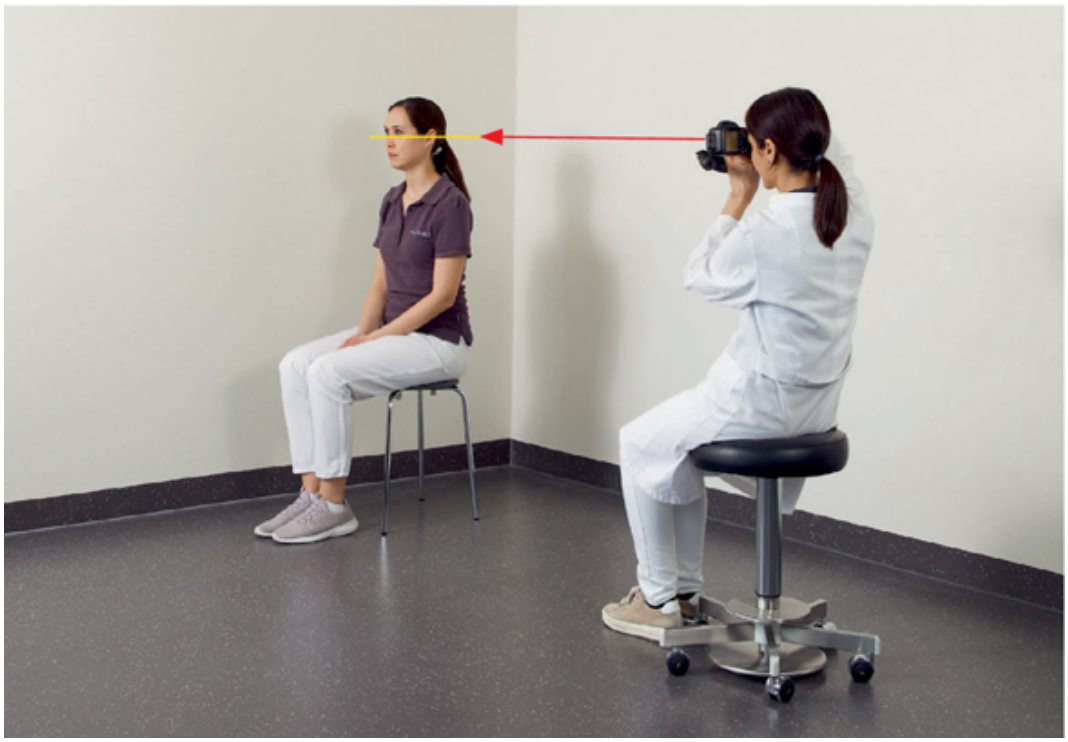

Fig 1-2a Positioning of the camera at the same height as the eyes of the patient (red line), and positioning of the patient's head so that the Frankfort horizontal plane (yellow line) is parallel to the floor.

Fig 1-2b Positioning of the interpupillary line parallel to the floor.

Fig 1-2c Positioning of the Frankfort horizontal plane parallel to the floor.

For precise adjustment of half-profile images, the photographer can roll to the side on a circular path without changing his or her posture.

1.2.3 Patient

Position the patient on a height-adjustable swivel chair or chair with a small headrest that does not take up too much space during the exposure.

Large earrings, jewelry, scarves, caps, glasses, etc, should be removed. Long hair should be tied up and tucked behind the ears. Eyes should be open so that the pupils are visible. The patient should sit upright with a straight spine. Shoulders should hang relaxed. Both soles of the feet should be placed completely on the floor.

The head should be kept straight so that the Frankfort horizontal line and interpupillary line are parallel to the floor (except for the frontal image in habitual posture) (Figs 1-3).

Fig 1-3 Habitual head position.

There should be sufficient distance to the background to avoid a drop shadow, or a slave flash can be used.

1.2.4 Recording

The entire head with attachment of shoulders should be photographed (caudal, eg, to the suprasternal notch).

For profile pictures, crop the image from the hair at the back rather than the tip of the nose at the front if cropping is required.

Frontal view in habitual posture

The patient should sit down on the chair and hold their head in their individual “natural” posture. The neck and the base of the shoulders are included in this photo, so that the posture can be judged.

It is important to check whether the patient is holding their head at an angle. Referral to an orthopedist may be necessary for assessment of the cervical spine/vertebral column (eg, scoliosis), or clarification of other syndromes (eg, hemifacial microsomia), depending on whether only the face is asymmetrical or if there is an additional scoliosis of the spine.

In the photographic example (Fig 1-3), the patient holds her head slightly tilted to the left and twisted to the right (the left tragus is more visible than the right).

All other frontal views

The eyes should be horizontal, so that the interpupillary line is parallel to floor.

The head should be kept straight (not turned or tilted). Check that both ears can be seen at the same distance, and note that the ears may stick out different amounts.

Frontal view with relaxed lips

This view is shown in Fig 1-4. In addition, here the teeth should be in resting position (let the patient hum “Mmmm” if necessary).

Fig 1-4 Frontal view with relaxed lips.

Lips must be relaxed (if necessary, have the patient moisten their lips with the tongue). In the case of lip closure insufficiency, the lips would be open accordingly.

This image is important to measure:

- zygomatic contour
- lip closure insufficiency
- the facial thirds (upper, middle, and lower face)
- the ratio of upper lip length to lower lip length, of lip white to lip red.

The photographic example (Fig 1-5) shows the following:

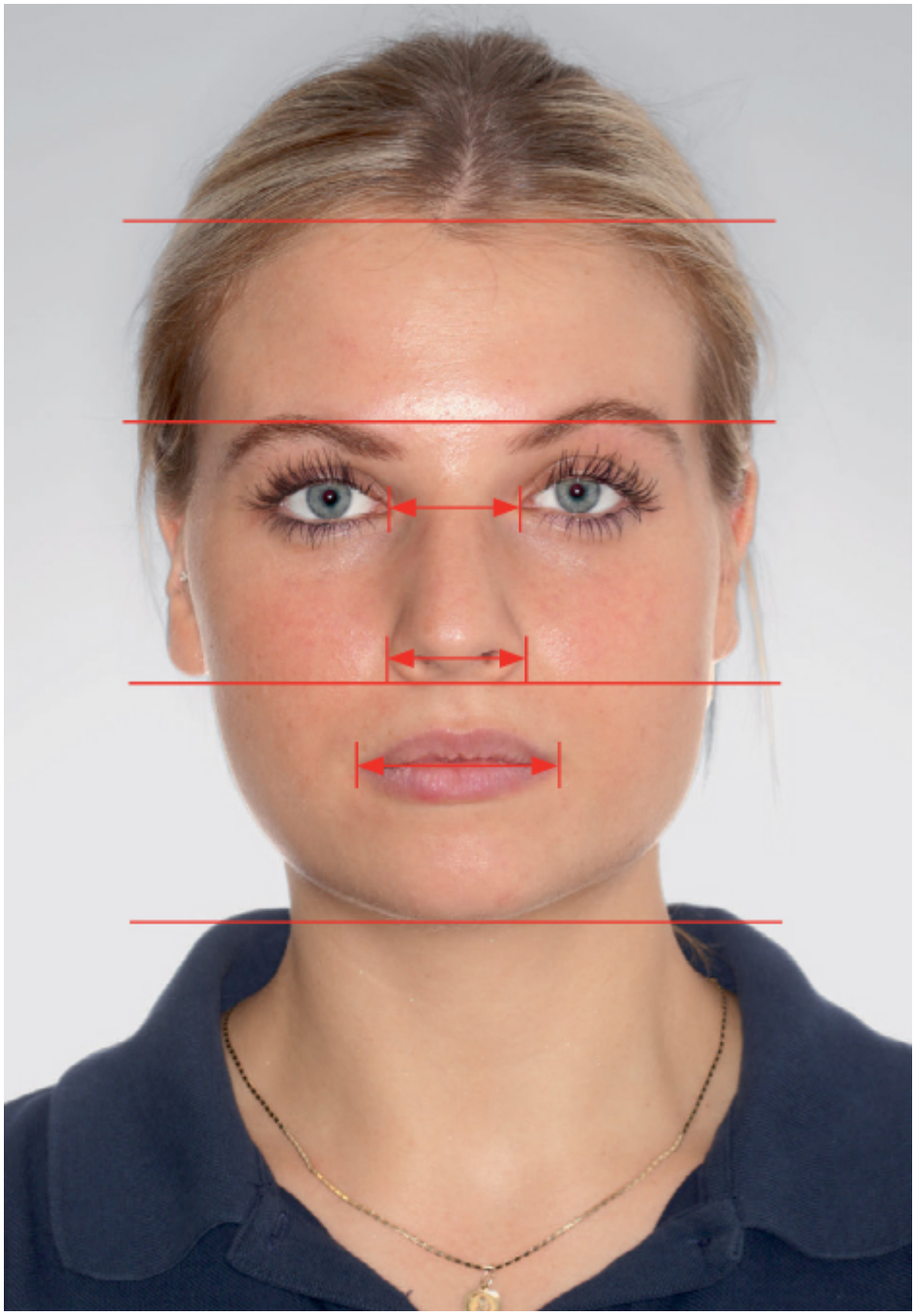

Fig 1-5 Frontal view showing the facial thirds, the distance between the median corners of the eyes, width of mouth, and alar width.

- Position of the facial thirds:
  - Upper face (UF) = hairline to glabella

  - Midface (MF) = glabella to anterior nasal spine
  - Lower face (LF) = anterior nasal spine to the underside of the chin
  - Target: UF/MF/LF = ⅓:⅓:⅓.
- Measurement of the width of thew oral fissure:
  - Target: not wider than the interpupillary distance.
- Measurement of the width of the nose (= alar base):
  - Target: corresponds to the distance of the median eyelid angles.

Frontal view with slightly open mouth

For this view (Fig 1-6), refer to the frontal view requirements above. The upper lip should be relaxed. Maxillary anterior teeth should be visible up to the incisal edg (if visible with relaxed lips).

Fig 1-6 Frontal view with slightly open mouth.

This view is important for the following reasons:

- Assessment of the position of the bony maxilla in relation to the upper lip = maxillary anterior tooth show with the upper lip

relaxed, to determine the vertical position of the maxilla in relation to the upper lip.

The photographic example (Fig 1-7) shows the following:

Fig 1-7 Measurement of the anterior maxillary teeth.

- Measurement of the maxillary anterior tooth show
- Target: 3 to 4 mm.

Frontal view smiling

For this view (Fig 1-8), refer to the frontal view requirements above. The patient should smile in a relaxed manner.

Fig 1-8 Frontal view smiling.

This view is important for the following reasons:

- Determination of whether the upper lip on smiling and laughing are different.

- Assessment of the symmetry and height of the anterior dental arch, and whether the dental arch is straight.
- Determination of facial symmetry. The interpupillary line in relation to the facial midline is important for determining the symmetry of the maxilla and mandible and as a basis for postoperative changes in the face.

Identification of the facial midline is demonstrated in the photographic example (Fig 1-9):

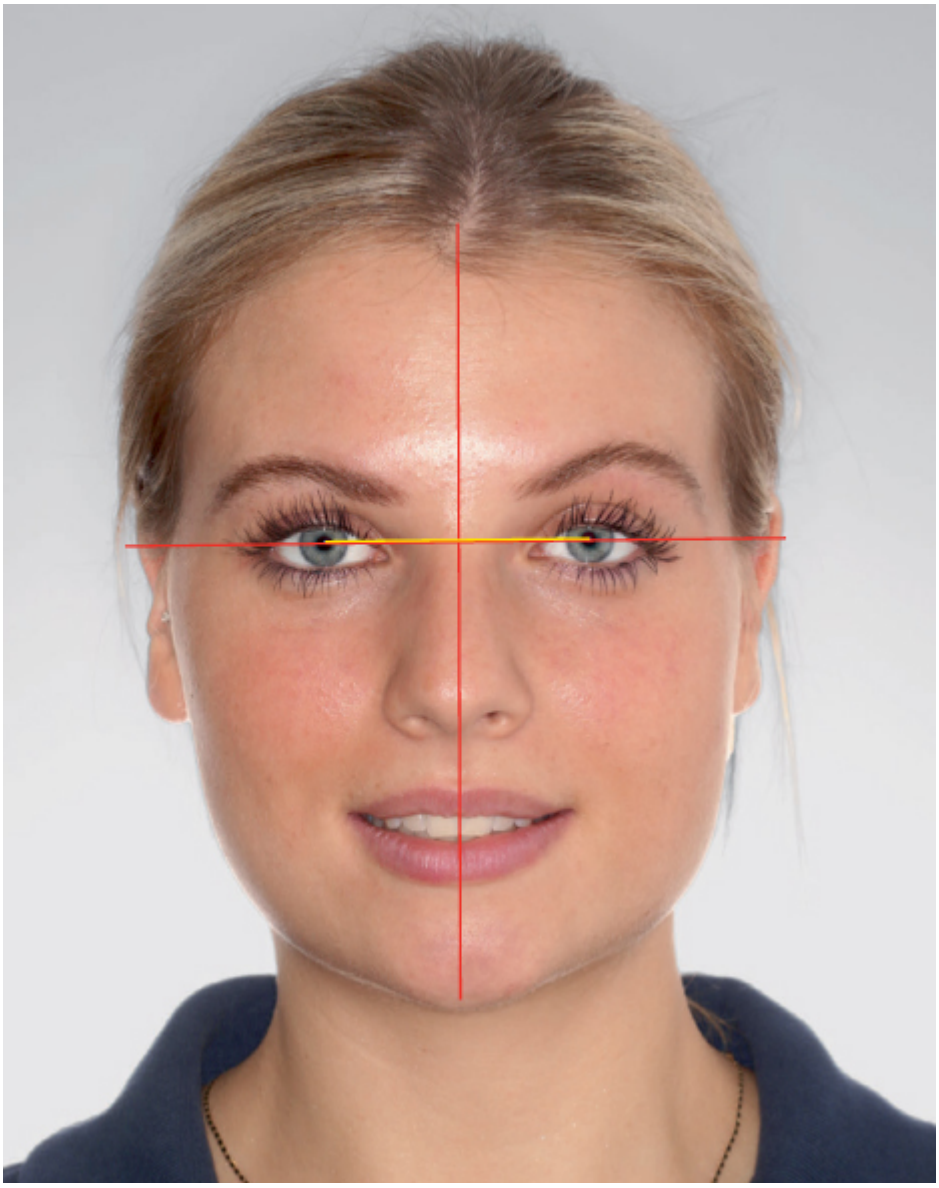

Fig 1-9 Interpupillary line (red horizontal line), determination of the middle of the face via half of the distance from the pupils (yellow lines), and identification of the facial midline (red vertical line).

- Check that the photo is taken symmetrically: Is the head held turned? Are the ears the same size? Can the tragus be seen to the same extent on both sides? In this case, the patient has tilted her head slightly to the right.
- The interpupillary line can be drawn (between the two pupillary light reflexes): Check that the eyes are at the same level (they could be different eg, in case of hemifacial microsomia or after fractures). Only then can the reconstructed facial midline be used for surgical planning. Alternatively, the median eyelid angles can be used for reconstruction of the facial midline.
- Determination of the facial midline: Determine the midpoint between the pupillary light reflexes and draw down perpendicularly. Alternatively, determine the midpoint between the two median eyelid angles (to be used especially in case of unilateral strabismus) and draw down perpendicularly. Check whether the constructed facial midline is on the glabella/nasal bridge center. If not, is the photo really taken symmetrically (see above)?
- Determination of the lateral deviation to the facial midline of the nose tip, anterior nasal spine, philtrum, center of the maxilla (= approximal contact 11/21 [tooth numbering according to FDI notation]), center of the mandible (= approximal contact 31/41), and chin tip.
- Target: The tip of the nose, anterior nasal spine, upper lip, lower lip, and chin should ideally be in the middle.

Frontal view laughing

For this view (Fig 1-10), refer to the frontal view requirements above.

Fig 1-10 Frontal view laughing.

This is the natural maximum smile, and is important for assessment of:

- Anterior smile show
- Lip contour when smiling
- Whether a “gummy” smile is present (ie, part of the gingiva is visible)
- Buccal corridors (black triangles next to the maxillary posterior region) to determine the transverse width and shape of the

maxilla. Note whether posterior teeth are visible, and any asymmetry of the lateral dental arch or canines.

The photographic example shows the anterior tooth show during laughter.

- Target: no or a low gingival smile.

Frontal view with spatula

For this view (Fig 1-11), refer to the frontal view requirements above.

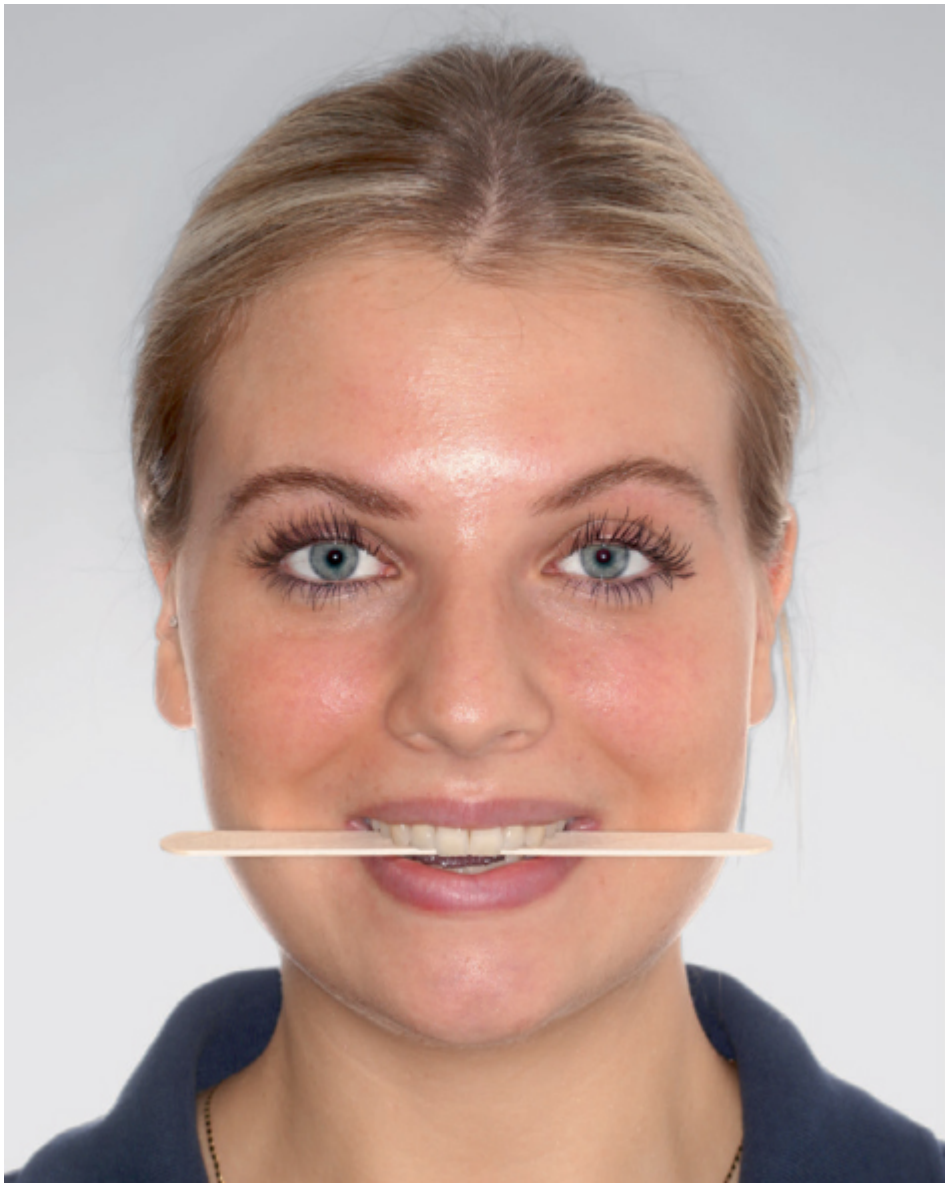

Fig 1-11 Frontal view with spatula.

Check beforehand that the spatula is not bent or twisted. Place the spatula on the tips of the maxillary canine. The patient should hold the spatula carefully with the teeth. The spatula must not be bent, but must remain straight. If necessary, have the patient hold the spatula from below with their thumb (Fig 1-12).

Fig 1-12 Frontal view with retained spatula.

This view is important for the following reasons:

- Determination of the facial midline and the position of the tip of the nose, anterior nasal spine, maxilla, mandible, and chin in relation to the determined facial midline
- To check if the interpupillary line is parallel to the spatula (ie, if the maxilla is parallel to the interpupillary line).

The photographic example (Fig 1-13) shows the following:

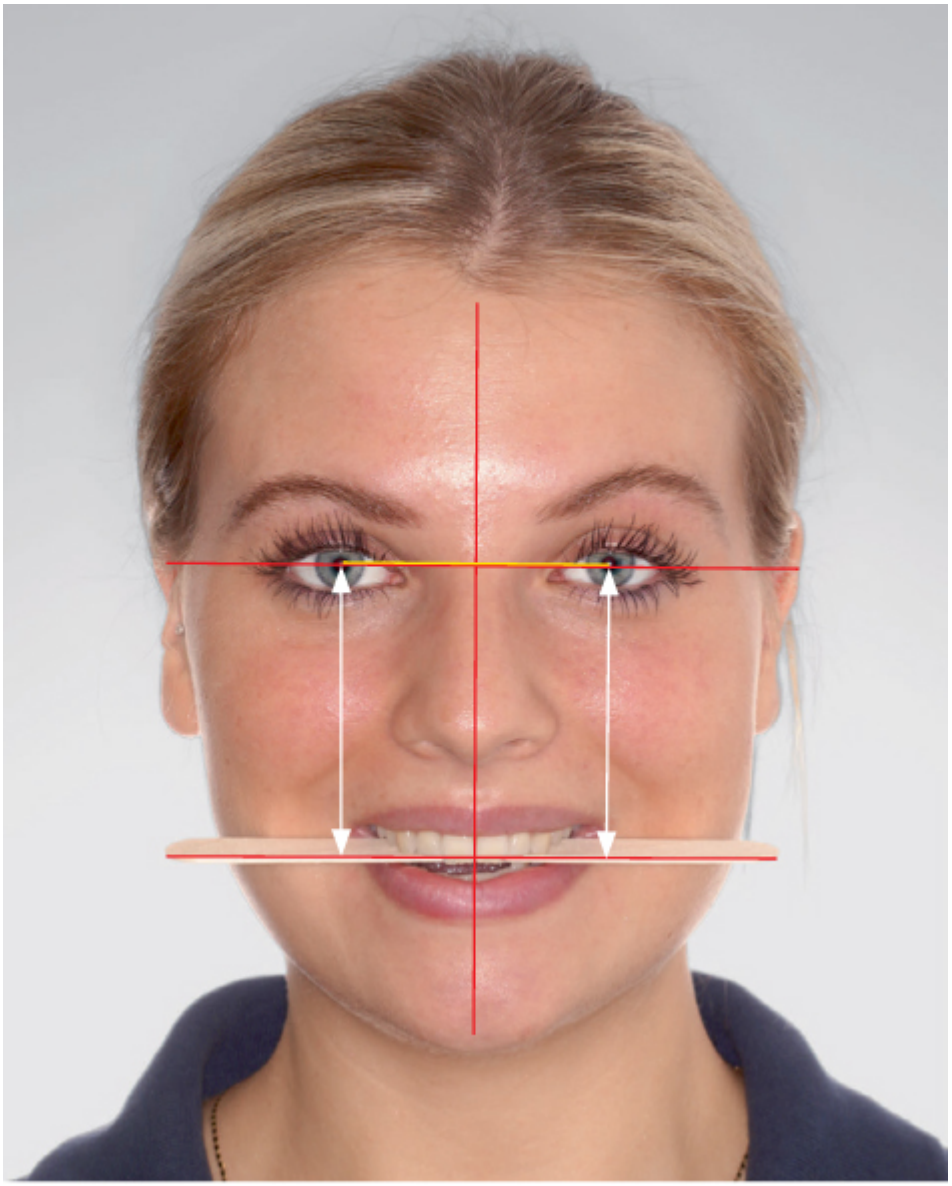

Fig 1-13 Determination of whether the transverse maxillary plane (lower red horizontal line) is parallel to the interpupillary line (yellow line).

- Determination of the correct position of the maxillary transverse plane:
  1. Draw the interpupillary line
  2. Connect the tips of the canines (lower red horizontal line)
  3. Draw the perpendicular lines down from the pupillary light reflexes to the top of the spatula (white arrows)

4. Measure the distance on both sides (white arrows).

- Target:
  – the tip of the nose, anterior nasal spine, and center of the maxilla and the mandible should be in the middle of the face
  – the maxilla (= top of the spatula) should be parallel to the interpupillary line.

In the example, measured from the canine tips, this patient's maxilla is parallel to the interpupillary line.

Caution: If the canines are differently abraded or a canine is intruded, this level cannot be used as a reference for the maxillary position. Alternatively, it is possible to use other teeth, ie the premolars, to determine the transverse maxillary plane.

Frontal view with photo cheek retractors

For this view (Fig 1-14), refer to the frontal view requirements above.