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Cone-beam Volumetric Imaging
in Dental, Oral and Maxillofacial Medicine

Fundamentals, Diagnostics and Treatment Planning

With contributions by:
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Foreword

The diagnostic requirements in dental medicine are determined not only by oro-maxillofacial surgical therapeutic concepts but also by the increasing esthetic expectations of the patient. The trend to performing even extensive dental surgical procedures on an outpatient basis requires minimally invasive surgical techniques so that any necessity for postoperative inpatient treatment is largely avoided. Successfully performing minimally invasive surgical techniques requires a comprehensive three-dimensional diagnostic system, which also reduces the risk of complications. Therefore, we at the University of Cologne quickly initiated the use of three-dimensional imaging for computer-assisted surgery.

However, three-dimensional radiological imaging has not yet been routinely established in dental medicine and generally dentists have used the orthopantograph for diagnostic purposes. The development of cone-beam volumetric imaging was intended to allow the use of legally permitted levels of dental radiation for a wider range of applications. Using this technique a computed tomographic scan of the cranium is an acceptable item for billing under medical fees schedules in Germany. In addition to the use of the technique for clear dental indications, it was also important to assess how good it would be in detecting asymptomatic conditions. In the initial trial phase, we were surprised by the frequency of discovery of asymptomatic pathological entities by chance. This led to the idea of illustrating the various, sometimes rare, findings in an atlas to provide the user of cone-beam volumetric imaging with a reference for use in day-to-day assessments.

The GALILEOS software primarily used in this atlas is unique because it produces a three-dimensional orthopantograph that can be studied three-dimensionally using the assessment window. Naturally, this dynamic assessment cannot be illustrated in a book. Therefore, we have compiled a DVD with an original data set and numerous on-screen videos of assessments in different dental disciplines in order to demonstrate the identification of anatomical and pathological structures.

We hope that the first-time reader will find much enjoyment in this introduction and we hope to provide the experienced reader with a reference work for the various findings.

Prof. Dr. Dr. *J. E. Zöller*
Dr. *J. Neugebauer*
and co-authors

Preface

The dentist's working volume is hardly more than one liter, but this human body part contains within a very confined space a multitude of bones, vessels, nerves and anatomical structures of singular importance to the patient's quality of life and communication options.

Therefore, radiological diagnostics has represented an essential source of information for the dentist's spatial orientation since the beginnings of modern dental medicine. However, classical radiological techniques still depict this information in two dimensions. Three-dimensional radiological diagnostics enables the dentist to acquire accurate spatial information. However, regular utilization of this technology has been limited by the high equipment cost and the radiation exposure, which is not justifiable in all indications. Therefore, these systems have essentially developed under radiological considerations and do not meet the dentist's needs for pathological assessment.

The GALILEOS system that has been scientifically tried and proven at the University of Cologne is the first method that enables the dentist to perform three-dimensional diagnostics in dental radiology. All indications in which cone-beam volumetric imaging is indicated in the oro-maxillofacial area are excellently described in this atlas. The numerous, well-documented case examples provide the new user with an orientation, particularly with regard to the recognition of secondary findings, since the entire facial cranium is always documented in a single image.

However, in addition to diagnostics, the use of this three-dimensional information is equally important for the course of further treatment. The oral surgery, orthodontic and implantological therapy options are presented with numerous examples. The rare indications for computer-assisted navigation or orthognathic surgery also illustrate the options available in system applications.

In this work, the team of authors with Prof. Zöller discuss the scientific studies carried out in recent years and demonstrate the utilization of the technique, both scientifically and in practice, using numerous patient examples. Modification of three-dimensional image data for dental radiology thus adds a new therapeutic dimension for the dentist. To meet the increasing demands of our patients for minimally invasive procedures and optimal restoration of lost or damaged dental substance, three-dimensional diagnostics with familiar dental imaging is another important tool for high-quality dentistry.

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Contents

Technology

Diagnostics

Treatment Planning

DVD: Examples of 3D Assessment

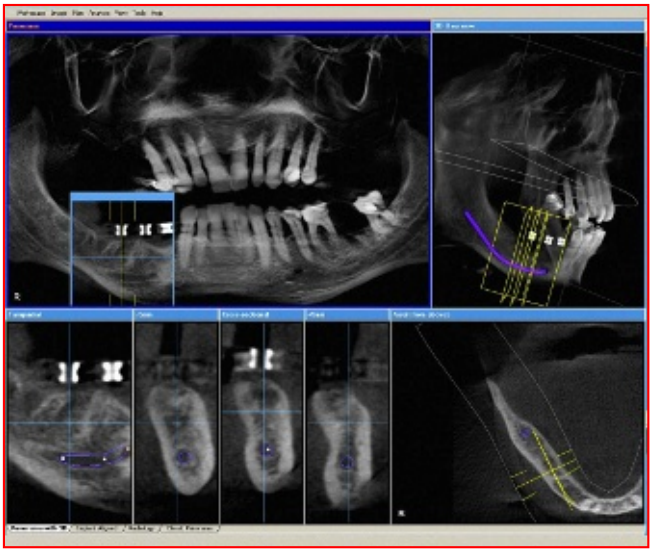

Fig 14-1 *Planning of three implants to replace teeth 44 through 46. Display of the drill sleeves positioned according to technical considerations, with deviations in angulation and still adequate bone availability.*

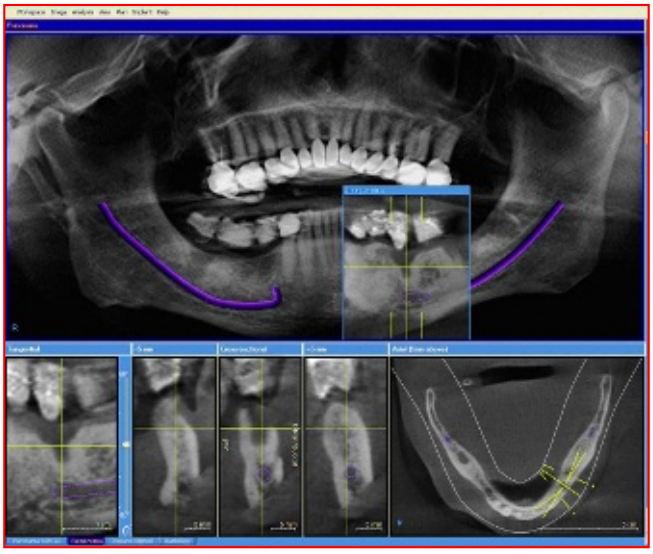

Fig 14-2 *Prosthetic treatment proposal prepared in barium sulfate vaccum-formed stent for the purposes of orientation in the determination of implant positions.*

14.1.1 Quantitative Evaluation of Bone Availability

Three-dimensional diagnostics provides a measurement feature for metric analysis. Since the imaging of the slices has already been metrically calibrated, it is not necessary to use a reference ball for calibration, as required in the panoramic tomograph. Bone availability can be determined in the horizontal and vertical dimensions using the measurement function. However, in addition to a purely quantitative analysis, it is also important to be oriented as to the position of the prosthetic device when planning a procedure. This can be done using a classic drill template by depicting the drill sleeves attached by the dental technician or by using an x-ray template (Figure 14-1). The latter results from the prosthetic proposal of the dental technician (backward planning), implemented in a radiological template containing barium sulfate, which is radiopaque in the image. Even when sufficient bone is available for implant insertion, it may not be possible to utilize it if the positioning could lead to difficulties with the prosthetic axis. In using a prosthetic proposal, the best implant position can be selected without requiring further augmentative procedures (Figure 14-2).

14.1.2 Qualitative Evaluation of Bone Availability

A surgeon who is aware of the bone quality can plan the procedure, particularly for drilling pilot holes. The often highly cortical structure in the posterior mandibular area abuts the soft spongioid medullary cavity area. Depending on the cutting behavior of the drill, a large amount of force may be needed to prepare the cortical bone. After preparing the implant cavity in the cortical bone, it is very easy to make the preparation too deep in the subsequent soft sections of the spongiosa, resulting in damage to anatomical structures (Figure 14-3).

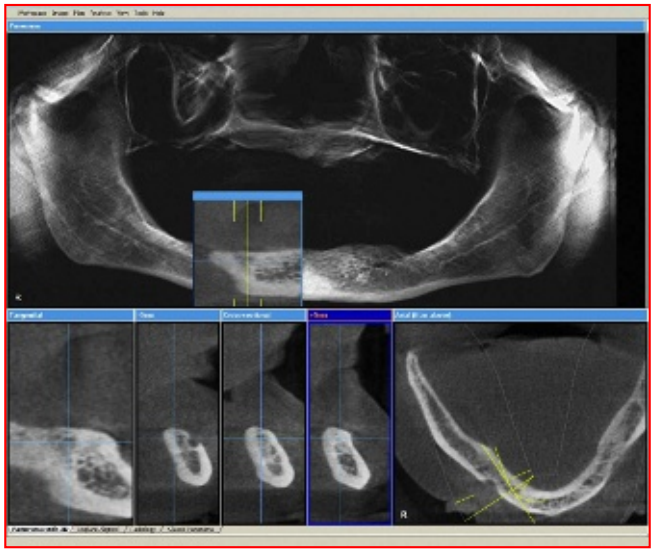

Fig 14-3 *Evaluation of bone quality in the area of the right mental foramen with pronounced cortical bone, dense spongiosa in the interforaminal area, and wide-meshed spongiosa in the posterior area.*

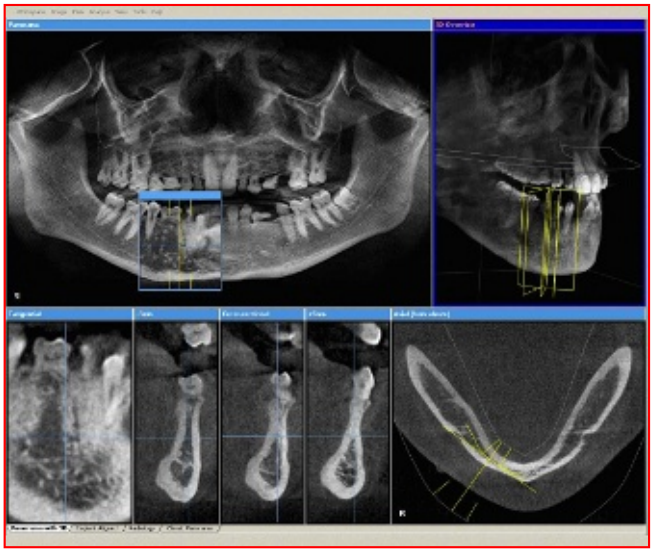

Fig 14-4 *Planning of implant insertion in region 44 with almost complete root resorption of tooth 84 and significant retraction of the alveolar process and lack of spongiosa. Because of the broad crestal alveolar ridge, bone chip augmentation of the apical perforation area is planned during implant insertion.*

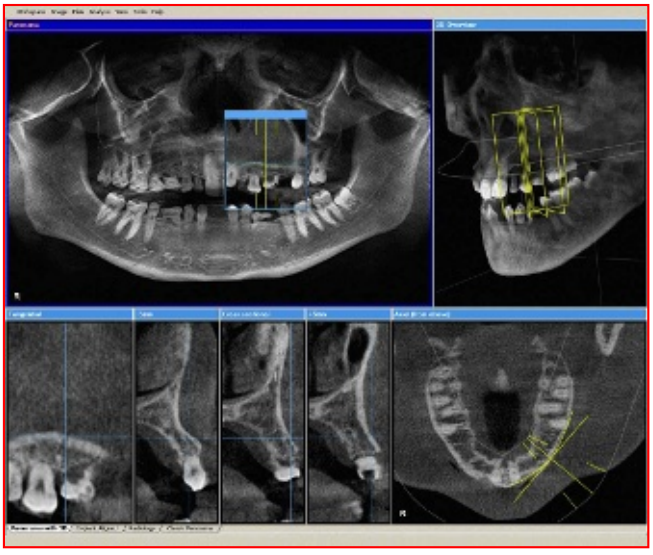

Fig 14-5 *Planning of implant insertion in a patient with multiple maxillary agenesia. The bone structure in region 25 indicates a pronounced thin cortical layer vestibularly, with a slightly mineralized finely meshed spongiosa.*

If the bone in the mandible is very cortical, preoperative diagnostics also permits the planned use of intermediate drills to ensure very careful preparation. The cortical structures of the mandible particularly can yield bone chips for use in regional augmentation where bone availability is reduced (Figure 14-4).

If osteotomes are used for implant bed preparation, in particular in the maxilla,[1] CBVI provides precise information on the trabecular structure of the bone. The optional use of a bone condenser can be precisely planned (Figure 14-5). If cortical structures predominate, one can resort to classical drill preparation early on, and complications associated with cortical damage and consequent bone resorption can be reduced.[2]