INTERPRETATION BASICS
OF CONE BEAM
COMPUTED TOMOGRAPHY

INTERPRETATION BASICS of Cone Beam Computed Tomography is an easy-to-use guide to cone beam CT technology for general dental practitioners and dental students. It covers normal anatomy, common anatomical variants, and incidental findings that practitioners must be familiar with when interpreting CBCT scans. In addition to functioning as an identification guide, the book presents and discusses sample reports illustrating how to use this information in day-to-day clinical practice.

Organized by anatomical regions, the book is easy to navigate and features multiple images of examples discussed. A valuable section on legal issues surrounding this new technology provides guidance essential for informed and appropriate use.

- Thorough coverage of the basics of CBCT imaging for dental applications
- Ideal for general practitioners and dental students
- Numerous normal anatomical figures with images of incidental findings to sharpen identification skills
- Organized anatomically for quick reference
- Includes access to a companion website hosting additional photos and case examples

THE EDITOR
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A companion website with additional resources is available at www.wiley.com/go/gonzalez/cbct
Interpretation Basics of Cone Beam Computed Tomography
Interpretation Basics of Cone Beam Computed Tomography

Edited by
Shawneen M. Gonzalez

WILEY Blackwell
For Tyson, Max, and Rugan
Contents

Preface ix
Acknowledgments xi
About the Companion Website xiii

1. Introduction to Cone Beam Computed Tomography 3
   Shawneen M. Gonzalez
   Introduction 3
   Conventional Computed Tomography (CT) 3
   Cone Beam Computed Tomography (CBCT) 4
   Conventional CT Versus Cone Beam CT 4
   Viewing CBCT Data 6
   Artifacts 9
   Common Uses 12

2. Legal Issues Concerning Cone Beam Computed Tomography 25
   Shawneen M. Gonzalez
   Introduction 25
   Standard of Care 25
   Recommendations 26
   Summary 29

3. Paranasal Sinuses and Mastoid Air Cells 31
   Gayle Reardon
   Introduction 31
   Anatomy 31
   Inflammatory Disease of the Paranasal Sinuses 45
   Intrinsic Diseases of the Paranasal Sinuses 49
   Postsurgical Changes of Paranasal Sinuses 56

4. The Sinonasal Cavity and Airway 59
   Gayle Reardon
   Introduction 59
   Anatomy 59
   Surgical Variations 75
   Inflammatory Diseases 77
   The Pharynx 80
   The Nasopharynx 80

vii
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Oropharynx</td>
<td>82</td>
</tr>
<tr>
<td>The Hypopharynx (Also Called Laryngopharynx)</td>
<td>83</td>
</tr>
<tr>
<td>The Parapharyngeal Space</td>
<td>83</td>
</tr>
<tr>
<td><strong>5. Cranial Skull Base</strong></td>
<td>85</td>
</tr>
<tr>
<td>Shawneen M. Gonzalez</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>85</td>
</tr>
<tr>
<td>Anatomy</td>
<td>85</td>
</tr>
<tr>
<td>Incidental Findings</td>
<td>93</td>
</tr>
<tr>
<td><strong>6. Soft Tissue of the Brain and Orbits</strong></td>
<td>103</td>
</tr>
<tr>
<td>Shawneen M. Gonzalez</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>103</td>
</tr>
<tr>
<td>Anatomy—Soft Tissue of the Brain and Orbits</td>
<td>103</td>
</tr>
<tr>
<td>Incidental Findings—Soft Tissue of the Brain</td>
<td>108</td>
</tr>
<tr>
<td>Incidental Findings—Orbits</td>
<td>118</td>
</tr>
<tr>
<td><strong>7. Cervical Spine and Soft Tissues of the Neck</strong></td>
<td>123</td>
</tr>
<tr>
<td>Shawneen M. Gonzalez</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>123</td>
</tr>
<tr>
<td>Anatomy—Cervical Spine and Soft Tissues of the Neck</td>
<td>123</td>
</tr>
<tr>
<td>Incidental Findings</td>
<td>129</td>
</tr>
<tr>
<td><strong>8. Temporomandibular Joints</strong></td>
<td>143</td>
</tr>
<tr>
<td>Gayle Reardon</td>
<td></td>
</tr>
<tr>
<td>The Temporomandibular Joints</td>
<td>143</td>
</tr>
<tr>
<td>Normal Anatomy and Function</td>
<td>143</td>
</tr>
<tr>
<td>Developmental Abnormalities</td>
<td>147</td>
</tr>
<tr>
<td>Soft Tissue Abnormalities</td>
<td>152</td>
</tr>
<tr>
<td>Remodeling and Arthritis</td>
<td>153</td>
</tr>
<tr>
<td>Trauma</td>
<td>163</td>
</tr>
<tr>
<td>Tumors</td>
<td>165</td>
</tr>
<tr>
<td><strong>9. Implants</strong></td>
<td>167</td>
</tr>
<tr>
<td>Shawneen M. Gonzalez</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>167</td>
</tr>
<tr>
<td>Imaging for Implant Purposes</td>
<td>167</td>
</tr>
<tr>
<td>Linear Measurement Accuracy</td>
<td>169</td>
</tr>
<tr>
<td>Grey Values and Hounsfield Units</td>
<td>170</td>
</tr>
<tr>
<td>Mandibular Canal</td>
<td>171</td>
</tr>
<tr>
<td>Virtual Implant Placement Software</td>
<td>172</td>
</tr>
<tr>
<td><strong>Appendix 1: Sample Reports</strong></td>
<td>177</td>
</tr>
<tr>
<td>Shawneen M. Gonzalez</td>
<td></td>
</tr>
<tr>
<td><strong>Appendix 2: Resources</strong></td>
<td>189</td>
</tr>
<tr>
<td><strong>Index</strong></td>
<td>191</td>
</tr>
</tbody>
</table>
It is the goal of this book to help practitioners and students gain a better understanding of anatomy and common disease processes that frequently present on cone beam computed tomography scans. This book seeks to fill the gap in the current literature where little is presented on common radiographic appearances on cone beam CT. In addition to this book, there are five sample cases with selected images online at www.wiley.com/go/gonzalez/cbct, where you can practice working your way through each region and using the knowledge you will acquire in this book.

The beginning of the book covers general information about different unit parameters and how these can play a role in the outcome of the scan including but not limited to slice thickness and what is recommended based on what is being evaluated (i.e., possible root fracture versus bone quantity for implants). The second chapter is about legal considerations of owning a cone beam CT, referring patients for a cone beam CT scan, and/or interpreting cone beam CT scans. This information is lacking in the current literature and is something many professionals do not consider but should be aware of before purchasing or using a cone beam CT unit.

Each book chapter is an anatomical region covering the topics of normal anatomy, common anatomical variants, and frequently seen disease processes. The first regions presented are the paranasal sinuses and mastoid air cells and nasal cavity and airway, which are intimately involved with each other. The normal anatomy section covers pertinent anatomy to evaluate when interpreting or reviewing a scan. The next section covers common anatomical variants with various images showing how they appear on axial, coronal, and sagittal views. The last section covers commonly seen disease processes, such as sinusitis, that should be noted on a written radiology interpretation.

The following chapters on the cranial skull base and brain and orbits are also intimately involved as they are directly adjacent to each other. There are many anatomical landmarks in the cranial skull base such as canals, foramina, air cells, and more making this a difficult region to interpret. Key anatomy is shown on various views (axial, coronal, and sagittal) to aid the practitioner and the student in orienting themselves on the scan. There is no key anatomy covered for the soft tissue of the
brain due to limitations of soft tissue imaging on cone beam CT scans. Disease processes and anatomical variants of entities such as vascular markings and pineal gland calcifications are covered in their respective chapters.

The region of the cervical spine and soft tissue of the neck cover normal anatomical appearances to disease processes such as degenerative joint disease and arterial calcifications. Degenerative joint disease is progressive with multiple appearances based on the degree of bony damage. This chapter has many example images of degenerative joint disease at various points in the disease process.

The last region covered is the temporomandibular joints, which is very thorough thanks to the contributions of Gayle Reardon who has studied and continues to study this region in depth. The temporomandibular joints have a unique set of disease processes and developmental appearances beyond arthritic changes. This chapter covers entities many practitioners and students should be aware of even if they are not seen in daily practice.

The appendices show example written reports of cone beam CT scans for practitioners and students to view and consider when writing their own radiology interpretation. There is also a short section with recommended websites and books to learn more about cone beam CT with more obscure disease processes such as malignancies, benign neoplasms, and cysts covered in detail in the recommended books.
I’d like to thank Gayle Reardon for her contributions to this book and sharing her knowledge of the paranasal sinuses, nasal cavity and airway, and temporomandibular joints. Thanks to the staff at Wiley for guidance and support in the creation of this book. Thank you to my students for their questions and comments as they challenge me to continually improve how I share my radiology knowledge. Last, big thanks to my family (Tyson, Max, and Rugan) for their love and support throughout this entire process. I would not have been able to complete this without them.
About the Companion Website

This book is accompanied by a companion website: www.wiley.com/go/gonzalez/cbct
The website includes:

- Case studies
- Powerpoints of all figures from the book for downloading
- Powerpoints of all tables from the book for downloading
Interpretation Basics of Cone Beam Computed Tomography
Introduction

This chapter will cover basics of cone beam computed tomography including comparison to traditional computed tomography, common uses, artifacts frequently seen, and views created with a cone beam computed tomography dataset.

Conventional Computed Tomography (CT)

General Information

Computed tomography (CT) is credited to Godfrey Hounsfield, who in 1967 wrote first about the technology and then created a unit in 1972. He was awarded the Nobel Prize in Physiology/Medicine in 1979. Conventional CT units are both hard-tissue and soft-tissue imaging modalities. The first CT, first generation, had a scan time of 10+ minutes depending on how much of the body was being imaged. The processing time would take 2½ hours or longer. All first-generation CT units were only a single slice. This means that one fan of radiation exposed the patient and would have to circle around the patient several times to cover the area of concern. Current CT units are fifth generation, or helical/spiral. The scan times have gone down to 20–60 seconds with a processing time of 2–20 minutes. The number of slices available is up to 64, 128, and 256. The more slices available makes it possible to scan more of the patient in one circle, hence the lower scan times. Conventional CT units work with the patient lying down on a table while being scanned. The table
moves in and out of the bore to cover the area of concern. Once all the data are received, they are compiled to create a dataset. This dataset can be manipulated to look at the information in many different angles.

**Cone Beam Computed Tomography (CBCT)**

**General Information**

Cone beam computed tomography (CBCT) was discovered in Italy in 1997. The first unit created was the NewTom. The NewTom was similar to conventional CT having the patient lying down with an open bore where the radiation exposes the patient. Instead of a fan of radiation (used in conventional CT units), a cone of radiation is used to expose the patient, hence the name cone beam computed tomography. As new CBCT units were created, companies started using seated or standing options. With continued updates to the units, the sizes have become smaller, with many needing only as much space as a pantomograph machine.

**Conventional CT Versus Cone Beam CT**

**Voxels**

Voxels are three-dimensional data blocks that representing a specific x-ray absorption. CBCT units capture isotropic voxels. An isotropic voxel is equal in all three dimensions (x, y, and z planes) producing higher resolution images compared to conventional CT units. Conventional CT unit voxels are nonisotropic with two sides equal but the third side (z-plane) different. The voxel sizes currently available in CBCT units range from 0.076 mm to 0.4 mm. The voxel sizes currently available in conventional CT units range from 1.25 mm to 5.0 mm. Resolution of the final image is determined by the unit’s voxel size. The smaller the voxel size the higher the resolution. However, the higher the resolution, the higher the radiation dose to the patient as well.

**Field of View**

Field of view (FOV) is the area of the patient irradiated. CBCT units vary, with some units having a fixed FOV and some having changeable FOVs. The ranges of FOVs are from 5 cm × 3.8 cm, commonly referred to as a small FOV, to 23 cm × 26 cm, commonly referred to as a large FOV (Figures 1.1 to 1.3).

**Radiation Doses**

Radiation doses with CBCT units are as varied as the field of view options. CBCT units have approximate radiation dose ranges of 12 microSieverts to 1073 microSieverts. Conventional CT units have much higher radiation doses due to their soft tissue capabilities with doses of 1200 microSieverts and higher per each scan, depending on the selected scan field.
Figure 1.1. (a) 3D rendering of a small FOV of 5 cm×8 cm from an anteroposterior (AP) view; (b) 3D rendering of a small FOV of 5 cm×8 cm from a lateral view.

Figure 1.2. (a) 3D rendering of a medium FOV of 8 cm×8 cm from an anteroposterior (AP) view; (b) 3D rendering of a medium FOV of 8 cm×8 cm from a lateral view.

Figure 1.3. (a) 3D rendering of a large FOV of 16 cm×16 cm from an anteroposterior (AP) view; (b) 3D rendering of a large FOV of 16 cm×16 cm from a lateral view.
Viewing CBCT Data

**Multiplanar Reformation (MPR)**

Multiplanar reformation, or MPR, is a view frequently of three different directional 2D images (axial, coronal, and sagittal planes) (Figure 1.4). Within this view, the images may be manipulated in the thickness of data, and direction of viewing can be altered. Reconstructed pantomographs and lateral cephalometric skulls (Figures 1.5 and 1.6) are possible without distortion from standard 2D radiography. The dataset may also be manipulated to create cross-sectional (orthogonal) views of the jaws and condyles (Figures 1.7 and 1.8).

**3D Rendering**

The most common form of 3D rendering offered in CBCT software is indirect volume rendering, which determines the grays of the voxels to create a 3D image (Figure 1.9). Another form of 3D rendering is referred to as direct volume rendering, or maximum intensity projection (MIP) (Figure 1.10).

Figure 1.4. Axial (A), sagittal (S), and coronal (C) views.
Figure 1.5. Sample reconstructed pantomograph with 3D view on bottom left, focal trough bottom middle, and preview on bottom right.

Figure 1.6. Sample reconstructed lateral cephalometric skull.