

Surgical and Radiologic **ANATOMY** for Oral Implantology

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With contributions by

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Quintessence Publishing Co., Inc

Chicago, Berlin, Tokyo, London, Paris, Milan, Barcelona, Beijing,
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and Warsaw

To the Anonymous Donors

We are respectful of and deeply indebted to the six anonymous individuals whose cadaver sections are shown in this book. They have made a donation to science that will enrich the fundamental knowledge base of human anatomy and will benefit today's students and clinicians of oral implantology. Future generations can then build on this foundational knowledge.

I have done all in my power to preserve, protect, and maintain the dignity of these individuals. We did not know them in life but studied them in death; whoever they were, we honor their remains and dignify their gift.

To these six, our deepest thanks.

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Dedication

This book is dedicated to Ala-al-din abu Al-Hassan Ali ibn Abi-Hazm al-Qarshi al-Dimashqi, known as Ibn al-Nafis.

Ibn al-Nafis was an Arab physician who is mostly famous for being the first to describe the pulmonary circulation of the blood. He was born in 1213 in Damascus. He attended the Medical College Hospital (Bimaristan Al-Noori) in Damascus. Apart from medicine, Ibn al-Nafis learned jurisprudence, literature, and theology. He became an expert on the Shafi'i school of jurisprudence and an expert physician.

In 1236, Al-Nafis moved to Egypt. He worked at the Al-Nassri Hospital and subsequently at the Al-Mansouri Hospital as a chief physician. When he died in 1288, he donated his house, library, and clinic to the Mansuriya Hospital.

Discovery of pulmonary circulation

The theory that was accepted prior to Al-Nafis was that of Galen from the 2nd century. Galen had theorized that the blood reaching the right side of the heart went through invisible pores in the cardiac septum, to the left side of the heart, where it mixed with air to create spirit and was then distributed to the body. According to Galen, the venous system was quite separate from the arterial system, except when they came in contact through the unseen pores.

Based on his anatomical knowledge, Al-Nafis stated that:

The blood from the right chamber of the heart must arrive at the left chamber but there is no direct pathway between them. The thick septum of the heart is not perforated and does not have visible pores as some people thought or invisible pores as Galen thought. The blood from the right chamber must flow through the vena arteriosa [pulmonary artery] to the lungs, spread through its substances, be mingled there with air, pass through the arteria venosa [pulmonary vein] to reach the left chamber of the heart and there form the vital spirit.

Elsewhere in his book, he said that:

The heart has only two ventricles...and between these two there is absolutely no opening. Also dissection gives this lie to what they said, as the septum between these two cavities is much thicker than elsewhere. The benefit of this blood [that is in the right cavity] is to go up to the lungs, mix with what is in the lungs of air, then pass through the arteria venosa to the left cavity of the two cavities of the heart and of that mixture is created the animal spirit.

In describing the anatomy of the lungs, Al-Nafis stated:

The lungs are composed of parts, one of which is the bronchi; the second, the branches of the arteria venosa; and the third, the branches of the vena arteriosa, all of them connected by loose porous flesh.

He then added that:

The need of the lungs for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores of the branches of this vessel into the alveoli of the lungs may mix with what there is of air therein and combine with it, the resultant composite becoming fit to be spirit, when this mixing takes place in the left cavity of the heart. The mixture is carried to the left cavity by the arteria venosa.

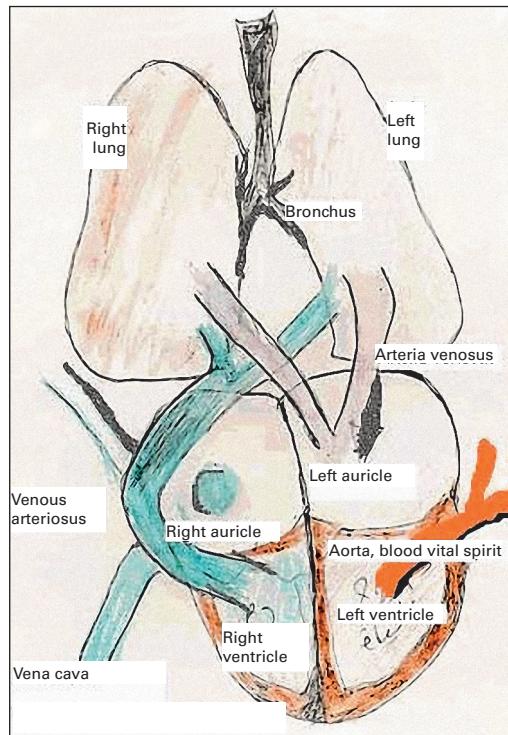
Al-Nafis also postulated that nutrients for the heart are extracted from the coronary arteries:

Again, his [Avicenna's] statement that the blood that is in the right side is to nourish the heart is not true at all, for the nourishment to the heart is from the blood that goes through the vessels that permeate the body of the heart.

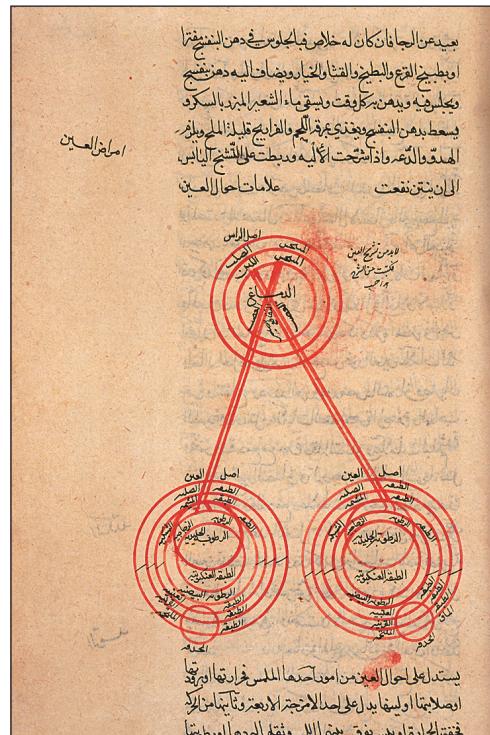
Writings

The most voluminous of his books is *Al-Shamil fi al-Tibb*, which was planned to be an encyclopedia comprising 300 volumes but was never completed because of his death. The manuscript is available in Damascus.

His book on ophthalmology is largely an original contribution. His most famous book is *The Summary of Law (Mujaz al-Qanun)*. Another famous book embodying his original contribution was on the effects of diet on health, entitled *Kitab al-Mukhtar fi al-Aghdhiya*.



The pulmonary circulation of the blood according to Ibn al-Nafis.



A page from the book on ophthalmology by Ibn al-Nafis.

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Preface

There are a number of excellent anatomical atlases and textbooks available to dental clinicians, but often these atlases fail to meet the clinical demands of defining intraoperative structures for oral implantologists because of the overwhelmingly detailed minutia.

The aim of this book is to present an adequate amount of anatomical material in a readable and interesting format. I have relied on my own clinical and teaching experience to determine what is adequate. No major omissions have been made intentionally, but the primary focus is the clinical relevance to oral implantology. Every effort has been made to sequence the information in a logical manner.

The illustrations in this book are the result of very hard work and cooperation between the illustrators and me. Nonetheless, certain anatomical landmarks are difficult to illustrate in a diagram format, which leads to confusion when students and professionals are confronted with actual specimens in the dissecting room or in the operatory. Therefore, photographs of some clinical cases and of dissected structures of the maxilla, the mandible, and the nasal cavity are provided in this book that show structures as they actually exist in the dissected or live body. I hope that they will bridge the gap that occasionally exists between books and the "real thing."

On another note, today's oral implantologists have the advantage of cone beam computed tomography (CBCT) volumetric imaging. This book provides several CBCT images of those anatomical landmarks that usually do not appear on two-dimensional imaging (eg, panoramic, intraoral, and cephalometric radiographs). I encourage the use of CBCT imaging for every dental implant surgery. The CBCT scan technology allows us to visualize the patient's anatomy and pathology like never before. With these images, we can measure the exact distance available for implant placement under or above certain anatomical landmarks, measure the exact bone density and the precise width of the available alveolar ridge, and select the most suitable locations for the planned implants. This will lead to improved treatment planning and reduced morbidity and will also reduce our liability.

It is my hope that these illustrations, CBCT images, photographs, and text will simplify the learning and the execution of implant-related surgical procedures in a region of the body that presents special topographic and anatomical difficulties.

Acknowledgments

To God, the creator of the perfect human body, who has made all my projects possible through his guidance and gracious love.

To my parents, Omar Al-Faraje and Nadia Al-Rifai, whose guidance and nurturing instilled in me a quest for perfection.

To my wife, Rana, who gave up many date nights and social events and supported me to the fullest throughout this project. I will make up the time, I promise.

To my children, Nadia, Omar, and Tim. Your smiles and inspiration provide the fortitude and drive in my life. I am very blessed.

My special thanks go to Dr Christopher Church for his contribution to the nasal and sinus anatomy sections of the book and to Arthur Rathburn, who provided the anatomical dissections and skull preparations used in this book. It is a privilege to have friends like you.

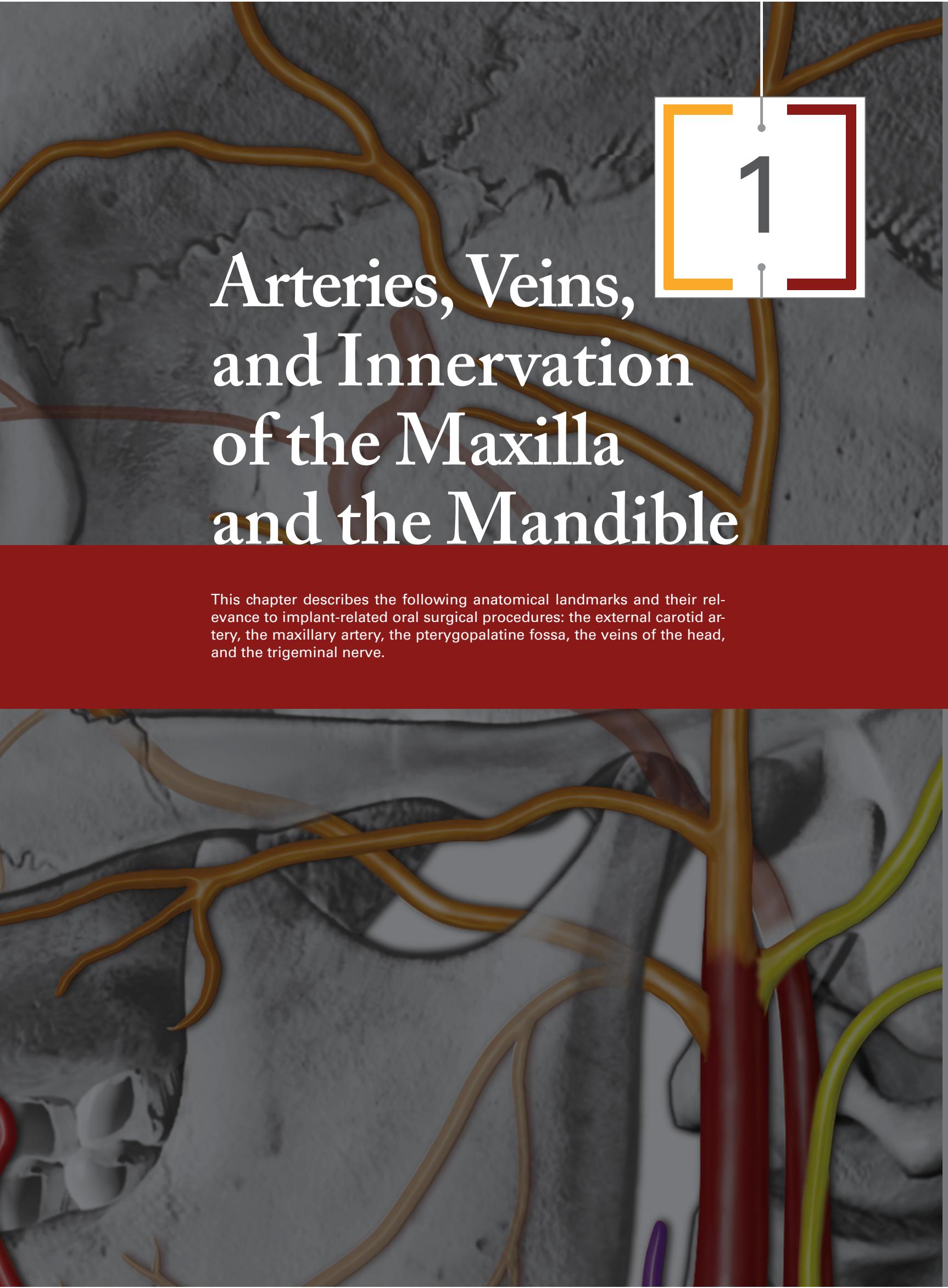
It is my pleasure to recognize the help of Mr Kim Jin Cheol, on behalf of DIO Implant, who facilitated the use of the company's resources for this project.

My deepest thanks to Lisa Bywaters from Quintessence Publishing for the opportunity to educate my colleagues on the special anatomical considerations for surgical oral implantology. I am very fortunate to have such a highly skilled and professional editor (I still do not believe that she is not a dentist).

To my patients, without whom I would not have been able to compile the clinical photographs I have. You make my profession so enjoyable and rewarding.

To all of my students at the California Implant Institute. It is always a pleasure and an honor to share with you my knowledge and expertise in implant dentistry. For the last few years, my greatest professional joy has been interacting with you and my colleagues at the California Implant Institute.

I am also particularly grateful to Jason Rohack and Qualis Media for delivering the illustrations used in this text at a high level and in a timely manner. Many hours were spent and countless emails were exchanged to produce these specific illustrations.



1

Arteries, Veins, and Innervation of the Maxilla and the Mandible

This chapter describes the following anatomical landmarks and their relevance to implant-related oral surgical procedures: the external carotid artery, the maxillary artery, the pterygopalatine fossa, the veins of the head, and the trigeminal nerve.

Bony structure

The adult maxillary sinus is roughly a laterally directed pyramid, averaging 3.75 cm high \times 2.5 cm deep \times 3 cm wide.¹⁵ The average volume is about 15 to 20 mL.¹⁶ The sinus usually has a single communication to the nose, found in the medial wall of the sinus (which is also the lateral wall of the nose). This wall (Fig 3-9) often contains several areas of incomplete bone formation, which may lead to extra communications between the nose and the sinus called *accessory ostia*, which are of questionable physiologic significance. The natural ostium of the maxillary sinus (Fig 3-10) averages 2.4 mm in diameter but can range from 1 to 17 mm.¹⁵ Considered from an intranasal perspective, this opening is found in the middle meatus, the space above the inferior concha (turbinate) and under the middle concha. Considered from within the sinus, the opening is high on the medial wall.

The posterior wall separates the sinus from the structures of the infratemporal and pterygomaxillary fossae. The lateral wall is formed by the zygoma. The anterior wall includes

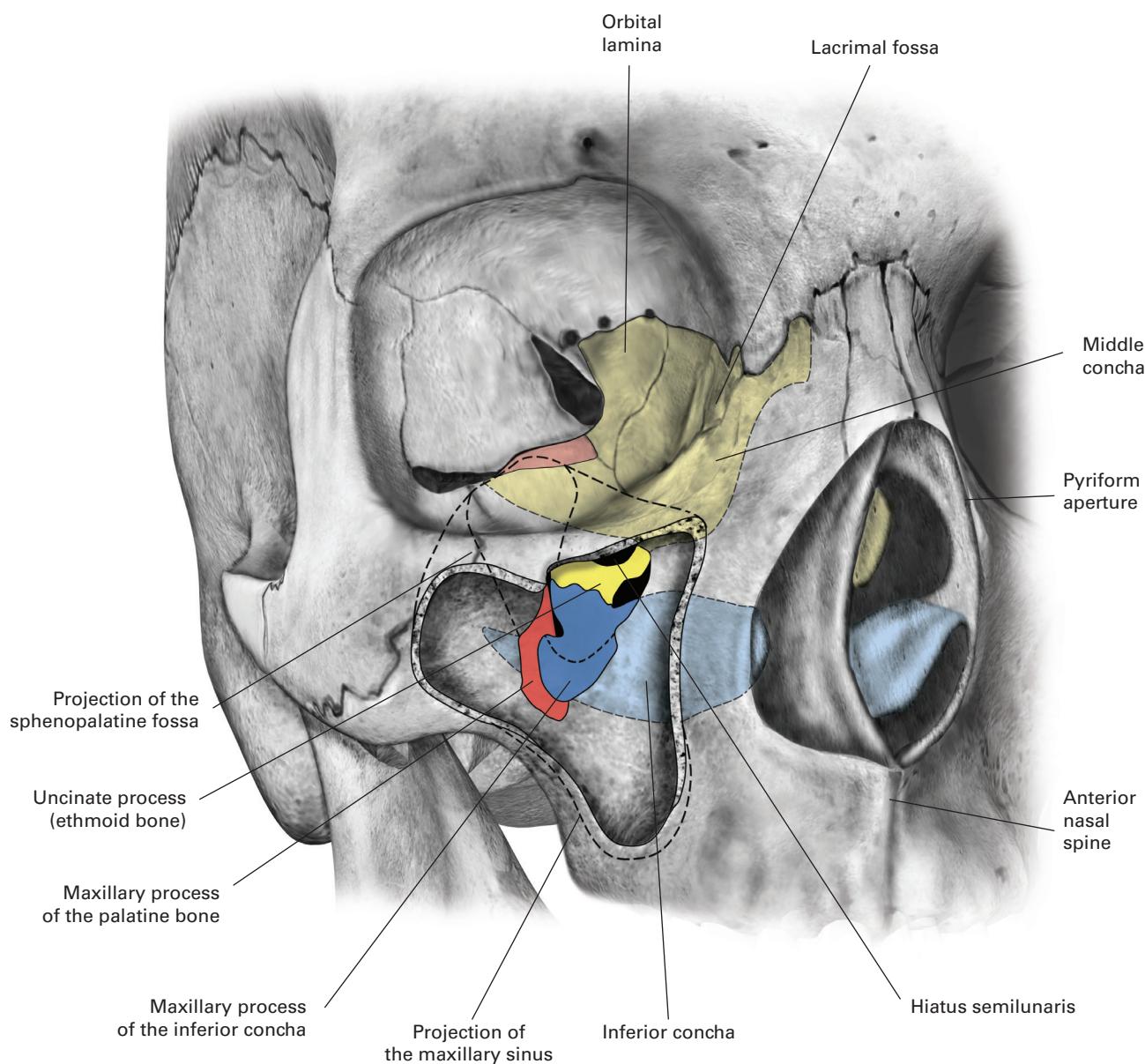


Fig 3-9 The bony structures that form the medial wall of the sinus. In a dry skull, there are two large, irregular openings from the nasal cavity into the maxillary sinus cavity, which are separated by a flake of bone called the *uncinate process*. In a living body, these openings are covered by soft tissue (except the natural ostium of the sinus, through which the sinus drains).

the canine fossa and the infraorbital foramen (through which the second branch of cranial nerve V exits into the soft tissues of the face). The roof of the sinus is also the floor of the orbit, and it contains the infraorbital canal, through which the maxillary nerve (V2) runs in a posterior-to-anterior direction before exiting through the infraorbital foramen. In up to 14% of sinuses, this nerve may be on a bony mesentery or may even be dehiscent.¹⁷ Because of its superior location, this rarely presents a concern for the implant surgeon. The floor of the sinus is comprised of the hard palate, alveolus, and dental portion of the maxilla and may be anywhere from 1 to 10 mm below the level of the floor of the nose.

A rare but significant anatomical variation of the maxillary sinus is called *maxillary sinus hypoplasia*. The hypoplastic sinus cavity is much smaller than normal and frequently features considerable bony thickening of the inferior and lateral walls. The etiology of a hypoplastic sinus is uncertain, but it is theorized to be related to deficient bone absorption or to the inability to adequately aerate the sinus cavity.¹⁸ A history of childhood facial trauma is not uncommon.

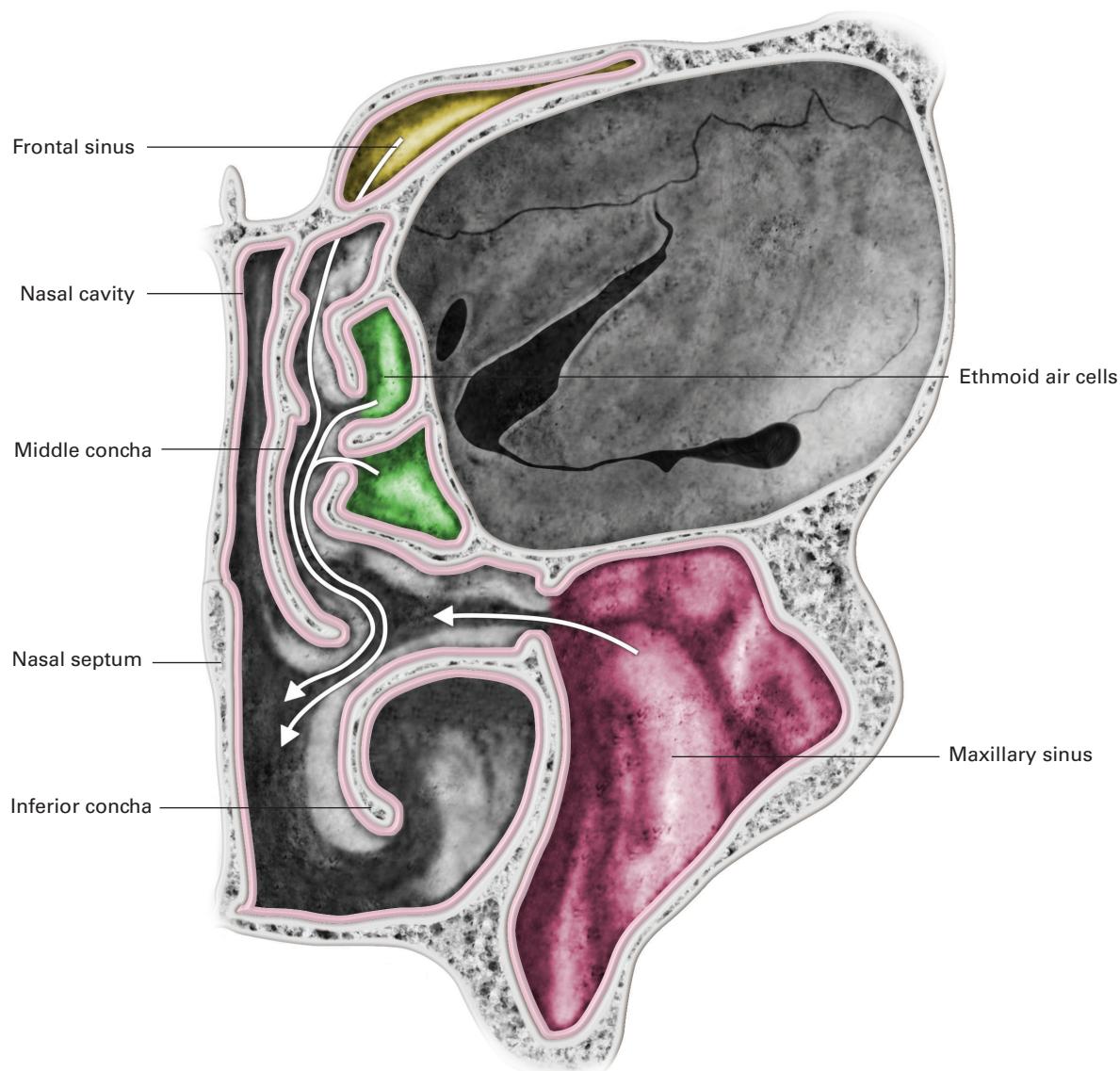


Fig 3-10 The maxillary sinus ostium into the nasal cavity.

Figures 3-24 and 3-25 show the sinus septa from various sections of a human cadaver skull.

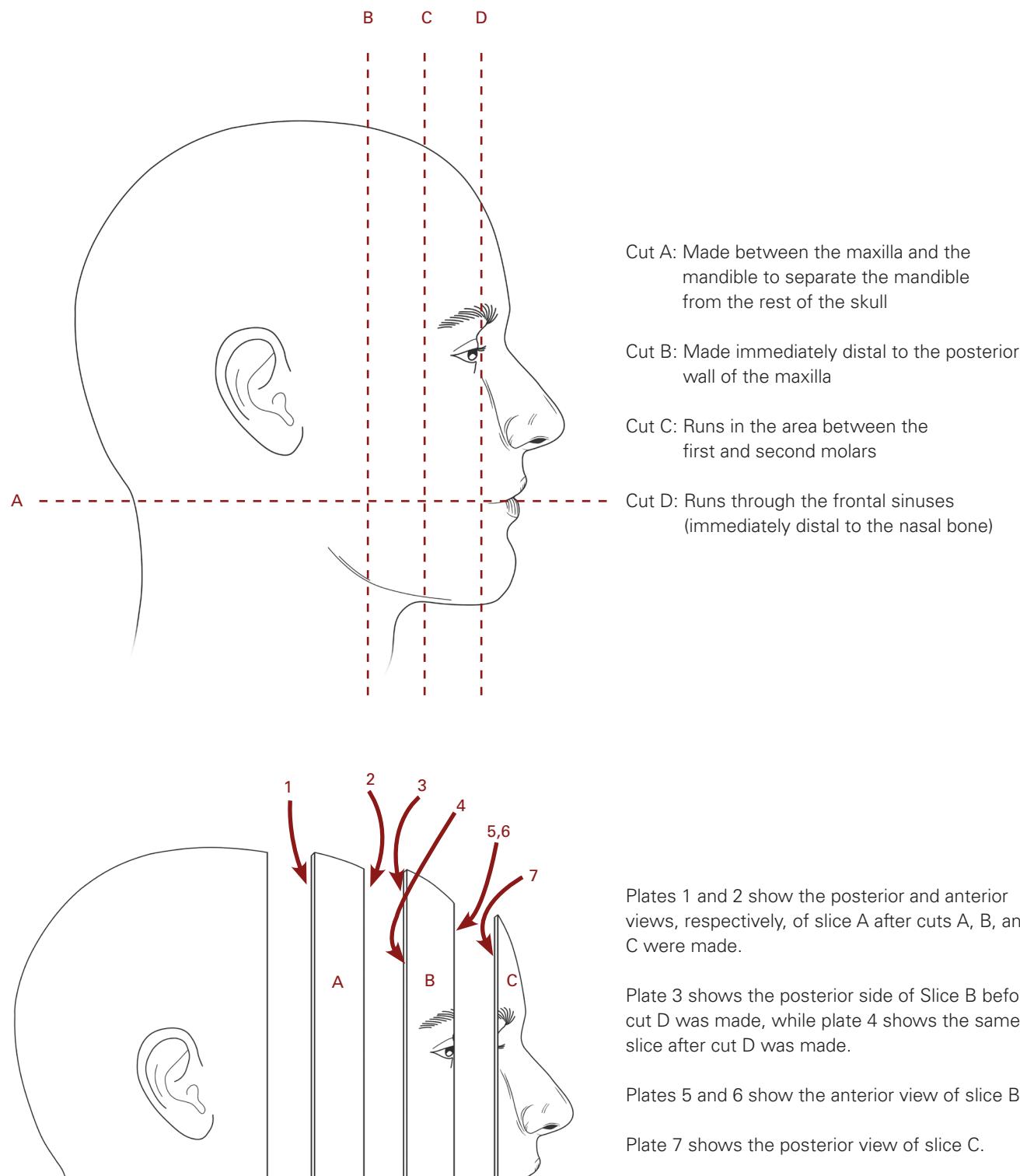
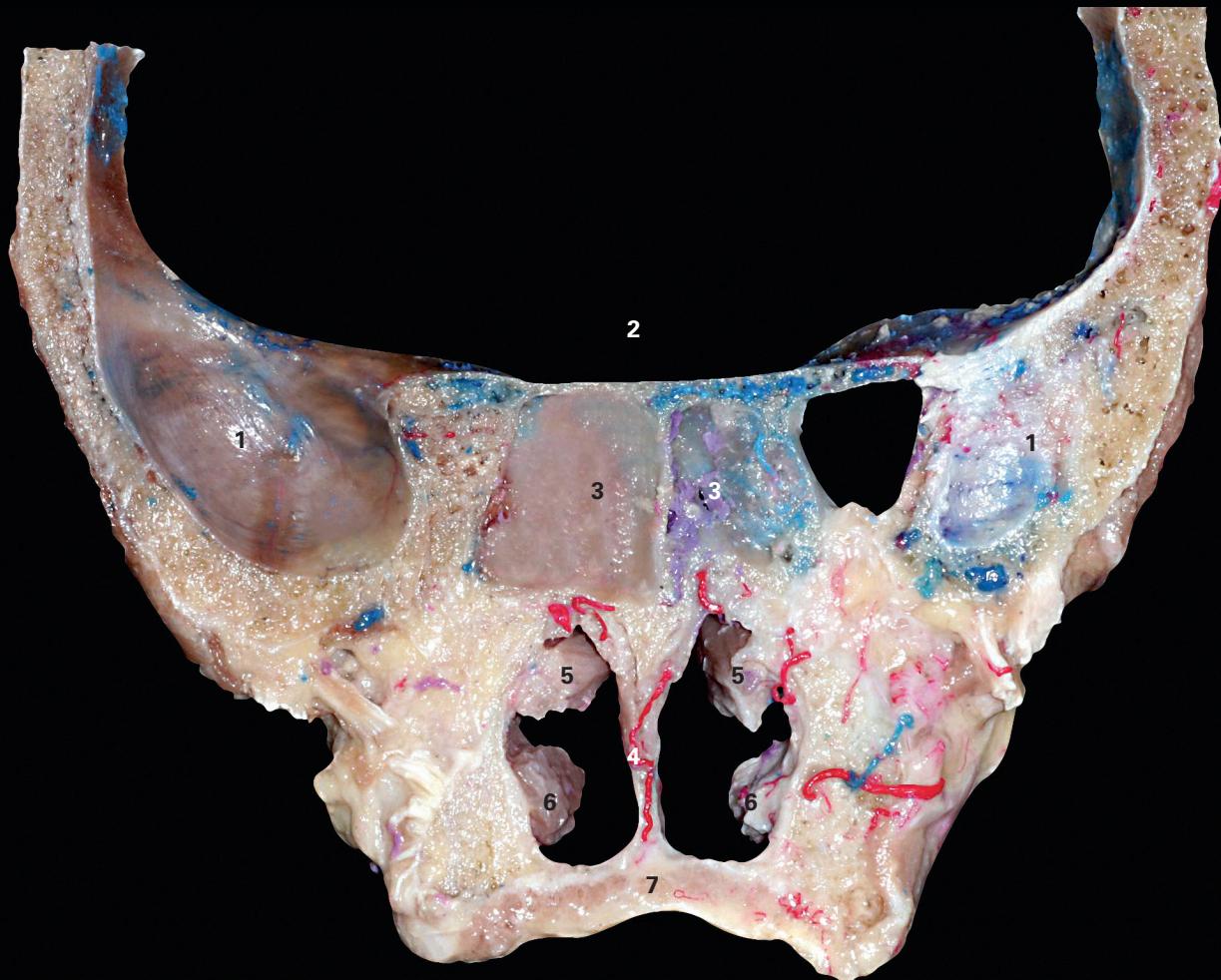


Fig 3-24

**Plate 1**

1. Middle cranial fossa
2. Anterior cranial fossa
3. Sphenoid sinus (anterior face)
4. Posterior nasal septum
5. Middle nasal concha
6. Inferior nasal concha
7. Hard palate

In 1988, Arthur Rathburn created the *resin arterial forced infusion method* for fresh disectable anatomical materials. This highly visual hands-on infusion technique provides a hallmark approach to the embodiment and clarity that one expects in natural coloration of real-life illustrations. The principle components of the arterial colorization is a nondissipating latex medium infused into the vessels at different intervals at a high rate of flow in conjunction with a gradual increase in psi flux. This task is accomplished by canalizing the major arteries and veins with a Luer-Lock system, preclamping any severed vessels and presetting the injection procedural rate at 3 to 5 psi (dual-tronic embalmers). As the injection process fills the arteries, a back pressure formulates, reducing the rate of arterial flow and/or formulating an increased incidence of arterial acceptance. Firming action is usually achieved within 1 to 2 hours at room temperature. This application process takes 5 to 10 minutes for every 60 mL of solution.

Figure 5-5 shows a clinical example of a block graft harvested from the ramus buccal shelf.

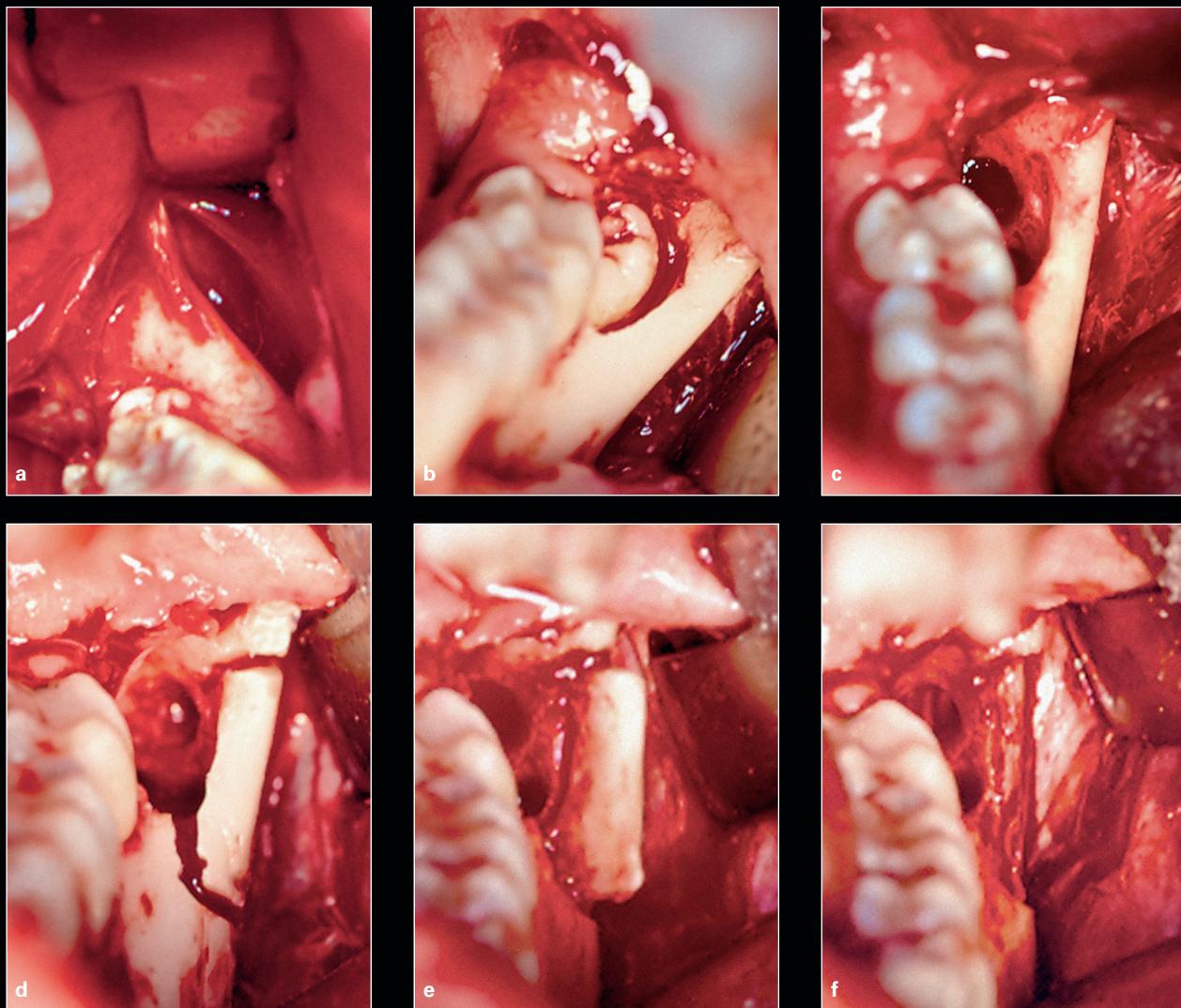


Fig 5-5 Clinical example of a block graft harvested from a ramus buccal shelf. (a) A full-thickness flap is reflected, and the anterior inferior area of the ramus is exposed. The attachment of the temporalis muscle at the inferior border of the mandible is noted, and the partially bony impacted third molar can be seen. (b) Immediate removal of the bone lateral to the third molar will outline the thickness of the ramus block. (c) Ramus area after removal of the third molar. (d) The medial wall of the block is extended toward the anterior slightly (per the required size of the recipient site). (e and f) After the other three cuts are made, the block graft is harvested.



Fig 6-4 Cross sections of four human mandible specimens (same as those in chapter 5) with different bone resorption patterns showing the position of the mental foramen relative to the IAN. In the middle of the alveolar bone, the nerve is considerably lower than the superior border of the foramen. (a) Mandible with minimal bone resorption. (b) Mandible with mild bone resorption. (c) Mandible with moderate to advanced bone resorption. (d) Severely resorbed mandible. On a panoramic radiograph of such a mandible, the mental foramen will be absent.

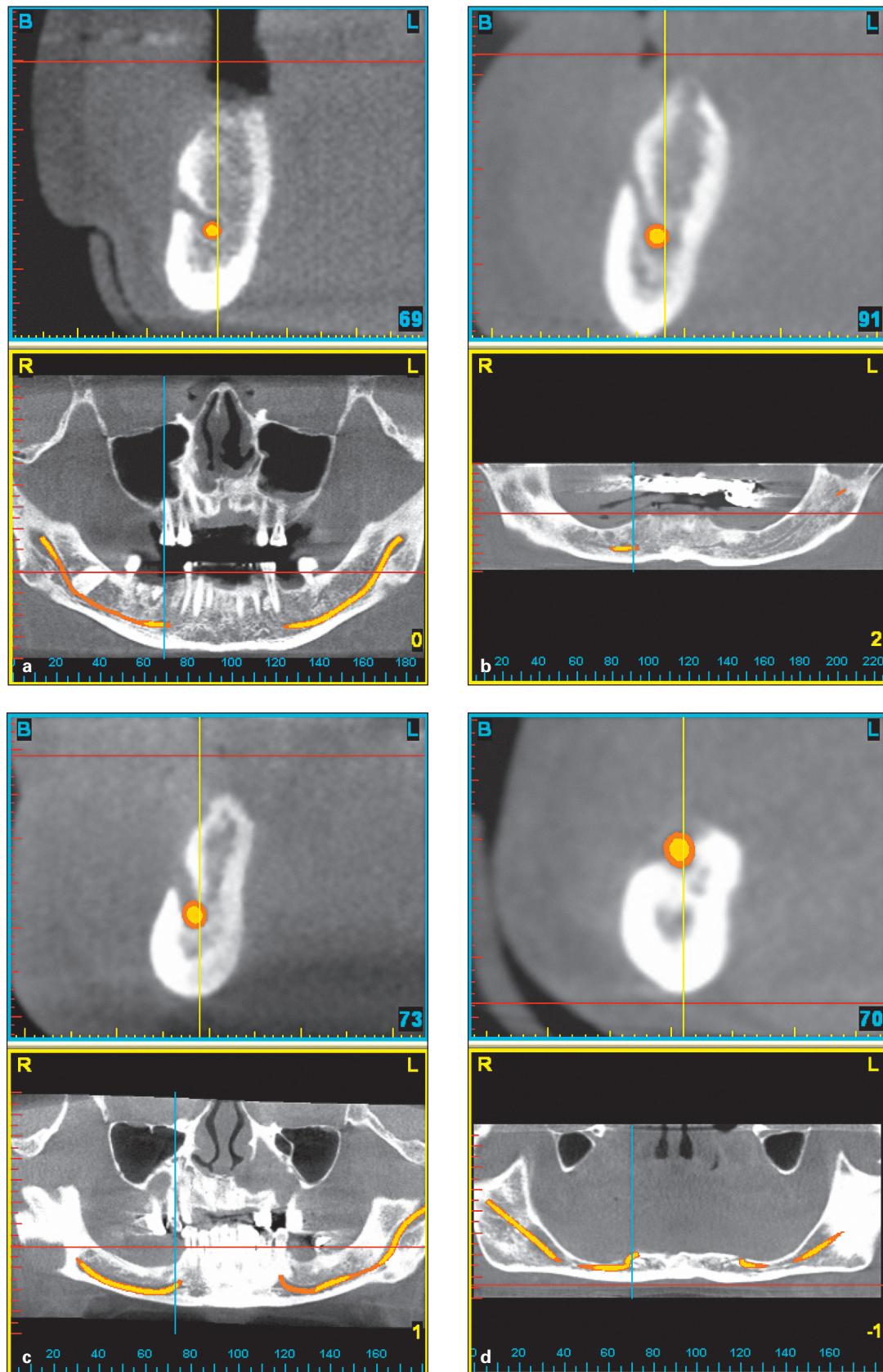


Fig 6-5 Computed tomography (CT) scans showing the precise locations of the mental foramen in mandibles with different patterns of resorption. (a) Mandible with minimal bone resorption. (b) Mandible with mild bone resorption. (c) Mandible with moderate to advanced bone resorption. (d) Mandible with severe bone resorption in which placement of implants is not possible in the vicinity of the mental foramen area.