

EDITION 2 VOLUME ONE

# ATLAS OF ORAL AND MAXILLOFACIAL SURGERY

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ELSEVIER

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# Foreword

2016 marked the introduction of the first edition of this comprehensive atlas of Oral and Maxillofacial Surgery and it quickly became the authoritative atlas for this discipline. Six years later (2022), the second edition of this treatise goes to press. Like all other surgical specialties, oral and maxillofacial surgery continues to rapidly evolve, and the new edition reflects the changing nature of surgery, the technological advances and the therapeutic modalities that have developed over this short timeframe. Why this atlas is titled Oral and Maxillofacial Surgery and not Craniomaxillofacial Surgery is bewildering. The title does not reflect the encompassing scope of surgery included in this book. This authoritative atlas will have appeal to multiple specialties from the traditional fields interested in facial, head, neck and oral surgery.

Having edited several textbooks involving multiple authors, I have experienced the complexities involved with the ambitious undertaking of this atlas. Deepak and Paul are very well organized and disciplined and have achieved success with this challenging task. They have recruited almost 300 contributors to provide 116 chapters for the new edition of this atlas. The work is divided into 13 sections which provides a comprehensive overview of the topics of: head and neck anatomy, oral surgery, implants, orthognathic surgery, craniofacial surgery, cleft lip and palate surgery, craniomaxillofacial trauma surgery, benign facial pathology surgery, malignant pathology involving the skull base, face and neck including the thyroid and parathyroid glands, reconstructive surgery including soft tissue, bone, cartilage, nerve, and facial transplantation, facial cosmetic surgery, TMJ surgery and obstructive sleep apnea surgery. This inclusive scope of practice is beyond most but embodies the multiple pathways available to contemporary surgeons wanting to pursue craniomaxillofacial surgery. The latest edition includes a separate section on obstructive sleep apnea surgery, which adds to the comprehensiveness of this

edition. As with the first edition, the chapters are well illustrated and are encyclopedic.

Most of the authors are representative of the contemporary training of oral and maxillofacial surgeons including both dental and medical degrees, general surgery experience, as well as fellowship training. The commonality of most of the authors is their dental and medical background and surgical expertise dedicated exclusively to the head, face, oral cavity, and neck. Most of the chapters are co-authored by well known and experienced clinicians teamed with more nascent surgeons who are the future leaders of the specialty. Deepak and Paul are known internationally and have networked with many current and future leaders of the specialty. The international representation of the contributors (numerous countries on 6 continents) has an appealing draw and reflects the global practice of craniomaxillofacial surgery.

Deepak and Paul have similar educational backgrounds, credentials, and career pathways as well as being fellowship trained providers of surgical care. They are both very experienced clinicians and educators. Both have research experience, and both are active administratively with their respective institutions and with service commitments to multiple national and international organizations. Fellowship training pursued by Deepak was oncology and microvascular reconstruction, while Paul pursued fellowship in cleft and craniofacial surgery. The 2 editors have a dynamic synergism which is reflected in this high-quality comprehensive work. Their energy and enthusiasm for what they do is apparent. This atlas mirrors their love and dedication to their work, their patients, their residents and fellows, and to the future of craniomaxillofacial surgery.

*by, Timothy A. Turvey, DDS, FACS*

# Foreword

I am honored to provide comment on the second edition of what I consider to be the most complete, and masterfully illustrated, atlas of oral and maxillofacial surgery ever published. This encyclopedic overview will enable our trainees, and practicing surgeons, to make evidence-based surgical decisions and afford our patients better outcomes. It is a stunning display in text, photographs, and illustration of the breadth and complexity of contemporary oral and maxillofacial surgery. A fledgling discipline that began formally in 1918 as “oral surgery,” was propelled, in the first fifty years, by advances in office-based surgery, anesthesia, pharmacology, surgical instrumentation, sterile technique, and experiential wisdom gained from trauma surgery in two World Wars. Starting in the late ‘60s, and early ‘70s, our training programs were formalized and broadened to include more exposure to general surgery and surgical subspecialties. An explosion of knowledge in surgical instrumentation, reconstructive and craniofacial techniques, microsurgery, biomaterials, implants, and imaging in the last fifty years has brought us to the current state of our specialty. This remarkable tome is not only the quintessential reference in oral and maxillofacial surgery, but a testimonial to that century of progress.

Dr. Ira Rutkow in *American Surgery: An Illustrated History* stated that “there is no way to separate present day surgery,

and one’s own practice routines, from the experiences of all the surgeons and all the years that have gone before.” This exceptional text brings an organized, consistent, visual pedagogic methodology covering office-based minor procedures to the most complicated head and neck reconstructive surgeries. In the late 19th century, the English novelist Samuel Butler once said, “Diseases come of their own accord, but cures come difficult and hard.” Drs. Kademani and Tiwana have created an exceptional single-source reference for our most current understanding of maxillofacial surgical procedures. Contemporary therapeutic decisions must be based on fact, evidence, and experience. Only scientific evidence can adjudicate those difficult decisions we all make daily as surgeons. I personally am indebted to Deepak and Paul for this Herculean effort to synthesize the past, present, and future of our specialty.

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# Preface

The first edition of *Atlas of Oral and Maxillofacial Surgery* was received positively. While many operations do not change significantly with the passage of time, the incorporation of refinements to technique and new technology begins the process of reshaping old into new. These modifications in technique, and the ever-broadening depth of our specialty, provided us the impetus to write this updated edition.

Although our foundations are based in dentistry, the specialty of Oral and Maxillofacial Surgery has evolved to include both a medical and a dental basis of training. While variations in the scope of practice still occur in the specialty across regions of the world, we have observed that these gaps have perceptibly narrowed with time. This change has been driven through the globalization of educational experiences, research, and clinical fellowships. The latter is the most important in this process of driving the specialty forward into a *Pangaea*. This Atlas was written to take advantage of the unifying strengths of our specialty as the premier surgical specialty caring for oral, craniomaxillofacial, and head & neck conditions that require operative intervention. It provides a navigational aid that can guide both experienced surgeons and surgeons in training through new operations and provide a basis for refinements of already established operations in their repertoire. Each chapter is organized in a similar fashion, guiding surgeons through the complex

anatomy, instrumentation, technical operative surgery, and modifications. Besides updating chapters from the first edition, many new chapters and a new section on Obstructive Sleep Apnea have been added. Our aim is that this Atlas will define and capture the current global perspective of Oral and Maxillofacial Surgery.

This book is written to provide practicing surgeons, residents, and students the most up-to-date reference for the technical performance and reasoning behind the many types of operations used in our specialty. From the basic to the most complex, readers will find that each chapter is sequentially organized to provide a comprehensive, concise, and practical description of the operative details needed for the contemporary surgical delivery of oral and maxillofacial surgical care. A formal section on relevant surgical anatomy has been incorporated to further assist the reader. Each chapter has been written by an expert surgeon and author who has a specific area of expertise. We would like to express our gratitude to all the section editors and authors for lending their time and expertise to the development of this Atlas.

It is our hope that the information presented here will continue to define the scope of practice of Oral and Maxillofacial Surgery and will provide a basis for education and training for surgeons in the future, with the goal of improving the quality of patient care across the world.

# Acknowledgments

We are deeply grateful to our many friends and colleagues who have supported us and contributed to this Atlas. We wish to thank our section editors, Gary F. Bouloux, Eric R. Carlson, Joseph E. Cillo Jr., Richard Allen Finn, Ghali Ghali, Alan S. Herford, Deepak G. Krishnan, Faisal A. Quereshey, Martin Steed, Steven M. Sullivan, and Brent B. Ward, who worked tirelessly to complete their editorial efforts. We thank them immensely for sharing their expertise and for their confidence and support in bringing this project to fruition.

We are also indebted to the many authors who gave their time and expertise in contributing to this book to make it a reality. We owe a particular debt of gratitude to our artist on this project, Joe Chovan. His artistic interpretation of anatomy and surgical procedures has set a new standard for the specialty and was simply breathtaking.



# Contents

## VOLUME ONE

### PART I

#### Surgical Anatomy of the Head and Neck

- 1 The Neurocranium, 1  
*Laurence D. Pfeiffer and John N. Phelan*
- 2 The Orbit and Eye, 11  
*Alan S. Herford, Trevor E. Treasure, and Rahul Tandon*
- 3 The Paranasal Sinuses, 19  
*Shyam Prasad Aravindaksha*
- 4 The Auditory System, 27  
*Kyle P. Allen*
- 5 The Anatomy of the Face, Mouth, and Jaws, 35  
*Christopher Morris*
- 6 The Salivary Glands, 50  
*Brandyn Herman and Melvyn Yeoh*
- 7 The Neck, 57  
*Jeffrey S. Dean and Rahul Tandon*
- 8 Fascial Spaces of the Head and Neck, 68  
*Joseph E. Cillo Jr.*
- 9 Embryology of the Head and Neck, 75  
*Janine Prange-Kiel*

### PART II

#### Oral Surgery

- 10 Routine Extraction of Teeth, 85  
*Rachel Uppgaard*
- 11 Surgical Extraction of Erupted Teeth, 94  
*Greg Tull, David Hinkl, and Paul S. Tiwana*
- 12 Impacted Teeth, 100  
*Louis J. Christensen and Mary Ann C. Sabino*
- 13 Canine Exposure, 112  
*Shravan Renapurkar, Pamela J. Hughes, and Christopher K. Ray*
- 14 Alveoloplasty, 121  
*Stephanie Joy Drew*
- 15 Palatal and Lingual Torus Removal, 128  
*Gregory M. Ness*
- 16 Apicoectomy, 135  
*Peter B. Franco, Luke C. Soletic, and Vasiliki Karlis*
- 17 Inferior Alveolar Nerve and Lingual Nerve Repair, 145  
*Leon Assael*
- 18 Odontogenic Infection, 153  
*Dan Q. Tran and A. Omar Abubaker*
- 19 Vestibuloplasty, 161  
*Vincent J. Perciaccante and Deepak G. Krishnan*

### PART III

#### Implant Surgery

- 20 Endosseous Dental Implants, 178  
*R. Gilbert Triplett, Jorge Gonzalez, and Andrew Read-Fuller*
- 21 Implants in the Esthetic Zone, 190  
*Waldemar D. Polido and Dean Morton*

- 22 All-on-Four Technique, 204  
*David Knight Sylvester II and Daniel Joseph Pinkston*
- 23 The Role of the Zygoma Implant in Maxillary Reconstruction, 212  
*Edmond Bedrossian and Edmond Armand Bedrossian*
- 24 Pterygomaxillary Implants, 224  
*David Knight Sylvester II and Daniel Joseph Pinkston*
- 25 Site Preservation and Ridge Augmentation, 233  
*Tara Aghaloo, Joan Pi-Anfruns, and Danny Hadaya*
- 26 Distraction Osteogenesis for Height, Width, or Repositioning of the Alveolar Process, 242  
*Ole T. Jensen, Zvi Laster, Amir Laviv, and Nardy Casap*
- 27 The Maxillary Sinus Lift, 253  
*Patrick J. Louis*
- 28 Endosseous Craniofacial Implants, 264  
*Sabine C. Girod*
- 29 Implant Rehabilitation and Maxillomandibular Free Flap Reconstruction, 273  
*Devin Joseph Okay and Daniel Buchbinder*
- 30 Implant Salvage Procedures, 290  
*Christian A. Loetscher*
- 31 Prosthodontic Temporization Procedures in Implant Dentistry, 303  
*Edward R. Schlissel*
- 32 Soft Tissue Augmentation Surgery for Dental Implants, 311  
*Meaghan Bradley and Hussam Batal*

### PART IV

#### Orthognathic Surgery

- 33 Computer Planning for Orthognathic Surgery, 324  
*Stephanie Joy Drew*
- 34 Genioplasty, 340  
*Ron Caloss*
- 35 Mandibular Subapical Osteotomies, 356  
*Paulo Jose Medeiros and Fabio G. Ritto*
- 36 Intraoral Vertical Ramus Osteotomy, 367  
*Samuel J. McKenna and James B. Lewallen*
- 37 Inverted L Mandibular Osteotomy, 375  
*Joseph E. Van Sickels*
- 38 The Bilateral Sagittal Split Ramus Osteotomy, 382  
*Johan P. Reyneke and Steven M. Sullivan*
- 39 The Anterior Segmental Maxillary Osteotomy, 397  
*Dror M. Allon and Neeraj Panchal*
- 40 Surgically Assisted Rapid Palatal Expansion, 409  
*Andrew Henry and Pushkar Mehra*
- 41 The Le Fort I Osteotomy, 421  
*Steven M. Sullivan*
- 42 Model Surgery Planning, 438  
*Joseph J. Fantuzzo*
- 43 Bimaxillary Orthognathic Surgery, 448  
*Vincent J. Perciaccante and Deepak G. Krishnan*
- 44 Combined TMJ and Orthognathic Surgery, 458  
*Larry M. Wolford and Reza Movahed*

## PART V

## Craniofacial Surgery

- 45 Endoscopic and Strip Craniectomy, 469  
*David A. Koppel and Jaime Grant*
- 46 Fronto-Orbital Advancement and Anterior Cranial Vault Reconstruction, 474  
*Ramon L. Ruiz, Paul S. Tiwana, and David C. Trent*
- 47 Posterior Cranial Vault Remodeling, 492  
*Douglas P. Sinn, Rahul Tandon, and Paul S. Tiwana*
- 48 Total Cranial Vault Remodeling, 501  
*Andrew Alistair Heggie and Anthony David Holmes*
- 49 The Le Fort III Osteotomy, 512  
*Paul S. Tiwana and Timothy A. Turvey*
- 50 Orbital Box Osteotomy, 526  
*Likith Reddy*
- 51 Monobloc and Facial Bipartition Osteotomies for the Reconstruction of Craniosynostosis Syndromes, 537  
*Jeffrey C. Posnick and Paul S. Tiwana*
- 52 Techniques for Skull Base and Cervical Spine Access, 568  
*James B. Holton*
- 53 Facial Translocation, 586  
*Kaushik H. Sharma and Deepak Kademani*
- 54 Mandibular Distraction Osteogenesis in Craniofacial Deformities, 598  
*Cesar A. Guerrero, Marianela Gonzalez, Elena Mujica, and Gisela Contasti-Bocco*
- 55 Maxillary Intraoral Distraction Osteogenesis, 616  
*Cesar A. Guerrero, Marianela Gonzalez, and Mariana Henriquez*

## PART VI

## Cleft Lip and Palate

- 56 Unilateral Cheilorhinoplasty—Delaire, 627  
*David S. Precious and Jean-Charles Doucet*
- 57 Rotation-Advancement Unilateral Cheilorhinoplasty, 634  
*Suzanne Barnes, Suganya Appugounder, and Paul Kloostera*
- 58 Unilateral Cheilorhinoplasty—Fisher, 642  
*David Yates and Patrick Wong*
- 59 Unilateral Cheilorhinoplasty—Talmant Protocol, 654  
*Jean-Charles Doucet and Jean-Claude Talmant*
- 60 Bilateral Cheilorhinoplasty, 665  
*Ghali E. Ghali and Jennifer E. Woerner*
- 61 Cleft Palate—Modified Two-Flap Technique, 672  
*Fabio G. Ritto, David Gailey, and Kevin Smith*
- 62 Cleft Palate—Furlow, 680  
*Brent Golden and Michael Jaskolka*
- 63 Cleft Palate Repair—Intravelar Veloplasty, 692  
*John Francis Caccamese Jr. and Max R. Emmerling*
- 64 Techniques in Bone Grafting the Cleft Maxilla and Palate, 702  
*Renie Daniel, Caitlin B. L. Magraw, and Timothy A. Turvey*
- 65 Pharyngoplasty for Velopharyngeal Incompetence, 712  
*Bernard J. Costello and Ramon L. Ruiz*
- 66 Cleft (Secondary) Rhinoplasty in the Adult Patient, 723  
*Andrew Alistair Heggie*
- 67 Cleft Le Fort Osteotomy, 738  
*Nabil Samman*
- 68 Secondary Surgery in Cleft Patients, 751  
*John Francis Caccamese Jr., Patrick Byrne, Shaun C. Desai, and Mingyang Liu Gray*

## PART VII

## Craniomaxillofacial Trauma

- 69 Repair of Facial Lacerations, 765  
*Neeraj Panchal and Hwi Sean Moon*
- 70 Techniques for Maxillomandibular Fixation, 778  
*Duke Yamashita, Nam Cho, and Allen Huang*
- 71 Surgical Correction of Injuries of the Nasolacrimal System, 785  
*John Vorrasi and Radhika Chigurupati*
- 72 Control of Facial Hemorrhage, 795  
*Todd R. Wentland, Roderick Y. Kim, and Herman Kao*
- 73 Principles and Biomechanics of Rigid Internal Fixation of the Mandible, 805  
*Michael R. Markiewicz and Mark Engelstad*
- 74 Dentoalveolar Trauma, 816  
*Stone Thayer and Ravi Chandran*
- 75 Anterior Mandibular Fractures, 825  
*Brian Bast and Stanley Yung-Chuan Liu*
- 76 Mandibular Body Fractures, 833  
*Mark Stevens and Hany Emam*
- 77 Mandibular Angle and Ramus Fractures, 841  
*Jayini Thakker, Rahul Tandon, Jason Rogers, and Meagan Miller*
- 78 Mandibular Condyle Fractures, 851  
*Likith Reddy and Andrew Read-Fuller*
- 79 Atrophic Edentulous Mandibular Fractures, 860  
*Jeffrey S. Marschall, George M. Kushner, and Brian Alpert*
- 80 Comminuted Mandibular Fractures, 869  
*David B. Powers*
- 81 Pediatric Mandibular Fractures, 880  
*Srinivas M. Susarla and Zachary S. Peacock*
- 82 Principles and Biomechanics of Rigid Internal Fixation (RIF) of the Midface and Upper Face, 887  
*Sebastian Sauerbier, Rainer Schmelzeisen, and Robert Nadeau*
- 83 Nasal Fractures, 896  
*Shahrokh C. Bagheri and Behnam Bohluli*
- 84 Zygoma Fractures, 909  
*Larry Cunningham Jr. and Blake Chaney*
- 85 Orbital Fractures, 919  
*Paul S. Tiwana and Deepak Kademani*
- 86 The Naso-Orbito-Ethmoid Fracture, 932  
*Mariusz K. Wrzosek and Stephen P. R. MacLeod*
- 87 Le Fort Injuries, 942  
*Justine Moe and Martin B. Steed*
- 88 Pediatric Midface Trauma, 952  
*Sean P. Edwards*
- 89 Management of Frontal Sinus Fractures, 961  
*David A. Bitonti*
- 90 Panfacial Fractures, 974  
*Alan S. Herford and Rahul Tandon*

## VOLUME TWO

## PART VIII

## Benign Pathology

- 91 Biopsy Techniques, 985  
*J. Michael McCoy*
- 92 Temporal Artery Biopsy, 993  
*Michael Awadallah*



- 93 Enucleation and Curettage of Benign Oral and Maxillofacial Pathology, 998  
*Joseph E. Cillo Jr.*
- 94 Marsupialization, 1006  
*Mehran Hossaini-Zadeh*
- 95 Marginal Mandibulectomy, 1011  
*Jasjit K. Dillon, Karl Pennau, and Li Han Lai*
- 96 Maxillectomy for Benign Tumors, 1021  
*Jonathan Bailey, Craig Norbutt, and Baxter Jones*
- 97 Segmental Resection of the Mandible, 1030  
*Ricardo Lugo, George Zakhary, and D. David Kim*
- 98 Sublingual Gland Excision and Ductal Surgery, 1036  
*Brian M. Woo*
- 99 Submandibular Gland Excision, 1049  
*Eric R. Carlson and Andrew W. C. Lee*
- 100 Superficial Parotidectomy, 1063  
*Daniel Oreadi*
- 101 Sialendoscopy, 1075  
*Maryam Akbari and Michael D. Turner*
- 102 Thyroidectomy, 1084  
*Curtis Hanba, Brendan H. G. Pierce, Ashok R. Jethwa, and Maria Evasovich*
- 103 Parathyroid Gland Surgery for Hyperparathyroidism, 1095  
*Brett A. Miles and Matthew R. Idle*
- 104 Thyroglossal Duct Cyst, 1106  
*Omotara Sulyman, Tanisha Hutchinson, and David Hamlar*
- 105 Management of Branchial Cleft Cysts, Sinuses, and Fistulae, 1113  
*Mehmet Ali Altay and Dale A. Baur*
- 106 Carotid Body Tumor, 1124  
*Julio Acero and Fernando Almeida*

## PART IX

## Malignant Pathology

- 107 Excision of Facial Skin Malignancy, 1133  
*Thomas Schlieve, Pooja Gangwani, and Antonia Kolokythas*
- 108 Local Flaps for Facial Reconstruction, 1144  
*Hans C. Brockhoff II and Felix Jose Amarista*
- 109 Panendoscopy, 1166  
*Michael R. Markiewicz and Tuan G. Bui*
- 110 Cricothyroidotomy and Tracheostomy, 1178  
*Raymond P. Shupak, Fayette C. Williams, and Roderick Y. Kim*
- 111 Local Excision of Oral Malignancy, 1189  
*Brian Louis Ruggiero and Justine Moe*
- 112 Glossectomy, 1204  
*Allen C. Cheng and Jonathan James Jelmini*
- 113 Composite Resection, 1218  
*Robert Ord and Donita Dyalram*
- 114 Maxillectomy, 1229  
*Brandyn Herman and Melvyn Yeoh*
- 115 Orbital Resection, 1239  
*Beomjune Kim, Matthew Radant, and Deepak Kademani*
- 116 Neck Dissection, 1250  
*Deepak Kademani, Scott T. Claiborne, and Kaushik H. Sharma*
- 117 Sentinel Node Biopsy for Oral Squamous Cell Carcinoma, 1267  
*Marcus A. Couey, Andrew M. Baker, and R. Bryan Bell*

- 118 Laryngectomy, 1275  
*Marcus A. Couey and Ashish A. Patel*
- 119 Pharyngectomy, 1291  
*Moni A. Kuriakose and Swagnik Chakrabarti*

## PART X

## Reconstructive Surgery

- 120 Buccal Fat Pad Flap, 1303  
*Adam P. Fagin and Peter B. Franco*
- 121 Tongue Flap, 1308  
*Daniel J. Meara*
- 122 The Palatal Flap, 1318  
*Sharon Aronovich and Paul Shivers*
- 123 Temporalis Axial Flap, 1324  
*Jeffrey S. Dean and Rahul Tandon*
- 124 Pectoralis Major Myocutaneous Flap, 1331  
*Kaushik H. Sharma, Scott T. Claiborne, and Deepak Kademani*
- 125 Submental Island Flap for Reconstruction of Head and Neck Defects, 1339  
*Dale A. Baur, David Collette, and Petra Olivieri*
- 126 Latissimus Dorsi Flap, 1346  
*Genevieve C. Bonin and Nicholas M. Makhoul*
- 127 Radial Forearm Flap, 1357  
*Joshua E. Lubek*
- 128 Fibula, 1371  
*David R. Kang and Brent B. Ward*
- 129 Scapular Free Flap, 1386  
*Marina Morante Silva and Rui P. Fernandes*
- 130 Rectus Abdominis Free Flap, 1396  
*Andrew Salama and Rushil R. Dang*
- 131 Deep Circumflex Iliac Artery Free Flap, 1405  
*Daniel A. Hammer, Brett Shirley, and Fayette C. Williams*
- 132 Anterolateral Thigh (ALT) Free Flap, 1413  
*Omar Breik, Prav Praveen, and Sat Parmar*
- 133 Skin Grafting, 1424  
*Miller H. Smith and Colin MacIver*
- 134 Anterior Iliac Crest Bone Grafting (AICBG), 1439  
*Ravi Agarwal and George Obeid*
- 135 Posterior Iliac Crest Bone Grafting, 1449  
*Shahid R. Aziz*
- 136 Tibial Bone Graft, 1454  
*George M. Kushner and Brian Alpert*
- 137 Costochondral Graft, 1461  
*Deepak G. Krishnan*
- 138 Calvarial Bone Graft, 1468  
*William J. Curtis, Brent Golden, and Michael Jaskolka*
- 139 Intraoral Bone Harvesting Techniques, 1479  
*Hans C. Brockhoff II, David M. Yates, and Richard Allen Finn*
- 140 Auricular Cartilage Graft Harvest, 1485  
*Joli Chou*
- 141 Facial Nerve Repair and Reanimation, 1491  
*David Hamlar, Kenneth Wan, Joel Stanek, and Sofia Lyford-Pike*
- 142 Face Transplant, 1503  
*Marissa Suchyta, Waleed Gibreel, Karim Bakri, Carrie E. Robertson, Thomas J. Salinas, Sebastian Cotofana, Hatem Amer, and Samir Mardini*
- 143 Autogenous Auricular Reconstruction, 1510  
*Omotara Sulyman, Tsung-yen Hsieh, and David Hamlar*

## PART XI

## TMJ Surgery

- 144 TMJ Arthrocentesis, 1519  
*Gary F. Bouloux*
- 145 Temporomandibular Joint Arthroscopy, 1526  
*Joseph P. McCain, Reem H. Hossameldin, and Christopher A. Fanelli*
- 146 Arthroplasty and Eminectomy, 1538  
*Shyam Sunder Indrakanti, Helaman Erickson, and John R. Zuniga*
- 147 Custom Total Temporomandibular Joint Replacement, 1550  
*Louis G. Mercuri*
- 148 Stock Alloplastic Temporomandibular Joint Reconstruction, 1563  
*Eric J. Granquist and Peter D. Quinn*
- 149 Temporomandibular Joint (TMJ) Ankylosis, 1575  
*Nigel Shaun Matthews and Matthew H. Pham*

## PART XII

## Facial Cosmetic Surgery

- 150 Brow Lifting, 1587  
*Tirbod Fattahi and Sepideh Sabooree*
- 151 Facelift, 1593  
*Jon D. Perenack*
- 152 Rhinoplasty and Septoplasty, 1607  
*Tirbod Fattahi*
- 153 Otoplasty, 1617  
*Faisal A. Quereshey and Ashley E. Manlove*
- 154 Laser Skin Resurfacing, 1624  
*Craig E. Vigliante and Carrie E. Cera Hill*
- 155 Liposuction of the Face and Neck, 1637  
*Angelo L. Cuzalina and Pasquale G. Tolomeo*

- 156 Scar Revision, 1649  
*Erik Jon Nuveen*
- 157 Neuromodulators and Injectable Fillers, 1658  
*Courtney Caplin*
- 158 Augmentation of the Midface and Mandible With Alloplastic Implants, 1665  
*Ron Caloss*
- 159 Micrografting and Hair Transplantation Surgery, 1680  
*David Stanton, Deepak Kademani, and Paul S. Tiwana*

## PART XIII

## Obstructive Sleep Apnea

- 160 Genioglossus Advancement/Hyoid Suspension for Obstructive Sleep Apnea (OSA), 1690  
*David J. Dattilo*
- 161 UPPP, LAUP, and RAUP Procedures for Obstructive Sleep Apnea, 1697  
*Joseph E. Cillo Jr.*
- 162 Tongue Reduction for Obstructive Sleep Apnea, 1705  
*John M. Nathan, Yuliya Petukhova, and Christopher F. Viozzi*
- 163 MMA for Obstructive Sleep Apnea, 1711  
*Yedeh Ying and Peter D. Waite*
- 164 Hypoglossal Nerve Stimulation for Obstructive Sleep Apnea, 1719  
*Stanley Yung-Chuan Liu and Allen Huang*
- 165 Functional Nasal Surgery, 1726  
*Hwi Sean Moon and Neeraj Panchal*
- 166 Mandibular Distraction in Infancy for Airway Obstruction, 1739  
*Jocelyn M. Shand*

# Video Contents

- 59.1 Dissection of the Nasal Septum
- 59.2 Dissection of the Upper Lateral Cartilages
- 59.3 Complete Nasal Dissection
- 59.4 Nasal Retainer
- 63.1 Sommerlad Video
- 78.1 Trauma Retromandibular Approach
  
- 1 Trauma Transconjunctival Approach
- 2 Trauma Upper Blephroplasty
- 3 Trauma Transcaruncular Approach
- 4 Trauma Submental Approach
- 5 Trauma Submandibular Gland Excision
- 6 Trauma Subciliary Approach
- 7 Trauma Risdon Approach
- 8 Trauma Pericranial Flap
- 9 Trauma Pericranial and Coronal Flap
- 10 Trauma Pectoralis Flap
- 11 Trauma Maxillary Vestibular Approach
- 12 Trauma Intraoral Mandibular Angle Approach
- 13 Trauma Coronal Flap
- 14 Trauma Approach to ZF Suture
- 15 Trauma Anterior Mandible Vestibular Approach

# The Neurocranium

Laurence D. Pfeiffer and John N. Phelan

## The Neurocranium<sup>1</sup>

The oft-heard maxim “anatomy is destiny” was coined by Sigmund Freud in summary of his assertion that gender is the primary determinant of personality traits. For surgeons, the same quote can be applied to the importance of mastering the intricate construction of the portion of the human body for which they are responsible. Thorough comprehension of anatomy allows the surgeon to work safely and precisely, thereby optimizing restoration of health and minimizing morbidity. In this chapter, the structure of the neurocranium and how it relates to oral and maxillofacial surgery are examined.

The skull consists of the cranium (Fig. 1.1) and the mandible (Fig. 1.2). The cranium is divided into the neurocranium and the viscerocranium (see Fig. 1.1). The neurocranium encases the brain and is found above the orbits. Below the orbits, the viscerocranium, alternately called the *splanchnocranium* or midface, supports the nasal passages and the oral cavity and makes up the face.

The neurocranium may be considered in two parts: the roof, or cranial vault (also called by its Latin name, the *calvaria*), and the floor, or cranial base. The space within the neurocranium occupied by the brain is the cranial cavity. The calvaria is formed anteriorly by the frontal bone, posteriorly by part of the occipital bone, and laterally by the paired parietal bones and squamous portions of the temporal bones (Fig. 1.3). Although most bones develop by endochondral ossification, which involves the formation of a cartilaginous template that is gradually replaced by bone, the bones of the calvaria develop through intramembranous ossification, whereby mesenchymal cells forming a membrane over the brain condense into a collection of nodes and differentiate directly into osteoblasts. The osteoblasts secrete a matrix that becomes calcified, resulting in the formation of flattened bone within the membrane. The nodes or islands of bone enlarge radially, but at birth the bones of the calvaria are still separated from each other by the mesenchymal membrane.<sup>2-4</sup> The largest areas of noncalcified membrane, called *fontanelles*, are found where the frontal and occipital bones meet the parietal bones on the superior aspect of the calvaria (see Fig. 1.3). The failure of the calvarial bones to fuse prior to infancy allows the cranium to deform during passage through the birth canal and allows the volume of the neurocranium to continue to expand after birth to accommodate enlargement of the brain. Intramembranous ossification continues

through infancy until the bones of the calvaria meet and form fibrous suture joints, which usually fuse during adulthood.

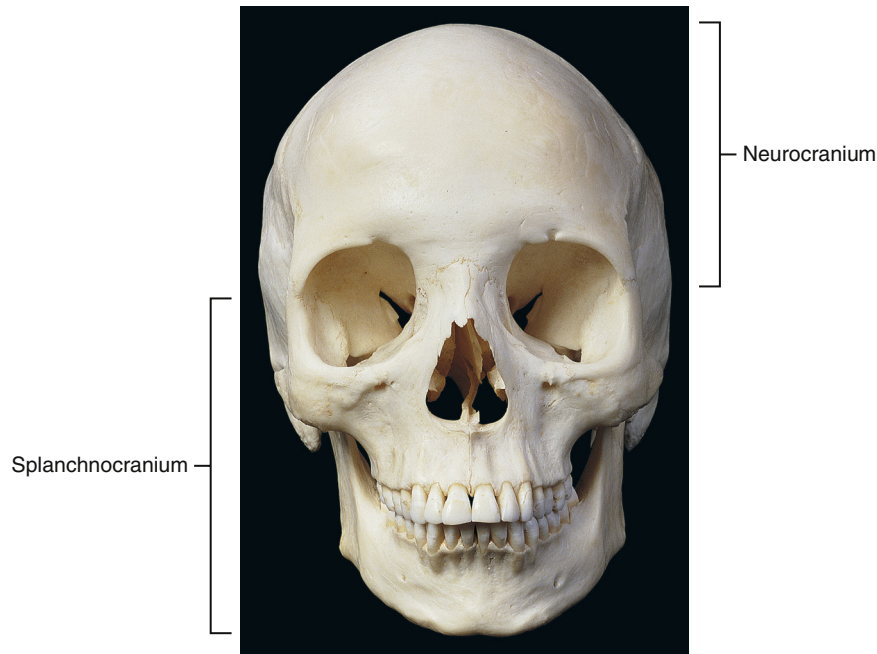
One or more of the sutures between the bones of the calvaria may prematurely fuse during fetal development. Virchow's law states that this event, called *craniosynostosis*, results in imbalanced development of the skull; enlargement perpendicular to the fused suture is limited, and enlargement of the area where the sutures remain open is correspondingly increased. The resulting malformation has the potential to cause compression of a portion of the brain, which may result in neurologic abnormalities.<sup>5</sup>

After fusion, the sutures remain visible on the external and internal surfaces of the calvaria (see Fig. 1.3). Along the midline, the sagittal suture is located between the left and right parietal bones. The vertex, a conceptual point indicating the apex of the skull, would be located on the sagittal suture on a perfect skull. On the internal surface of the calvaria, an indentation is normally visible along the midline that corresponds to the superior sagittal sinus, a venous sinus within the dura mater (this is discussed in more detail with the cranial base). The coronal suture runs between the frontal bone and parietal bones, and the lambdoid suture is found between the occipital bone and the parietal bones. The sagittal suture intersects the coronal suture at the bregma and the lambdoid suture at the lambda (Fig. 1.4).

Bilaterally on the calvaria, the squamosal suture is visible between the parietal bone and the squamous portion of the temporal bone. The area where the parietal, temporal, and occipital bones meet is called the *asterion*, which serves as a neurosurgical landmark. More anteriorly, the frontal, parietal, and temporal bones intersect with a bone involved in the formation of the cranial base, the sphenoid bone, to form an H-shaped suture called the *pterion* (Fig. 1.5). The middle meningeal artery, which arises from a branch of the external carotid artery called the *maxillary artery*, runs along the inside of the neurocranium and crosses the pterion. Trauma to the skull at the pterion can rupture the underlying middle meningeal artery, leading to a potentially fatal epidural hematoma.

The floor of the neurocranium is formed by the occipital, temporal, sphenoid, ethmoid, and frontal bones. The internal surface of the floor of the neurocranium, upon which the brain rests, is divided into the anterior, middle, and posterior cranial fossae (Fig. 1.6).





**Figure 1.1** The cranium and its divisions. (From Abrahams PH, Spratt JD, Loukas M, van Schoor AN. *McMinn and Abrahams' Clinical Atlas of Human Anatomy*. 7th ed. St Louis, MO; Mosby; 2013.)



**Figure 1.2** The mandible. (From Abrahams PH, Spratt JD, Loukas M, van Schoor AN. *McMinn and Abrahams' Clinical Atlas of Human Anatomy*. 7th ed. St Louis, MO; Mosby; 2013.)

The majority of the anterior cranial fossa consists of the orbital plates of the frontal bone, which form the roofs of the orbits. The orbital roofs bear impressions that mirror the undulating sulci and gyri of the overlying cerebrum. An explanation of how the gelatinous brain might influence the structure of rigid bone is found in Melvin Moss's functional matrix hypothesis, which states that the development of bone sequentially follows, and is thus dependent on, structural changes in the collections of developing soft tissues called *functional matrices*. The cerebrum would thus be a component of the functional matrix for which the associated bone is the frontal bone, or more specifically, the orbital plates of the

frontal bone. Likewise, the superior sagittal sinus is a component of the functional matrix associated with the parietal bones, hence, the impression along the internal surface of the sagittal suture described earlier.

Part of the ethmoid bone is found between the orbital plates of the frontal bone (Fig. 1.7). The vertical ridge at the midline is the crista galli, named for its resemblance to a rooster's crest. The cerebral falx, a vertical sheet of dura mater separating the cerebral hemispheres, attaches to the crista galli. On either side of the crista galli are the cribriform plates, which have numerous perforations. Branches of the first cranial nerve, the olfactory nerve, pass through these perforations to reach the nasal cavity.

Posterior to the frontal and ethmoid bones are the lesser wings of the sphenoid bone, which form the posterior edge of the anterior cranial fossa. Extending posteriorly from the medial ends of the lesser wings are the anterior clinoid processes, to which attaches the cerebellar tentorium, a horizontal sheet of dura mater that separates the cerebrum from the cerebellum. The jugum, which is the flattened area between the anterior clinoid processes, supports the olfactory tracts.

The middle cranial fossa is formed by the greater wings and body of the sphenoid bone anteriorly and by the temporal bone posteriorly. The temporal lobes of the brain rest in the lateral recesses of this fossa. At the center of the middle cranial fossa is a portion of the body of the sphenoid bone called the *sella turcica*, which is named for its resemblance to a Turkish saddle. The pituitary gland hangs down from the brain and "sits" in this saddle. The depression for the gland in the center of the sella turcica is the hypophyseal fossa. On either side of the hypophyseal fossa is a concavity occupied by