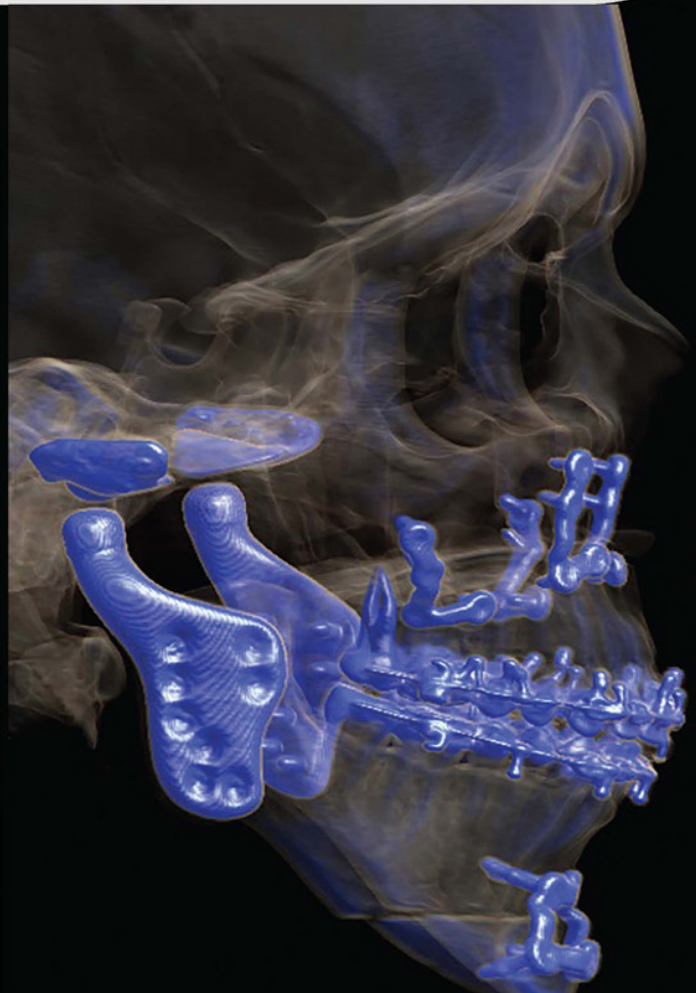
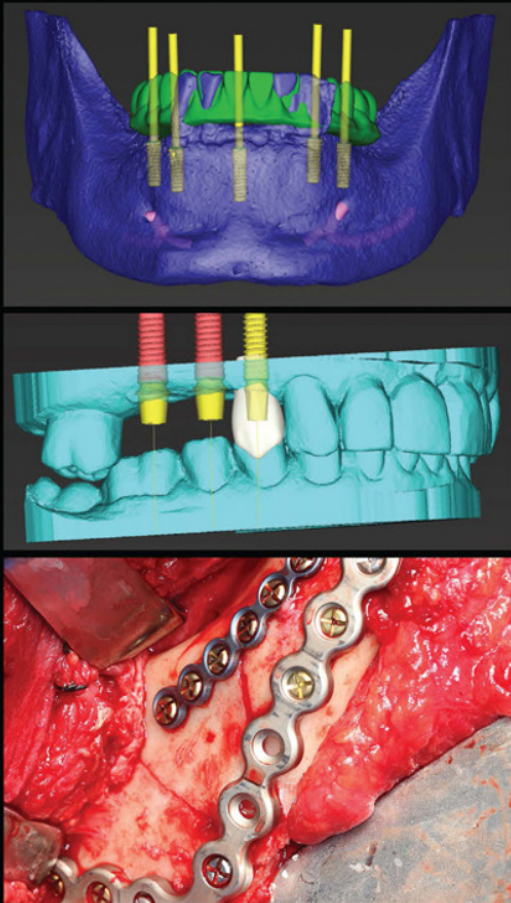


**SECOND EDITION**

ATLAS OF

# OPERATIVE ORAL AND MAXILLOFACIAL SURGERY

Edited by **Christopher J. Haggerty** | **Robert M. Laughlin**



**WILEY** Blackwell

# ATLAS OF OPERATIVE ORAL AND MAXILLOFACIAL SURGERY

# ATLAS OF OPERATIVE ORAL AND MAXILLOFACIAL SURGERY

**Second Edition**

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This edition first published 2023  
© 2023 John Wiley & Sons, Inc.

*Edition History*  
John Wiley & Sons, Inc. (1e, 2015)

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*Library of Congress Cataloging-in-Publication Data is applied for*

Hardback ISBN: 9781119683810

Cover image: Courtesy of Thaer Daifallah and Christopher J. Haggerty  
Cover design by Wiley

Set in 10/12pt Meridien by Straive, Pondicherry, India

# CONTENTS

**List of Contributors** x

**Acknowledgements** xvi

**About the Companion Website** xvii

## **PART ONE: DENTOALVEOLAR AND IMPLANT SURGERY**

1. ANATOMIC AND LEGAL CONSIDERATIONS IN DENTOALVEOLAR SURGERY 3  
*Pooja Gangwani, Antonia Kolokythas, and Michael Miloro*
2. EXPOSURE AND BONDING OF AN IMPACTED TOOTH 12  
*Kevin Austin, Neil C. Kanning, and Christopher J. Haggerty*
3. PRE-PROSTHETIC SURGERY 28  
*Daniel Clifford and Christopher J. Haggerty*
4. EXTRACTION SITE (SOCKET) PRESERVATION 37  
*Dale J. Misiak*
5. ONLAY BONE GRAFTING 41  
*Christopher J. Haggerty*
6. SINUS LIFT GRAFTING 58  
*Dale J. Misiak and Christopher J. Haggerty*
7. ZYGOMATIC IMPLANTS 72  
*Luis Vega and Patrick J. Louis*
8. IMMEDIATE IMPLANT PLACEMENT 78  
*Brett M. Sullivan*
9. CONE BEAM CT GUIDED DENTAL IMPLANT TREATMENT PLANNING, SURGERY,  
AND TEMPORARY PROSTHESIS PLACEMENT 91  
*Christopher J. Haggerty*
10. REMOVABLE RESTORATION OPTIONS OF THE EDENTULOUS ARCH 128  
*Christopher J. Haggerty*
11. IMMEDIATE IMPLANT-SUPPORTED RESTORATION OF THE EDENTULOUS ARCH 147  
*Jonathan X. Esquivel, Karen Bruggers, and Robert M. Laughlin*
12. IMPLANT COMPLICATIONS 157  
*Michael S. Block*

## **PART TWO: INFECTION**

13. REVIEW OF SPACES 173  
*Matthew W. Hearn, Christopher T. Vogel, Robert M. Laughlin, and Christopher J. Haggerty*
14. OSTEOMYELITIS 204  
*Matthew W. Hearn, Christopher T. Vogel, Thaer A. Daifallah, Robert M. Laughlin, and Christopher J. Haggerty*

15. SURGICAL MANAGEMENT OF MEDICATION-RELATED OSTEONECROSIS OF THE JAWS (MRONJ) 217  
*Eric R. Carlson*

### **PART THREE: MAXILLOFACIAL TRAUMA SURGERY**

16. SURGICAL MANAGEMENT OF THE AIRWAY 231  
*Thaer A. Daifallah and Christopher J. Haggerty*
17. MANDIBULAR FRACTURES 254  
*Christopher J. Haggerty*
18. LE FORT FRACTURES 301  
*Shahid R. Aziz*
19. ISOLATED ZYGOMA AND ZYGOMATICOMAXILLARY COMPLEX (ZMC) FRACTURES 307  
*Christopher J. Haggerty*
20. ORBITAL FRACTURES 320  
*Michael R. Markiewicz, Christopher T. Vogel, Matthew Sniegowski, Christopher J. Haggerty, and R. Bryan Bell*
21. NASAL FRACTURES 348  
*Hani F. Braidy, Vincent B. Ziccardi, and Christopher J. Haggerty*
22. FRONTAL SINUS FRACTURES 359  
*Gabriel C. Tender, Arnett Klugh, III, Min S. Park, Robert M. Laughlin, and Christopher J. Haggerty*
23. PANFACIAL AND NASO-ORBITO-ETHMOID (NOE) FRACTURES 375  
*Celso F. Palmieri Jr, Andrew T. Meram, and Nathan Yang*
24. MAXILLOFACIAL GUNSHOT WOUNDS (GSW) 392  
*Jayson Terres and Christopher J. Haggerty*
25. SOFT TISSUE INJURIES 406  
*Nicholas Callahan, Antonia Kolokythas, Robert A. Nadeau, Christopher J. Haggerty, and Michael Miloro*

### **PART FOUR: ORTHOGNATHIC AND CRANIOFACIAL SURGERY**

26. VIRTUAL SURGICAL PLANNING (VSP) IN ORTHOGNATHIC SURGERY 429  
*Adam Fagin and Brian B. Farrell*
27. MAXILLARY OSTEOTOMIES 438  
*Brian B. Farrell and Andrew Megison*
28. MANDIBULAR OSTEOTOMIES 456  
*Brian B. Farrell and Michelle Zoccolillo*
29. ATYPICAL MANDIBULAR OSTEOTOMIES 478  
*Wendall Mascarenhas and Brian B. Farrell*
30. GENIOPLASTY (ANTERIOR SLIDING OSTEOTOMY) AND GENIOGLOSSUS ADVANCEMENT 493  
*Peter C. Dennis and Brian B. Farrell*
31. MAXILLARY AND MIDFACE DISTRACTION 501  
*Jeffrey N. James, Chris Ibrahim, Jessica Anderson, and Lester Machado*
32. DENTOALVEOLAR CLEFT REPAIR 510  
*Joshua A. Stone, Michael Oh, and Jeremiah Jason Parker*
33. CLEFT PALATE REPAIR (PALATOPLASTY) 517  
*Jeffrey N. James and Alexander Faigen*



34. CLEFT LIP REPAIR (CHEILORHINOPLASTY) 525  
*George Zakhary and Sloan Rehder*
35. ORTHOGNATHIC SURGERY IN THE CLEFT PATIENT: LE FORT I OSTEOTOMY 533  
*Joshua A. Stone and John T. Brothers*
36. CRANIOSYNOSTOSIS AND VAULT SURGERY 547  
*Jeffrey N. James*

## PART FIVE: TEMPOROMANDIBULAR JOINT SURGERY

37. TEMPOROMANDIBULAR JOINT IMAGING 563  
*Joshua A. Stone and Christopher J. Haggerty*
38. ARTHROCENTESIS OF THE TEMPOROMANDIBULAR JOINT 569  
*Robert M. Laughlin and Christopher J. Haggerty*
39. ARTHROSCOPIC ARTHROPLASTY OF THE TEMPOROMANDIBULAR JOINT 572  
*Joseph P. McCain and Reem Hamdy Hossameldin*
40. ALLOPLASTIC RECONSTRUCTION (TMJ CONCEPTS) OF THE TEMPOROMANDIBULAR JOINT AND ASSOCIATED STRUCTURES 582  
*John N. Kent, Christopher J. Haggerty, Billy Turley, and Robert M. Laughlin*
41. AUTOGENOUS RECONSTRUCTION OF THE TEMPOROMANDIBULAR JOINT 604  
*John N. Kent and Christopher J. Haggerty*
42. EMINECTOMY 610  
*Joseph P. McCain and Reem Hamdy Hossameldin*
43. CONCOMITANT TEMPOROMANDIBULAR JOINT REPLACEMENT AND ORTHOGNATHIC SURGERY 619  
*Thaer A. Daifallah and Daniel Margolis*

## PART SIX: FACIAL COSMETIC SURGERY

44. INNOVATIONS IN FACIAL COSMETIC SURGERY 639  
*Kayvan Fathimani, Jon D. Perenack, and Anne Scruggs*
45. NEUROMODULATOR (BOTOX) MANAGEMENT OF FACIAL RHYTIDS 648  
*Waheed V. Mohamed*
46. SOFT TISSUE VOLUMIZERS 655  
*Waheed V. Mohamed*
47. CHEMICAL PEELS 661  
*Jon D. Perenack, Kayvan Fathimani, and Brian W. Kelley*
48. FACIAL CO<sub>2</sub> LASER RESURFACING 667  
*Matthew R. Hlavacek*
49. BROW LIFT 674  
*Jon D. Perenack, Kayvan Fathimani, and Earl Peter Park*
50. RHYTIDECTOMY 690  
*Jennifer Elizabeth Woerner and Ghali E. Ghali*
51. UPPER AND LOWER LID BLEPHAROPLASTY AND TEAR TROUGH IMPLANTS 699  
*Dustin M. Heringer and L. Angelo Cuzalina*
52. RHINOPLASTY 715  
*Jon D. Perenack, Kayvan Fathimani, and Shahrouz Zarrabi*

## **PART SEVEN: MAXILLOFACIAL PATHOLOGY SURGERY**

- 53. BENIGN CYSTS OF THE JAWS 741  
*Christopher M. Harris, Christopher J. Haggerty, and Thaer A. Daifallah*
- 54. BENIGN TUMORS OF THE JAWS 752  
*Christopher M. Harris, Christopher J. Haggerty, and Thaer A. Daifallah*
- 55. PALATAL PATHOLOGY 766  
*Jordan Gigliotti, Earl Peter Park, and Anthony B. Morlandt*
- 56. OCULAR ENUCLEATION AND EVISCERATION 774  
*Mark A. Welch and Eric Murnan*
- 57. TRANSCERVICAL STYLOIDECTOMY AND THE FORGOTTEN TRIANGLES OF THE NECK 782  
*Mark A. Welch and Andrew Megison*
- 58. SURGICAL MANAGEMENT OF THE NECK 787  
*Earl Peter Park and Anthony B. Morlandt*
- 59. SURGICAL MANAGEMENT OF LIP CANCER 802  
*Terence E. Johnson, Michael Grau Jr, Craig Salt, and Robert M. Laughlin*
- 60. SALIVARY GLAND PATHOLOGY 806  
*Michael Grau Jr, Markus S. Hill, Billy Turley, Vincent Slovan, Christopher J. Haggerty, and Robert M. Laughlin*

## **PART EIGHT: MAXILLOFACIAL RECONSTRUCTIVE SURGERY**

- 61. CLOSURE OF ORAL-ANTRAL COMMUNICATIONS 831  
*Brent B. Ward*
- 62. ANTERIOR ILIAC CREST BONE GRAFT 841  
*Joshua A. Stone and Michael Carson*
- 63. POSTERIOR ILIAC CREST BONE GRAFT 849  
*Patrick B. Morrissey, Robert A. Nadeau, and Eric P. Hofmeister*
- 64. PROXIMAL TIBIAL BONE GRAFT 855  
*Nathan Steele and J. Michael Ray*
- 65. PARIETAL BONE GRAFT 858  
*Christopher J. Haggerty*
- 66. COSTOCHONDRAL GRAFT 863  
*Brian W. Kelley and Christopher J. Haggerty*
- 67. TONGUE FLAP RECONSTRUCTION OF LIP DEFECTS 867  
*Jayson J. Terres and Aujin Kim*
- 68. PARAMEDIAN FOREHEAD FLAP 873  
*Chris S. Kim, Eric Murnan, and Earl Peter Park*
- 69. PECTORALIS MAJOR MYOCUTANEOUS FLAP 879  
*Eric R. Carlson and Andrew W.C. Lee*
- 70. LATISSIMUS DORSI FREE FLAP 889  
*Beomjune Kim, Waleed Zaid, and Matthew R. Radant*
- 71. MICROVASCULAR PRINCIPLES 895  
*Christopher M. Harris, Allen O. Mitchell, and Robert M. Laughlin*
- 72. FREE VASCULARIZED FIBULA GRAFT HARVEST 901  
*Earl Peter Park and Robert M. Laughlin*



73. ANTEROLATERAL THIGH (ALT) PERFORATOR FREE FLAP 915  
*Waleed Zaid and Beomjune Kim*
74. RADIAL FOREARM FREE FLAP 920  
*Christopher M. Harris and Remy H. Blankaert*
75. NERVE HARVEST AND REPAIR 924  
*Thaer A. Daifallah, Andrew B.G. Tay, and John R. Zuniga*

### **APPENDICES (all Appendices online only)**

#### APPENDIX 1: NEUROSENSORY MAPPING CHART

*Pooja Gangwani, Antonia Kolokythas, and Michael Miloro*

#### APPENDIX 2: ANTIBIOTIC CHART

*Yousef A. Hammad, Timothy W. Neal, Joshua A. Stone, Matthew W. Hearn, Christopher T. Vogel, Robert M. Laughlin, and Christopher J. Haggerty*

#### APPENDIX 3: ANTIRESORPTIVE CHART

*Timothy W. Neal, Yousef A. Hammad, and Joshua A. Stone*

#### APPENDIX 4: CRANIOFACIAL SURGERY TIMING CHART

*Yousef A. Hammad, Timothy W. Neal, and Joshua A. Stone*

#### APPENDIX 5: NEUROTOXIN TREATMENT LOG

*Waheed V. Mohamed*

#### APPENDIX 6: DERMAL FILLER TREATMENT LOG

*Waheed V. Mohamed*

#### APPENDIX 7: PATHOLOGY CHART

*Michael J. Isaac, Patrick Lucaci, Robert M. Laughlin, and Christopher J. Haggerty*

#### APPENDIX 8: BLOOD THINNER (ANTICOAGULANT) CHART

*Yousef A. Hammad, Timothy W. Neal, and Joshua A. Stone*

### **Index 944**

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# ACKNOWLEDGEMENTS

## **Christopher J. Haggerty**

I would like to sincerely thank the oral and maxillofacial surgery programs of Louisiana State University and the University of Missouri-Kansas City for their commitment and support of this project.

I would like to thank Jack Kent, Michael Block, John Perenack, Randy Malloy, David Klein and Gabriel Tender for their dedication, patience and guidance and for teaching me the artistry of surgery and patient management.

I would like to thank Brett Ferguson for allowing me to join the UMKC OMFS family and for trusting me with his residents.

I would like to thank Thaer Daifallah for being a supportive long-term friend and colleague and for being a leader in our great specialty.

I would like to thank my magnificent wife Ashley for her perpetual encouragement, unequivocal support and willingness to endure my long hours with this project, similar projects and at the hospitals.

I would like to thank my children: Savannah, Harper, Reagan and Declan for allowing dad to sit at the computer on the weekends to complete this project. You all keep me young at heart and enable me to be a big kid.

I would like to thank my sister Jennifer for her advice and insight.

I would like to thank my brother Nick for always keeping me centered and for sharing his living room with me on Sundays.

I would like to thank my long-term friend and collaborating editor Rob Laughlin.

Finally, I would like to thank my parents, Ed and Jean Haggerty, for their unconditional and eternal understanding, encouragement and support. Your unprecedented benevolence, selflessness and sacrifice have made us who we are today.

## **Robert M. Laughlin**

This second edition would not have been possible with the hard work and efforts of so many. I would like to thank my family, friends, mentors, residents and colleagues.

I would like to thank the programs at Louisiana State University Health Science Center, New Orleans and The University of Michigan for the outstanding training and support over the years.

To my mentors, John “Jack” Kent, Michael Block, Randy Malloy and Joseph Helman, for your investment in me and the continued support and guidance.

To my late father Ralph Laughlin who lost the battle to COVID-19 and my mother Dianne Laughlin, who brings me strength every day.

To my LSU family, I would like to especially thank LP, AD, KB, MO, TC, TL, FM, JC and MO, you all are amazing.

To the many contributors of oral and maxillofacial surgery, head and neck surgery and reconstruction for your investment to this second edition. I want to thank all of you for your commitment to excellence in education, patient care, and the advancement to of the specialty.

I would like to thank the support and love of my wife Christine and my children Conlan, Taylor and Catherine. You all make every day special.

Lastly, I would like to thank my co-editor and friend Chris Haggerty for his extraordinary efforts and his incredible passion and advancements to our specialty.

Rob and I have been fortunate to train residents (the future leaders of our specialty) at numerous institutions to include LSU, UMKC, Michigan and the Navy. There is no greater privilege and honor than to work with young minds and to see their efforts manifest into outstanding surgeons, both in academic and private practice settings. Please continue to overachieve and to apply new principles to further enhance our specialty.

We would like to acknowledge all of the contributors to the first edition that helped to pave the way for the expanded second edition of the Atlas of Oral and Maxillofacial Surgery. Without the dedication and efforts of Bart Farrell, Jason Jamali, Scott Curtice, Christopher Choi, Ray Lim, Stephan Alfano, Eric Nordstrom, Myron Tucker, Bart Nierzwicki, James MacDowell, Antoine Panossian, Jon Holmes, Anil Shah, Matthew Brigger, Melvyn Yeoh and Stavan Patel, the first edition would not have been a success.

A special thanks to Bill Winn for providing the vast majority of the medical illustration for this project.

Bill, you are truly the most accomplished and talented oral and maxillofacial, head and neck and plastic and reconstructive surgery medical illustrator of all time. Thank you very much for all of your efforts with this project and for putting up with all of our changes along the way.

# ABOUT THE COMPANION WEBSITE

This book is accompanied by a companion website:

**[www.wiley.com/go/haggerty/oral\\_maxillofacial\\_surgery](http://www.wiley.com/go/haggerty/oral_maxillofacial_surgery)**

The website includes:

- Appendices
- Foreword from Prior Edition

## **PART ONE**

# **DENTOALVEOLAR AND IMPLANT SURGERY**

# Anatomic and Legal Considerations in Dentoalveolar Surgery

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An understanding of the anatomical relationships within the region of dentoalveolar intervention is critical to the avoidance of complications. Radiographic imaging assists in the assessment of anatomical variation and allows for risk stratification and predictable treatment outcomes.

## Infratemporal Fossa

The infratemporal fossa is a space located deep to the zygomatic arch and masseteric muscle. The medial boundary of the infratemporal space involves the lateral pterygoid plate. The contents of the infratemporal fossa include the muscles of mastication, blood vessels (pterygoid venous plexus, retromandibular vein, maxillary artery and vein, inferior alveolar artery and vein, middle meningeal artery and vein, deep temporal artery and vein, and buccal artery and vein) and nerves (branches of the maxillary and mandibular nerves, otic ganglion, and chorda tympani).

Due to the complexity of the anatomy and of the contents of the infratemporal fossa, should a maxillary third molar become displaced within the infratemporal fossa (see Figure 1.1), the surgeon should make one to two conservative attempts to remove the displaced tooth only if the tooth can be directly visualized. Blind exploration of the infratemporal fossa is not recommended as it may cause further displacement of the tooth and damage vital structures. Should the attempts be unsuccessful, the procedure should be terminated, imaging in the form of full cranium cone beam computed tomography (CBCT) scans or hospital grade CT scans should be obtained. Three-dimensional imaging will confirm the location of the displaced maxillary wisdom tooth. The patient is informed and the tooth is allowed to fibrous for 3–4 months prior to removal in an OR setting with general anesthesia. A CT scan is obtained a few days prior to the removal of the displaced wisdom tooth in order to confirm its position as the tooth may migrate. If the maxillary third is impacted high within the infratemporal fossa, it is best approached with a horizontal or curved incision within the hairline at

the level of the superior temporal line (attachment of the temporalis fascia).

## Nasal Cavity

The palatal process of the maxilla contributes to the anterior three-fourths of the nasal floor. The posterior one-fourth of the nasal floor is comprised from the horizontal process of the palatine bone. Care must be taken during placement of anterior maxillary implants to avoid violating this region. Care must be taken when extracting impacted anterior maxillary supernumerary teeth to not displace impacted teeth within a potential space deep to the periosteum along the nasal floor (see Figure 1.2).

## Maxillary Sinus

The maxillary sinus is the largest of the paranasal sinuses. It is pyramidal in shape with its apex oriented toward the zygoma. It lies within the posterior maxilla bounded by the infratemporal fossa, lateral nasal wall, and floor of the orbit. As a result of pneumatization, extensive variation exists; however, the average volume in adults is roughly 15 mL. Additionally, the maxillary sinus cavity may occasionally be divided by septae. The maxillary sinus ostium is located along the superior aspect of the medial wall of the sinus and drains into the middle meatus of the nasal cavity.

Third molars may be displaced into the overlying maxillary sinus during their extraction. Should maxillary third molar displacement occur, the location of the third molar must be confirmed (maxillary sinus, soft tissue posterior to the tuberosity or infratemporal fossa). If the wisdom tooth can be visually or radiographically confirmed within the maxillary sinus (see Figure 1.3), one to two attempts should be made through the extraction site to remove the third molar. If this is not possible, a Caldwell Luc approach is indicated. Significant enlargement of the extraction site may lead to the development of an oral-antral communication and should be avoided.



**Figure 1.1.** Cone beam CT scan depicting maxillary third molar displaced within the infratemporal fossa during a routine wisdom teeth extraction procedure.



**Figure 1.3.** Tooth #1 traumatically displaced into the overlying maxillary sinus. The tooth was retrieved through the extraction site using a suction tip.



**Figure 1.2.** Coronal CBCT image depicting an impacted inverted mesiodens located along the nasal floor. Care should be taken during the extraction of anterior maxillary supernumerary teeth to not displace the impacted teeth outside of the alveolar process of bone and into the nasal cavity.

## Mandible

### Lingual Nerve

The lingual nerve (LN) provides sensation to the anterior two-thirds of the tongue. The lingual nerve is at risk for injury with the extraction of third molars and with procedures involving the floor of the mouth. Within the third molar region, the lingual nerve is located, on average, 3.0 mm apical to the crest of the alveolar ridge and 2.0 mm medially from the lingual cortical plate. In 17.6% of the population, the lingual nerve is at or above the crest of the alveolar bone. In 22% of the population, the lingual nerve contacts the lingual cortex adjacent to the third molar region. Within the second molar region, the lingual nerve is located, on average, 9.5 mm inferior to the cementoenamel junction (CEJ). Within the first molar and second premolar regions, the average vertical distances from the CEJ lingually are 13.0 and 15.0 mm, respectively. The lingual nerve begins to course toward the tongue between the first and second molar regions. Due to its anatomic location, as well as possible individual patient variations in position, the lingual nerve is at risk for injury during third molar surgery.

Lingual nerve injury can be associated with presurgical pericoronitis, the presence of a presurgical anatomic lingual cortical defect, lingual flap retraction, placement of



surgical incisions too far lingually, violation of the lingual cortex with rotary instruments, lingual angulation of the third molar tooth, and surgeon inexperience.

### Mental Nerve

The mental foramen typically lies between the first and second premolars in a line corresponding with a vertical reference from the infraorbital foramen. Variability in the vertical distance of the foramen may be problematic in edentulous mandibles with excessive alveolar bone resorption. The mental nerve courses superiorly before exiting the mental foramen. Additionally, the mental nerve commonly loops anteriorly (genu) before its exit from the mental foramen in approximately 48% of the population. The average length of the anterior loop (genu) is 0.89 mm with a range of up to 5.7 mm or more. However, only 5% of individuals have an anterior loop length longer than 3.0 mm and only 2% have an anterior loop length greater than 4.0 mm.

### Inferior Alveolar Nerve

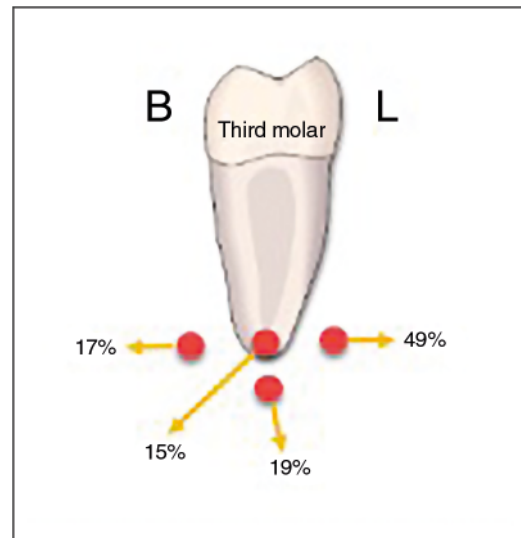
As the inferior alveolar nerve (IAN) descends from the base of the skull, it traverses the pterygomandibular space and enters the mandibular foramen approximately 1.5–2.0 cm inferior to the sigmoid notch. Within the corpus of the mandible, the course of the mandibular canal in the buccal-lingual dimension tends to follow one of three general patterns:

- Type 1: in the majority of the population (approximately 70%), the canal follows the lingual plate within the ramus–body region.
- Type 2: in 15% of the population, the canal initially runs within the middle of the ramus when posterior to the second molar, and then follows the lingual plate as it passes through the region of the second and first molars.
- Type 3: in 15% of the population, the canal is positioned in the middle to lingual third of the mandible along its entire course.

In addition:

- In approximately 80% of the population, the inferior alveolar artery courses above the nerve within the bony canal.
- Older patients have been shown to have less distance between the buccal cortex of the mandible and the lateral aspect of the canal.
- In relation to impacted third molars, the inferior alveolar canal is located (see Figure 1.4):

Lingual to the third molar in 49% of the cases  
 Buccal to the third in 17% of the cases  
 Inferior to the third molar in 19% of the cases  
 Interradicular in 15% of the cases



**Figure 1.4.** Schematic demonstrating the location of the inferior alveolar nerve in relation to an impacted mandibular third molar.

In general, the risk of exposure of the inferior alveolar canal during third molar removal is greater in patients with lingual, rather than buccal, canal positioning. Among molars in the posterior mandible, the distance from the buccal cortex to the canal tends to be greatest within the region of the second molar.

The risk of IAN injury secondary to the extraction of third molars has been correlated with advanced age of the patient (35 years and older), female gender, the use of certain local anesthetics with high concentration, the presence of completely developed roots, the depth and angulation of the impacted third molar, the difficulty of the surgical procedure, the proximity of the tooth in relation to the mandibular canal, surgical sectioning of teeth with exposure of the IAN canal, the use of a surgical bur in close proximity to the mandibular canal, the use of intracanal medications for dry socket prevention, and surgeon inexperience.

### Legal Considerations with Nerve Injury (Lingual Nerve and Inferior Alveolar Nerve)

If a nerve injury is not observed at the time of procedure and is reported by the patient at a follow-up appointment, neurosensory testing should be performed to determine the degree of sensory impairment and to establish baseline criteria. Patients should then be followed every 2–4 weeks to monitor recovery. If the injury is a neurapraxia, spontaneous recovery is expected within 2 months, and no surgical intervention is indicated unless MRI demonstrates the presence of a foreign body impeding nerve regeneration.

Indications for microneurosurgery include observed nerve transection, persistent hypoesthesia for 3 months with no improvement, complete anesthesia, pain secondary to neuroma formation, symptoms due to nerve entrapment,

progressively worsening hypoesthesia, complaints of dysesthesia, and/or hypoesthesia that is unacceptable to the patient and the presence of a foreign body (root tip, bur, etc.) within the mandibular canal.

Imaging plays a vital role in evaluation of a nerve injury. Various imaging modalities can be utilized post-surgery for the assessment of nerve injury, including panoramic radiograph, CBCT scan, and high-resolution magnetic resonance imaging (MRI), as well as magnetic resonance neurography (MRN).

If microsurgical nerve repair is warranted, surgery should be performed within an appropriate time period to maximize the chance for recovery of sensory function. Despite the fact that there are several guidelines pertaining to the timing of surgical intervention, there is limited scientific evidence to support them. The general consensus is that prolonged delay may negatively affect the success of microsurgical repair.

In general, most spontaneous nerve recovery occurs within 3–9 months following nerve injury, but improvement may continue beyond that time frame. Most studies indicate that microneurosurgery that is performed within 3–9 months, when indicated for non-resolving paresthesia, is more likely to result in functional sensory recovery as opposed to delayed microneurosurgical repair. It has been postulated that when the nerve repair is carried out earlier, it may be easier to anastomose the two nerve stump ends. In addition, ganglion cell death may begin to occur within weeks to months following a non-resolving nerve injury, which may limit the prognosis for successful peripheral microneurosurgical repair. When additional time passes, neuroma formation occurs at the site of injury requiring more extensive nerve excision and anastomosis repair with a nerve graft, thereby possibly affecting the prognosis for recovery. It has also been determined that within 1 year from injury, a significant component of the distal nerve becomes atrophied via Wallerian degeneration and becomes more surgically challenging to repair.

Below is the recommended time frame for consideration for microsurgical nerve repair for non-resolving paresthesia:

Lingual nerve	1–3 months after injury
Inferior alveolar nerve	3–6 months after injury

Broadly, nerve injuries can be classified as observed/open or unobserved/closed injury. Observed nerve transection and nerve injuries with a foreign body present have the best prognosis if managed promptly. If an immediate microneurosurgical repair is not possible, then it should be performed within 3–4 weeks of injury. The optimal time from injury to surgical repair has been studied and most surgeons who perform microsurgical repair are of the opinion that unobserved injuries of the IAN could likely be followed for a longer period of time

compared with lingual nerve injuries due to the presence of the mandibular canal that functions as a conduit to allow for improved nerve regeneration, over the LN which resides in soft tissue and is prone to scar formation.

Oral and Maxillofacial surgeons may consider microsurgical repair of a non-resolving nerve injury by 3 months; however, the current evidence demonstrates that the majority of patients undergo surgery beyond this frame due to delayed referrals, insurance authorization, or evidence of continued improvement of sensation. Additionally, the presence of a lingual nerve deficit beyond 3 months has been correlated with a more severe nerve injury, thereby decreasing chances of its recovery either with or without an attempted nerve repair procedure. For this reason, referring a patient to the surgeon who specializes in microneurosurgery within the first 1–2 months after an unobserved injury with persistent symptoms may be beneficial. Patients who report worsening symptoms of hypoesthesia or dysesthesia should be considered for surgical repair promptly after the degree of injury is assessed and classified by an experienced microneurosurgeon, whereas patients who continue to improve, even slowly, may be monitored.

Regarding lingual nerve injuries, the recovery of taste (via the chorda tympani branch of the facial nerve) following nerve injury and/or nerve repair, may not correlate with recovery of sensation (lingual nerve) in the anterior two-thirds of the tongue.

### Key Points

1. Panoramic indicators of IAN proximity include darkening of the third molar root, interruption of the white line of the mandibular canal (see Figure 1.12 in Case Report 1.2), diversion or displacement of the mandibular canal (see Figure 1.9 in Case Report 1.1), abrupt deflection of the third molar roots, and abrupt narrowing of the tooth root.
2. CBCT scanners have aided greatly in the visualization and avoidance of neurovascular structures during dentoalveolar and implant placement surgery.
3. Patient discussions prior to any surgery should involve a detailed review of the consent forms and radiographs. Open ended discussions that thoroughly explain the risks of surgery and documentation of that discussion are necessary. Patients should be offered various treatments and should have an understanding of the advantages and disadvantages of all treatment options. For mandibular third molars in close association to the IAN, patients may be offered a coronectomy as an alternative to complete extraction.
4. All nerve injuries require detailed documentation with neurosensory mapping and completion of a neurosensory testing form, with or without clinical photographs (see Figures 1.7 and 1.8). A clinical

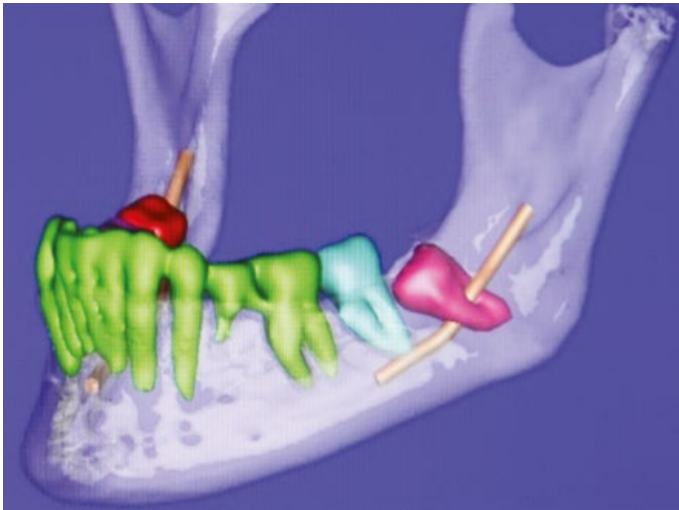
- neurosensory testing form should be completed at each patient visit in order to record and compare the areas of involvement over time. The additional documentation aids in determination of the patient's improvement, establishes a diagnosis and reasonable treatment strategy, and if necessary, helps to protect the surgeon against potential legal ramifications. A sample Clinical Neurosensory Testing Form can be found in **Appendix I** within the Appendix section of the Atlas. [www.wiley.com/go/haggerty/oral\\_maxillofacial\\_surgery](http://www.wiley.com/go/haggerty/oral_maxillofacial_surgery)
5. Nerve injuries require early documentation and close follow-up until either spontaneous recovery or until a referral is generated to a nerve specialist. It is crucial to discuss the nerve injury with the patient using universally accepted terminology that the patient can understand and if necessary, the reasoning behind initiating a referral for surgical consultation to an oral and maxillofacial surgeon who is trained in microneurosurgery.
  6. Nerve injuries are classified using either the Seddon or Sunderland classification system (Table 1.1).
  7. The referral to a nerve specialist in a timely manner is key for injuries that fail to improve over time. In general, the referral should be made within 3 months for lingual nerve injuries and within 6 months for IAN injuries.
  8. The decision to monitor versus treat, and how soon to perform microsurgical repair after a nerve injury is contingent upon various factors: (i) observed transection versus closed injury; (ii) patient's present

- complaints and symptoms; (iii) neurosensory testing and associated findings; (iv) diagnostic imaging; (v) continuous improvement; (vi) risks versus benefits if the repair is warranted. Ultimately, the best protocol is the one that can be tailored to the individual patient's needs.
9. The initial non-surgical management of nerve injuries, specifically neuropraxia, where a witnessed transection has not occurred, may involve agents such as corticosteroids and gabapentin. Steroids should be administered immediately after the clinical diagnosis of nerve injury and will decrease inflammation and edema at the surgical site. The exact dosage and duration of steroid administration is controversial. Gabapentin may be used to manage patients with neuropathic pain and discomfort. Therapeutic agents are not a substitute for definitive surgical repair of nerve injuries that fail to respond over time.
  10. Should a maxillary wisdom tooth disappear from the surgical field during its extraction, its location must be confirmed. The maxillary third molar will typically become displaced into the overlying maxillary sinus cavity, into the infratemporal fossa, or within the soft tissue posterior to the maxillary tuberosity. The displacement of maxillary third molars can be minimized by always having direct visualization of the tooth, by being judicious with the amount of pressure applied and of the vector of forces applied, and by placing a retractor along the posterior aspect of the impacted molar site to minimize posterior displacement.

**Table 1.1.** Seddon and Sunderland classification of nerve injuries.

Injury Classification	Etiology	Healing	Microsurgery
Neurapraxia (Seddon) First-degree injury (Sunderland)	Minor nerve stretch, compression, or traction injury; conduction block	Spontaneous recovery in less than 2 months	Not indicated unless foreign body impeding nerve regeneration
Axontmesis (Seddon) Second-degree injury (Sunderland)	Crush or traction injury	Spontaneous recovery in 2–4 months, Up to 1 year for complete recovery	Not indicated unless foreign body present
Third-degree injury (Sunderland)	Traction, compression, or crush injury	Some spontaneous recovery, but not complete	Microsurgery indicated if no improvement by 3 months
Fourth-degree injury (Sunderland)	Traction, compression, injection, or chemical injury	Poor prognosis for spontaneous recovery, High probability for neuroma formation or intraneural fibrosis	Microsurgery indicated if no significant improvement after 3 months
Neurotmesis (Seddon) Fifth-degree injury (Sunderland)	Transection, avulsion, or laceration of nerve trunk	Poor prognosis, Extensive fibrosis, neuroma formation, or neuropathic changes	Microsurgery indicated if no improvement after 3 months or development of neuropathic response





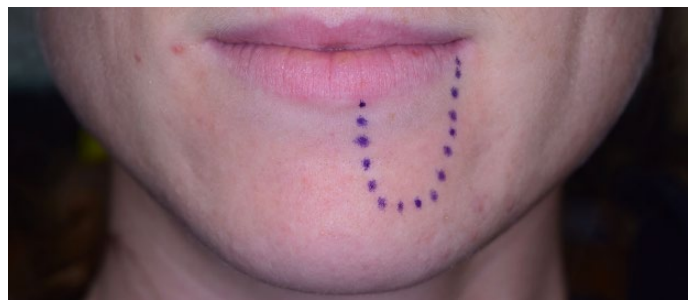
**Figure 1.5.** Three-dimensional image depicting the inferior alveolar nerve coursing directly through an impacted lower wisdom tooth.



**Figure 1.6.** Lower wisdom tooth extracted from the patient in Figure 1.5. The yellow paper represents the location of the inferior alveolar nerve through the apical portion of the wisdom tooth.



**Figure 1.7.** Photographic documentation of a lingual nerve (LN) injury.

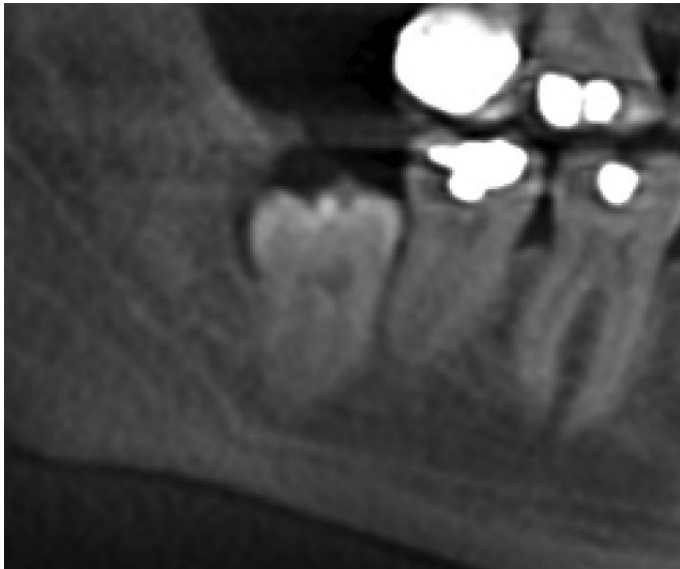


**Figure 1.8.** Photographic documentation of an inferior alveolar nerve (IAN) injury.

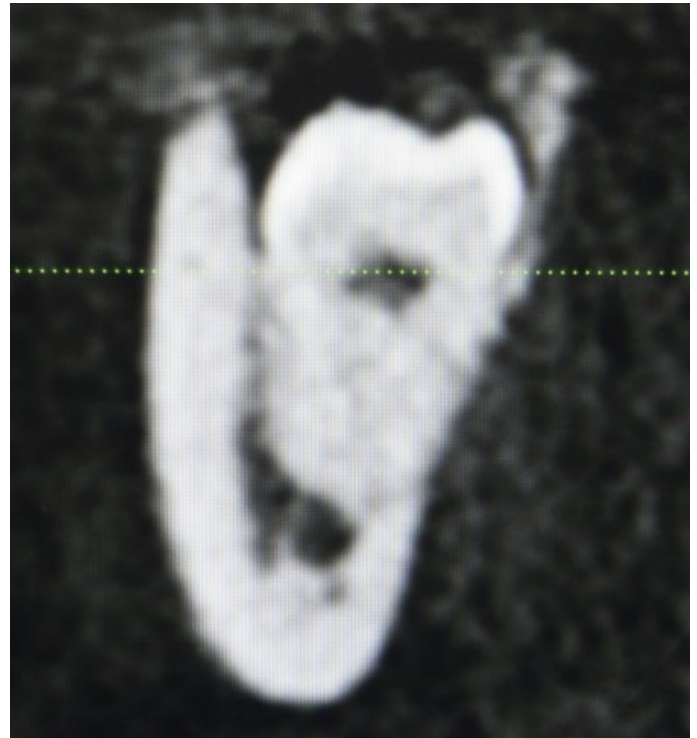
### Case Reports

**Case Report 1.1. Coronectomy.** A 63-year-old patient presents with a chief complaint of pain, foul taste, persistent food impaction, and chronic localized infection to site #32. Based on the patient's age, nerve

anatomy, and potential for permanent neurosensory damage, the decision was made to remove the coronal aspect (clinical crown) of the impacted tooth without extracting the root tips (i.e., **coronectomy**) (see Figures 1.9 through 1.11).



**Figure 1.9.** Two-dimensional film demonstrates impacted tooth #32 with diversion of the mandibular canal at the apex of the tooth.

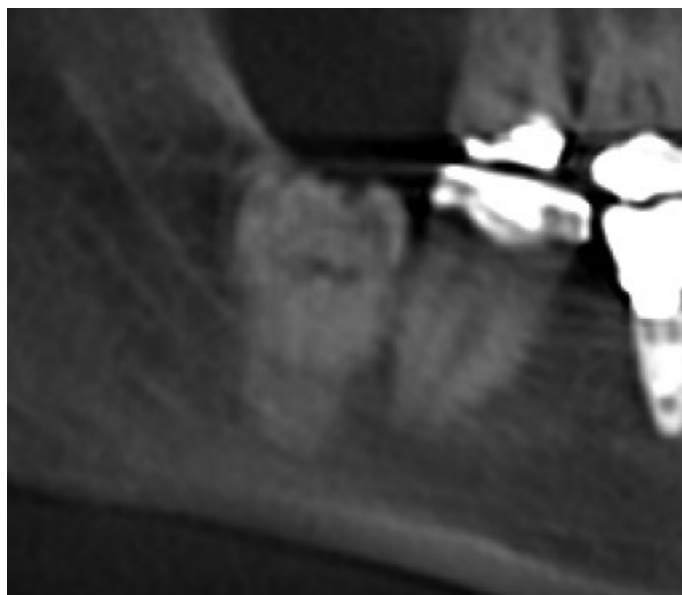


**Figure 1.10.** Cone beam computed tomography coronal view demonstrating the inferior alveolar nerve coursing through the apical third of tooth #32.



**Figure 1.11.** Periapical film demonstrating a coronectomy of tooth #32. Note that the entire clinical crown was removed by sectioning the tooth apical to the CEJ. The retained root structure was further reduced 3–4 mm below the bony margin to ensure that no residual enamel remained.

**Case Report 1.2.** A 57-year-old patient presents with a chief complaint of persistent local pain, referred pain, and documented deep probing depths to site #32 (see Figures 1.12 through 1.14).



**Figure 1.12.** Two-dimensional film demonstrating interruption of the white lines of the mandibular canal at the apex of impacted tooth #32.



**Figure 1.13.** Cone beam computed tomography coronal view demonstrating the inferior alveolar nerve coursing through the middle third of the third molar root.



**Figure 1.14.** Tooth #32 extraction site demonstrating an intact inferior alveolar nerve along the cortical plate of bone.



A neurosensory mapping chart can be found in **Appendix I** for reference.

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