Oral Board Review for Oral and Maxillofacial Surgery

Robert Reti
Damian Findlay
Editors

Springer

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To my wife Allison for her patience, understanding, and making my dreams come true. My son Ezra for giving me an understanding of what truly matters in this world. My grandmother Lili Friedman, a Holocaust survivor and toughest human I have ever met. My mother Marianne for giving up so much so I may achieve my dreams. My sister Susanne for always being a better person than I could hope to ever be. Drs. Richard Sorbera and William Gilmore for your patience, guidance, and instilling humility. To all my colleagues, dental students, residents, and fellows that I have been privileged to work with and learn from, I will forever be indebted to you.

Robert Reti, DDS, FACS

To the MOST HIGH: Thank you for giving me the opportunity to be a part of this most noble profession and surrounding me with multiple counselors that have been instrumental in my career progression.

To my wife (Torri) and children (Victoria-Rose and Michael Damian): Thank you for being my inspiration and for your patience during the development of this project.

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Lastly, I would like to thank every patient that has entrusted me with his or her care.

Damian Findlay, DMD, MD, FACS

Preface

Congratulations on completing the grueling gauntlet of Oral and Maxillofacial Surgery residency. Now it is time to take the exam to become a diplomate. Preparation for the ABOMS oral certifying exam can be a daunting task. You will not be the first surgeon to ask, where do I start? Why am I subjecting myself to this?

First, you need to understand that all training programs are unique. There are strengths and weaknesses of every program. Everyone has a gripe about deficiencies in their program, but there is no bad training program. The board is not meant to compare your training versus another person's training. The exam is standardized to ensure a fair exam. The purpose of the exam is not to humiliate you. It is an exam, which looks to examine your competency as a surgeon. It tests your knowledge of basic principles and assesses if you practice safe and evidence based oral and maxillofacial surgery. Board certification is a message to the community that a group of your colleagues have tested your knowledge and they are in agreement that you have achieved mastery of the basic knowledge as it relates to practicing oral and maxillofacial surgery.

The book is structured to provide a comprehensive review of various topics and to take you through a series of cases similar to those that you may see on the board exam. This book is not meant to replace other textbooks or board review courses. The purpose of this book is to both streamline your preparation with the salient didactic information and to be used as an adjunct to other resources including board review courses. There is so much information out there and you have a limited amount of time. The key to studying passed on from surgeon to surgeon is first; learn what you need to know (the basics), then what is nice to know, and, if time permits, what is nuts (impractical) to know.

We are not board examiners and this book is only to be offered for professional development and as an adjunct to studying. To our knowledge, no course or textbook is endorsed or sponsored by the American Association of Oral and Maxillofacial Surgeons or the American Board of Oral and Maxillofacial Surgery. However, we are young surgeons that have recently gone through the process and successfully passed the exam. We feel that we have put together a text that will be a major part of the equation of your pass-

ing the exam. You are juggling work life, family life, and your well-deserved free time. Our hope is to ease the anxiety of the diplomatic candidate and be instrumental in your successfully passing this exam.

St. Louis, MO, USA — Robert Reti
St. Louis, MO, USA — Damian Findlay

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Part I

Dentoalveolar, TMJ, Maxillofacial Infections, and Implantology

Dentoalveolar

1

Michael Barbick, David Chang, Robert Reti, and Anthony Kramer

Dentoalveolar

Impacted tooth – a tooth that cannot or will not erupt into its normal functioning position.

Management of Impacted Third Molars

Background

- Frequency of impacted third molars ~25% in most studies when present [1].
- Third molars are the most common teeth to be missing, followed by second premolars and maxillary lateral incisors.
- Third molars are the most likely teeth to be impacted followed by maxillary canines, mandibular premolars, maxillary premolars, and second molars.
- Third molar agenesis is reported between 10% and 41% [2].
- African Americans develop third molars faster than Caucasians.

Development of Third Molars

- Age 6–9 – follicles become visible on radiography.
- Age 9 – molar germ visible.
- Age 11– cusp mineralization, located anterior border of ramus.
- Age 14 – crown formation is done.
- Age 15 – tooth uprighting as roots form.
- Age 16 – 50% of root formed. Anterior border of ramus resorbs as mandible lengthens.
- Age 18 – root completely formed with an open apex.
- Age 24 – 95% of molars in final tooth position.
- Age 25 – little change in tooth positioning, but minor changes may occur past this age.

Theories of Tooth Impaction

1. Differential growth rate of roots causes under- or overrotation leading to impaction.
2. Arch length: Impacted third molars are larger than erupted third molars.
3. Ectopic position: abnormal germ position puts teeth in contact with a denser external oblique ridge.

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4. Late mineralization: tooth growth lags behind maturation of jaws due to decreased influence of resorption of jaw.
5. Attrition: softer diet leads to less attrition retaining mesiodistal space.

Classification for Mandibular Third Molars

Pell and Gregory based on radiographic review (Fig. 1.1).

Classes A–C based on relation to second molar occlusal plane.

A: Third molar occlusal plane in line or nearly in line with adjacent second molar.

B: Third molar occlusal plane between occlusal plane and cervical junction of the second molar.

C: Third molar occlusal plane below cervical junction second molar.

Classes 1–3 based on relation to the anterior border of ascending ramus.

1: Mesiodistal diameter of crown anterior to ascending ramus.

2: Half of crown covered by ramus.

3: Tooth is completely located within ramus.

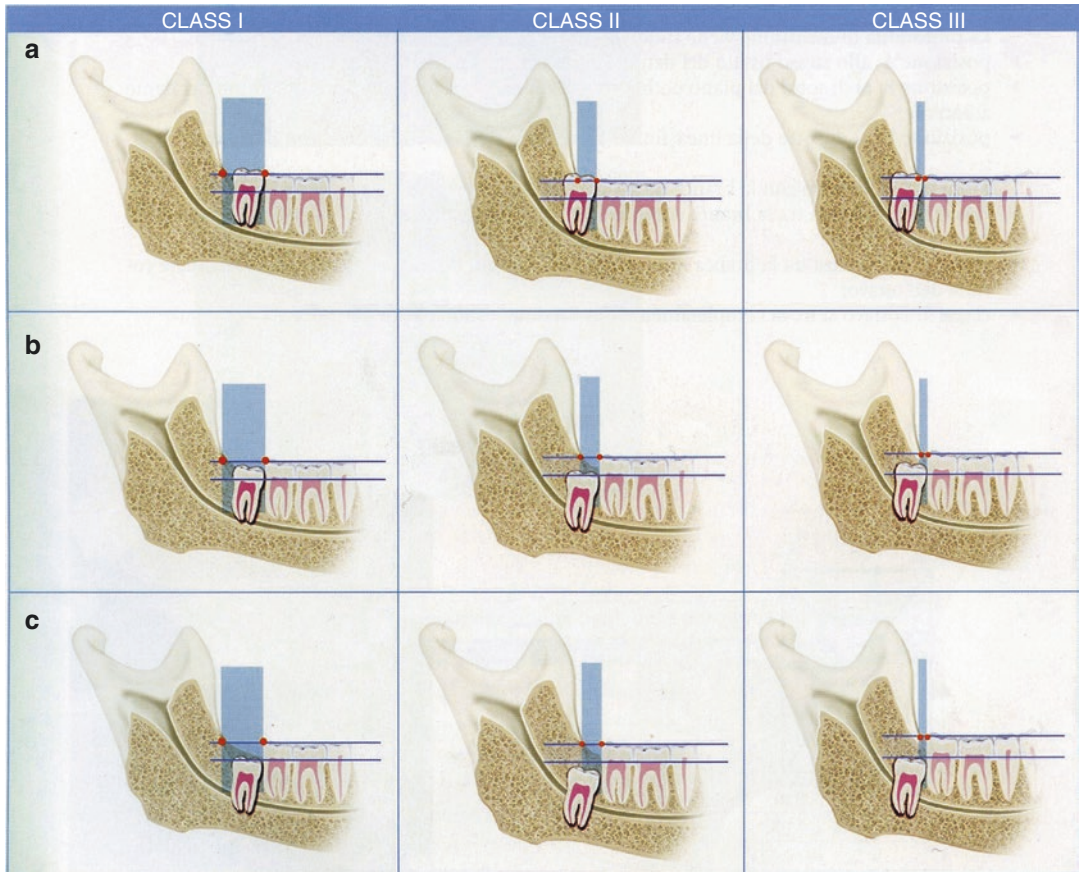

Fig. 1.1 Pell and Gregory classification. (Reprinted with Permission from Mantovani et al. [13])

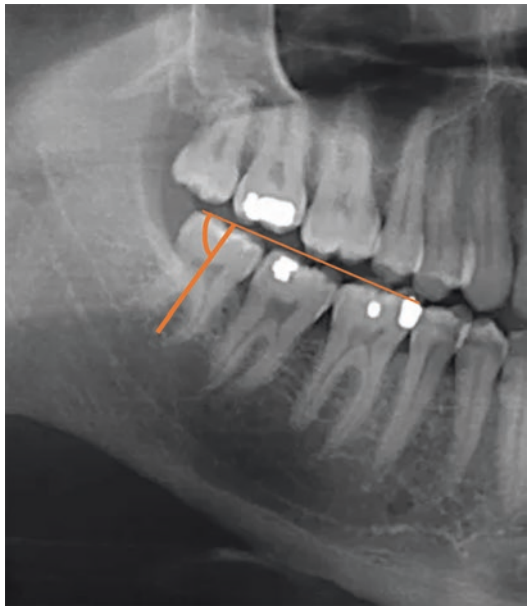

Fig. 1.2 Winter's classification is based on the angle between the occlusal plane and the longitudinal axis of the third molar

Winter's Classification [3] (Fig. 1.2):

- Most commonly used classification system.
- Angle between the occlusal plane and the longitudinal axis of the third molar.
- <0° = inverted, rare. As is buccoangular and linguoangular.
- 0° and 30° horizontal impactions, ~10% of impactions.
- 31° and 60° mesioangular impactions, ~45% of impactions.
- 61° and 90° vertical impactions, ~40% of impactions.
- >90° distoangular impactions, ~5%.

Indication for Third Molar Removal

Pericoronitis
- Most common reason over the age of 20.
- Associated with inflammation of the operculum (a dense fibrous flap of tissue).
- May be treated symptomatically with irrigation and antibiotics.
- Removal of third molars is the most predictable treatment.

Orthodontic Needs
- Dental crowding? No consensus if third molars associated with mandibular incisor crowding.
- Interference with orthodontic treatment may prevent distalization of other teeth.
- Orthognathic: surgeon may require third molars out 6–12 months prior to surgery to aid in bone fill. This allows an increase in bony area for fixation and may prevent bad mandibular splits.

Pericoronal Pathology
- Most common pericoronal pathology is a dentigerous cyst or an enlarged follicle. A pericoronal radiolucency >3 mm is suggestive of a dentigerous cyst.

Caries
- Inability to clean adequately, most commonly on cervical of second molar.
- Inability to isolate third molar for restorative measures.
- Access to distal caries on second molar.

Fracture
- Presence of third molars creates an area of lowered fracture resistance.
- Approximately 3× increase in angle fractures with third molar present due to disruption in cortical bone.
- Special consideration in patients in contact sports.
- Presence may complicate repair of angle fracture reduction.

Unexplained Pain
- 5% of third molars removed for this reason and often "cures" pain for reasons unclear.

Overlying Prosthesis
- Third molars are unpredictable in future position or eruption. There is evidence for pathology to develop if left in place under prosthesis.

- Up to clinician to remove or to watch but generally recommended to be removed unless 2 mm bone is surrounding the crown.

Periodontal Disease
- Consider removal if >5 mm pocketing with bleeding on probing or >1 mm attachment loss on adjacent second molar (may lead to future progression of periodontitis).
- Presence of third molars associated with elevated levels of periodontitis of adjacent teeth.

Pertinent Anatomy

Inferior Alveolar Nerve
- Provides sensation to mandibular lower teeth up to midline, chin, and lower lip.
- Injury incidence reported approximately 1% after third molar extraction.
- Generally the nerve is located buccal and apical to impacted third molars.

Lingual Nerve [4]
- Lies on average 2.8 mm below the crest and 2.5 mm medial to lingual cortex.
- 0.6–2.0% reported incidence of lingual nerve damage during third molar surgery.
- In 4.6–21.0%, the lingual nerve is at or above the crest of the bone.
- 22% reported at lingual plate of bone.
- Turns toward tongue at region of first and second molars.

Workup

CC/HPI: Reason for removal, is the patient experiencing pain, in progress or planning on orthodontic/orthognathic treatment? etc.

PMHx:

Age of the Patient
Advanced age:

- Increased healing time and increased risk of morbidity.
- Bone becomes more sclerotic and less elastic, which makes the removal complicated. This leads to the need for more bone removal.
- Patients who are 25 years and younger have decreased risk of complications and improved recovery after surgery.

Inadequate age:
- Unable to predict impaction when there is minimal tooth formation.
- Ideally remove tooth when there is ½–2/3 development of root formation.

Compromised Medical Status
- Benefits must outweigh the risks.
- A history of cardiopulmonary disease, immunocompromised states, or coagulopathies could prevent a safe extraction (may be best to watch until symptomatic).
- Consider treating patients in a more controlled setting should an extraction be indicated.

Anesthetic History
- Problems with induction or awakening.
- History of nausea or vomiting.

Temporomandibular Disorder (TMD)
- History of clicking, pain, or locking of joint.
- Difficulty of opening for long periods of time or limited opening.

Smoker
- Delayed healing.
- Higher risk of dry socket.
- Reactive airway for anesthesia.

Exam
General: Examine distress and anxiety (can help determine if sedative/anesthesia required for procedure). Also degree of difficulty will aid in decision.

Head and Neck Exam
- Customary head and neck exam is part of workup. Examine anesthesia considerations such as large neck, retrognathia, and limited range of motion of neck.

- TMJ documentation for clicks, cracks, or pops.
- Maximal incisal opening, ease of access for surgical procedure, and anesthesia considerations.
- Tongue size: large tongues can fall back and cause airway obstruction.
- General oral health. Could be higher risk for postoperative infection and delayed healing.
- Pathology or infection around third molar site? Pericoronitis.
- Are the third molars visible? Guide to difficulty of extraction.
- Mallampati score.
- Tonsil grade.
- Periodontal probing distal to second molars (>4 mm indication with bleeding on probing (BOP) could be sign of periodontal disease).
- Teeth are in good functional position and without disease. Direction of general dentist to have them removed based on an algorithmic approach to treatment is inappropriate. Surgeon should conduct a separate evaluation that deems this is a necessary procedure.

Radiographic Exam

Orthopantogram:

- For overall survey of third molars. Most studies on risk based on orthopantogram. Able to classify difficulty of extraction.
- Root morphology:
  - Ideally removal when two-thirds roots are developed.
  - Fused roots easier than flared roots.
  - Direction and severity of curved roots increase difficulty and can change the path of tooth extraction.
  - Periodontal ligament space, wider makes for easier extraction.
- Follicular sac – if present, the wider the sac, the less the bone required for removal and the easier to identify tooth crown.
- Density of bone:
  - Higher density leads to increased difficulty.
  - Patients >35 years of age regularly have increased density appreciated.
  - Higher likelihood of fracture due to lack of expansion and increased force required for removal.
- Radiographic signs on orthopantogram described by Rood and Shehab, aka Rood's Criteria, describing intimacy of Inferior Alveolar Nerve (IAN) with roots of mandibular third molar [5].
  1. Darkening of root
  2. Deflection of root
  3. Narrowing of root
  4. Bifid root apex
  5. Diversion of canal
  6. Narrowing of canal
  7. Interruption in white line of canal

CBCT

- Not routine, but can be selected if pathology is suspected or if there is intimacy with anatomical structures.
- Most software can convert imagery into a reformatted orthopantogram.

Treatment

* The approaches in this book are just a guide. On the board exam you are asked how *YOU* would perform the procedure. The key is to practice articulating what you do every day in a concise and efficient fashion. Provided is just a guide on how to articulate the procedure. Practice verbalizing your technique.

Surgical Approach to Extraction of Third Molars

- Local anesthetic with vasoconstrictor is administered (via, e.g., IAN, lingual and buccal nerve blocks, PSA, and greater palatine).
- A 15 blade is used to make a sharp incision to outline a full thickness mucoperiosteal flap. This flap is outlined from the mesiobuccal of the second molar and carried sulcular around the second molar with a distobuccal releasing incision.
- A periosteal elevator is used to carefully reflect a full thickness flap exposing the bony mandible/maxillae.
- Using a fissure bur under copious irrigation the bone surrounding the crown is carefully removed exposing the tooth and a buccal

trough is created. (Bone in the maxilla is thin and can usually be removed with a molt/periosteal elevator).
- Once the crown is uncovered, the tooth is luxated (if appropriate)/tooth is sectioned parallel to the mesiobuccal groove two-thirds through the width of the tooth to prevent cortical perforation.
- The tooth crown and fragments are carefully removed.
- The granulation tissue and follicle are curetted free of the socket.
- Bone rasp is used to smoothen the bony lip of the osteotomy.
- Saline irrigation is used to cleanse the socket. (Distilled water is hypotonic and leads to cell death).
- Visual inspection to ensure IAN/sinus not compromised.
- Reapproximate tissue with resorbable suture (e.g., 3-0 chromic gut).

Complications

- *Alveolar Osteitis* – Incidence reported between 1% and 30%, range due to subjective criteria [6]. Commonly seen at days 3–7 after extraction. Current theory is increased fibrinolytic activity leading to break down of clot. Symptoms include referred pain to ear, eye, and temple region, foul odor, extreme tenderness to palpation. Risk factors: tobacco smoke, increasing age, pericoronitis, birth control, female gender, inexperience of surgeon leading to traumatic extraction, inadequate irrigation, and increased medical comorbidities. Some evidence show that chlorhexidine can reduce incidence. Treatment is commonly with iodoform gauze or gel foam coated with eugenol (commercial pastes are also available) that acts by inhibiting neural transmission. Review panorex and/or CT scan prior to application as should not be used when IAN exposed due to neurotoxic effects of eugenol. If concerned for IAN exposure, consider the use of topical lidocaine in place of eugenol.
- *Root Fracture* – Can be left in place if (1) non-infected, (2) small, i.e., <2 mm, (3) and risk of surgery would outweigh benefits.
- *Bleeding* – Bleeding report as a result of third molar surgery ranges from 0.2% to 5.8% [7]. Must always rule out coagulopathies such as hemophilia or Von Willebrand disease. In general, postoperative bleeding from dental extractions reported to be at about 1% and about 7% when taking oral anticoagulation therapy such as a vitamin K antagonist. Patients on vitamin K antagonist need not stop it if INR <4. Hemostatic agents are listed in Table 1.1.

Table 1.1 Hemostatic agents

Surgical packing for tooth extraction sites	
Product	Properties
Absorbable gelatin sponge, e.g., Gelfoam®	Matrix for blood clot formation Gelatin made from purified porcine skin May cause excessive granuloma or fibrosis
Microfibrillar collagen, e.g., Avitene®	Mechanically broken down bovine collagen Aggregates platelets onto fibrils and acts as a matrix for blood clot formation
Chitosan dressing, e.g., HemCon® and ChitoFlex®	Polysaccharide from shellfish Positively charged to attract erythrocytes Acts as a scaffold for clotting New dental formulation dissolves in 48 hrs
Thrombin	Promotes clot formation through activated bovine prothrombin Activates factor IIA Acts as serine protease converting fibrinogen to fibrin
Oxidized regenerated methylcellulose, e.g., Surgicel®	Binds platelets Negative pH is bacteriostatic and precipitates fibrin More efficient at hemostasis than gelatin sponge Can be packed into socket to aid in pressure hemostasis Does cause some prolonged healing Be cautious when using in lower third molar sockets as Surgicel creates an acidic milieu which can be toxic to the inferior alveolar nerve
Cross-linked collagen, e.g., Collaplug® or Collatape	Promotes platelet aggregation

Table 1.1 (continued)

Surgical packing for tooth extraction sites	
Product	Properties
Tanin, e.g., found in teabag	Serves as a vasoconstrictor
Aminocaproic acid mouth rinse	Stabilizes clot by inhibiting plasmin
Tranexamic acid 5% mouth rinse	Antifibrinolytic, inhibits conversion of plasminogen into plasmin

- *Displacement of Root into Sinus* – Most commonly the palatal root of maxillary first molar; take PA to verify position. Several local measures should be made: (1) suctioning into sinus, (2) pack sinus with xeroform gauze and pull in one stroke (often root will attach to gauze), (3) perform antral lavage, (4) have patient block opposite nostril and blow nose to force into socket, (5) enlarge opening and explore. If attempts fail, fragments 3 mm or less that are non-infected may be left in place and patient be informed. Roots >3mm or those that presented with an infection/peri-apical pathology should be removed via a Caldwell-Luc approach is indicated.
- *Oral Antral Communications (OAC)* – Most small OACs will heal by themselves. Openings of 3–6 mm can be managed by placing gel foam and closing with a figure-of-eight suture technique. OAC >6 mm may require tension-free primary closure, excision of the fistulous tract, and inversion into the sinus. Consider treating larger OACs with a buccal fat pad closure, buccal finger flap, or tongue flap. Sinus precautions for 2 weeks (decongestants, antibiotics that cover sinus flora, no heavy nose blowing, saline nasal spray).
- *Displacement of Root or Tooth into Submandibular/Sublingual Space* – Lingual cortex thins out in the more posterior region. Displacement is often inferior to mylohyoid muscle. First attempts should be to "milk" root back through cortical hole via manipulation. An attempt at a lingual flap extended anteriorly to premolar with an incision to detach the mylohyoid muscle to gain access and visualization of crown. This can be difficult due to bleeding. Allow 6 weeks for fibrosis. Get a CT scan to localize the root. Patient may require a transcutaneous approach via a submandibular incision for retrieval.
- *Displacement into Infratemporal Space* – Likely due to lack of retractor protection with excessive force and poor visualization. Position most commonly lateral and inferior to pterygoid plate. May attempt to manipulate the tooth back manually into incision by placing finger high into vestibule near the plates and applying manual pressure. If good access and lighting, may attempt to extend incision and retrieve with hemostat. If primary efforts fail, allow 4–6 weeks to allow for fibrosis. Obtain a CT scan and use a spinal needle to identify, dissect along needle length. Needle-guided fluoroscopy may also be used. It also has been reported to perform a hemicoronal incision to gain access to infratemporal space. If no functional deficit and asymptomatic, may elect to leave in place.
- *Displacement into IAN Canal* – Retrieval attempts may lead to nerve damage, and single attempt with suction should be attempted. If root is not infected and no neurological abnormalities, consider leaving in place. If sensory complications, must retrieve. CT scan should be taken to ensure whether in canal space versus medial to mandible. IAN root retrieval may be attempted by unroofing the extraction site, lateral window intraoral, or via submandibular incision.
- *Aspiration of Foreign Object* – Heimlich maneuver may be attempted while patient is in beach chair position. If under anesthesia, deepen the level of sedation and attempt visualization and removal with Magill forceps. Cord pressure may help move objects caudally past the cords. If no respiratory distress, likely ingested, obtain abdominal and chest radiography to rule out. Always presume aspiration and place patient on right side in Trendelenburg. Continue monitoring and watch out for signs of hypoxia and respiratory distress. Refer to emergency room for removal.

Management of Impacted Maxillary Canines

Background

- Maxillary canines are the second most frequently impacted teeth (third molars are the most commonly impacted teeth).
- Maxillary impacted canine incidence of approximately 2% and mandibular 0.4% [8].
- 2:1 female to male ratio.
- Canines normally erupt between 11 and 12 years of age.
- Maxillary canine erupts along the lateral incisor, closing the diastema.
- Labial impacted canines thought largely due to arch length discrepancies.
- Palatal impacted canines more often seen in patients with peg laterals or missing laterals.
- Two theories:
  1. Genetic theory – genetic disposition or dental anomalies.
  2. Guidance theory- as the maxillary canines erupt along the lateral incisors, malformation or lack of the lateral incisor leads to failure of canine to erupt.
- Other possible causes are trauma, pathology, genetics, and malposition tooth germ.

Workup

Review CC/HPI and pertinent medical history.

Head and Neck Exam

- Pay attention to bulging of tissue for location of the impaction. Expect canine bulge on buccal by age of 10. Normally will have eruption by 1 year later.
- Look at the overall gingival health and quality of gingiva (thick vs. thin/presence of gingivitis). Quantify the amount of keratinized tissue. This may influence surgical approach as keratinized tissue is desirable for long-term periodontal health.
- Lateral incisor presence and position. Is the incisor compromised in size or shape? The canine will erupt along the lateral incisor.
- Examine airway for tonsil and adenoid size in children for planned sedation. It is normal to see large tonsils in children.
- Mobile teeth – aspiration risk or damage during procedure.
- Is the patient in active orthodontic treatment? (i.e., Are the brackets on the teeth? Is there an arch wire in place? Is the patient ready for treatment?) Where will the chain be secured? Has adequate space been made for canine (average 7.5 mm mesial-distal space at contact area)?

Localization/Radiography

- CBCTs.
- Clark's rule/shift rule (SLOB) – same lingual, opposite buccal.
- Orthopantogram – if horizontal, larger and out of focus likely palatal impaction. Labial impactions appear vertical in position.
- Orthopantogram and occlusal film (vertical parallax method).
- Examine root development. If vertical position and non-complete root development, can expect some movement. If apex closed, do not expect much potential for further eruption.
- Is there resorption of permanent central or lateral incisor? This requires exposure of permanent canine to correct path and reduce resorption.
- If canine crown is overlapping less than half of the root of lateral incisor, there is 91% chance of normalization of eruption path (if not this drops to 64%) [9].

Orthodontic Considerations

- Create room for the canine before exposing and orthodontically erupting the tooth.
- Stabilize teeth in arch with full thickness passive wire to allow anchorage to pull teeth through tissue.
- Average mesial-distal dimension maxillary canine is 7.5 mm.
- The more perpendicular the canine is to the lateral incisor, the more likely it should be extracted as opposed to being exposed and brought into occlusion.

Treatment Options

1. *Interceptive*
   - Extract primary canine before age 11 if not palpable on buccal. Expect 91% success

for eruption if crown distal to midline lateral incisor. Success drops to 64% if mesial to midline of lateral incisor [9].

2. *Apically Positioned Flap*
   - For labial impactions and not for displaced mesial or distal.
   - Maintains keratinized gingiva.
   - Use if less than 3 mm of keratinized gingiva is expected after an open window technique.
   - Do not use for canines high in alveolus as the thick palatal bone can push the canine buccally and create a dehiscence in the tissue. High labial impactions should be treated with a closed technique.
   - Technique:
     – Flap outline in the mesial distal width of tooth.
     – Remove bone over surgical margin and remove follicular remnants.
     – Reposition flap apically at cervical margin.
     – Tooth surface etched for 30 seconds with phosphoric acid 30% (know what you use and its requirement), then irrigate thoroughly.
     – Place primer if part of a step system and lightly puff air to make even spread.
     – Bonding agent of choice is, for example, glass ionomer (fluoride is released and can work in partially wet environment).
     – Suture keratinized tissue apically around CEJ of tooth.
3. *Open Exposure Technique (Window Technique)*
   - Crown is uncovered and left exposed. Some surgeons use electrosurgery/steel to expose tooth based on radiography. Other surgeons open a palatal flap, expose tooth, and create window after identification.
   - Ortho bracket may or may not be placed at the time of surgery.
     – Window of overlying gingival is removed or reflected.
     – Tooth may spontaneously erupt, or the site can be packed with periodontal packing open with or without bracketing (speak to orthodontist preference).
     – Packing normally left for 2–3 weeks.
4. *Closed Techniques*
   - Used when teeth are not in a position to allow for repositioning of the flap after crown is exposed.
   - Palatal impaction that is not close to the alveolar ridge.
   - Technique:
     – Local with vasoconstrictor.
     – Full thickness flap raised and the impacted tooth is exposed to level CEJ.
     – Tooth surface etched for 30 seconds with phosphoric acid 30% (know what you use and its requirement), then irrigate thoroughly. Acid etching can also aid in hemostasis.
     – Ensure adequate hemostasis; some surgeons opt to place retraction cord soaked with vasoconstrictor. This cord must not be forgotten.
     – Place primer if part of a step system and lightly puff air to make even spread.
     – Bonding agent of choice: e.g., glass ionomer (fluoride is released and can work in partially wet environment) with placement of bracket and chain.
     – Test chain to ensure there is a good bond.
     – The chain is then secured to a bracket or arch wire with a suture or wire.
     – The wire or chain may need to pass through the flap through a small incision.
     – Flap is sutured back into place.
   - Ortho can begin traction after ~1 week of tissue healing.

Complications

- *Failure of Eruption* – Re-explore the area and check for ankylosis. May percuss tooth, and if a metallic higher pitched sound heard, this could be an indication of ankylosis. Luxation of tooth may aid in mobility as this can cause bleeding and inflammation to encourage movement. May present as intrusion or teeth within arch. May consider segmental osteotomy or corticotomies to aid in movement. Consider other options including tooth

removal, space maintenance for dental implant, bicuspid substitution, or autotransplantation.
- *Resorption of Tooth* – Can occur from over-aggressive exposure (removal of bone below the CEJ). Halt orthodontic movement and re-evaluate treatment plan. Consider other options including tooth removal, space maintenance for dental implant, bicuspid substitution, or autotransplantation.
- *Lack of Attached Gingiva* – Due to poor quality of gingival mucosa, over-aggressive tissue removal and inappropriate treatment selection such as an open window happen. A connective tissue graft in future may aid in correction.
- *Bracket Detachment* – Can be due to ankylosis, disruption in path of guidance, over-aggressive movement, poor bonding, or outdated material. Re-exposure of tooth, check for ankylosis. Consider reattachment with removal of old bonding material and slight roughening of tooth (consider polish with pumice, diamond bur, or gentle painting with a carbide bur) to aid attachment or convert into open technique if a closed technique was used. Do not use ligature.

Pearls of Wisdom
- Least desirable way to obtain attachment of an impacted crown is to place a wire ligature around it. It will result in loss of periodontal attachment and root resorption (no longer recommended).
- Do not remove bone past CEJ, as it leads to root resorption, ankylosis, and periodontal disease. Over-exposure of tooth to beyond the CEJ further causes a junctional epithelium that will be severed irreparably. This leads to a longer clinical crown and poor periodontal condition months after exposure.
- A gold mesh chain is preferred for a light cured bonding agent as it allows penetration of the light.
- General consensus now on luxating tooth is not to. Luxation may actually initiate cervical root resorption and ankylosis, causing failure of orthodontic traction attempt.
- Place bracket as close to the incisal edge as possible for best mechanical traction.
- Remove excessive lag on chain as this is an annoyance to the patient and increases the chance of debonding of the bracket.

Impacted Canine Case

- *A healthy 14-year-old male presents for exposure of maxillary canine from the orthodontist. What would you like to know? What do you evaluate?*
  I would like to know the medical history and about previous surgeries requiring anesthesia. I would like to measure the adequacy of the mesial-distal space to ensure correct amount of room for orthodontic interception. I would assess the overall gingival health and the amount of keratinized gingiva. Is there a palpable bulge? I would conduct an airway exam (including tonsil size, Mallampati, etc.) and assess the entire dentition (loose teeth, any other missing or impacted teeth to suggest syndrome).
- *There is 9 mm of space between teeth # 5 and 7. There is 4 mm of keratinized gingiva. Airway evaluation shows grade 2 tonsils with a Mallampati score of 2. No history of anesthesia. No other missing or impacted teeth. Healthy gingivae, no signs of bleeding. What imaging would you like?*
  CBCT (Fig. 1.3).
- *What do you see on the CBCT?*
  Maxillary impacted tooth # 6 proximal to the floor of the nose with buccal positioning. No enlarged follicle or pathology appreciated. Resorption of the tooth root of #7 noted.
- *How would you want to treat this?*
  I would want to approach this with a closed technique.
- *Could you not do an apically positioned flap?*
  No, it would not be feasible in this situation as the tooth is too high up the alveolus. I would not have adequate area to secure the flap. Additionally, it is mesially positioned, so it would expose the bone over the lateral incisor.

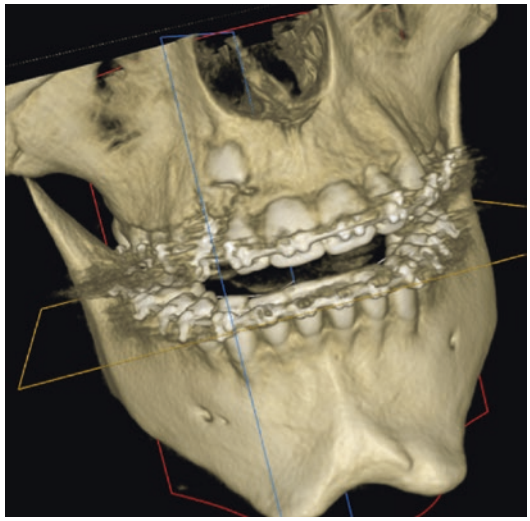

Fig. 1.3 Cone beam CT. (Image courtesy of Dr. Robert Reti)

- *What you would talk to the orthodontist about?*
  I would discuss whether a bracket and ligation is desired and timing with the orthodontist.
  (Some orthodontists want you to wait until there is enough room. Creating arch space for the canine. Enquire as to whether they would like a chain/bracket attached.)
- *What would you want to do about tooth #7?*
  There is apical resorption. I would explain to the patient and the parents the guarded prognosis of #7 and recommend vitality testing. During traction, the orthodontist would need to plan for the vector to prevent further damage.
- *How would you expose this tooth?*
  I would administer local anesthetic with a vasoconstrictor and allow 5 minutes for hemostasis. Reflect a flap with wide exposure to allow retraction of the flap. Identify the tooth and remove adequate buccal bone and follicle to the level of the CEJ. I would place retraction cord soaked in local anesthetic with vasoconstrictor around the osteotomy of the tooth. Etch and prime the tooth. I would bond a gold mesh bracket with glass ionomer light curing bonding agent (to the center and closer to the incisal edge). I would test to ensure adequate fixation by placing traction on the chain. I would secure the chain to a bracketed tooth (or arch wire) and remove excessive chain links. I would remove packing and ensure adequate hemostasis. I would replace the flap with 3-0 chromic gut sutures.

Fig. 1.4 Cone beam CT: sagittal view. (Courtesy of Dr. Robert Reti)

- *What kind of bonding agent would you use?*
  Glass ionomer.
- *Why?*
  It can work in a wet field and release fluoride to prevent decay.
- *How do you apply it?*
  Press firm, light cure for 20–40 seconds.
- *When should the patient see the orthodontist after application?*
  Within 1 week of activation.
- *After multiple attempts, you're unable to bond the bracket to the tooth, what's your alternative?*
  Convert into an open window technique, pack site and have the orthodontist place bracket in one week (High risk for thin or lack of keratinized gingiva).
- *Six weeks later, your orthodontic referral asks you to re-evaluate the area as he has not had*

any movement. You take a CBCT and you see this (Fig. 1.4). *What is going on?*
The chain has debonded from the tooth.

- *What could have been the reasons and why?*
  Wet field, obstruction in path, old material used, and tooth is ankylosed.
- *What would you like to do?*
  I would discuss with the orthodontist and patient the need for re-exposure and bracketing. It would be prudent to also discuss the possibility that the tooth may be ankylosed and another treatment plan should be considered if no movement occurs after reattachment. Alternative treatments such as removal with space maintenance for future dental implant placement, autotransplant, or bicuspid substitution if failure of a second attempt or noted ankylosis.
- *Would you put a cervical ligature to grasp the tooth?*
  No, as this causes external resorption of the tooth and is no longer practiced.

Impacted Third Molar Case

- *A 18-year-old female present with history of waxing and waning pain of her lower jaw. Her dentist placed her on a course of antibiotics, which resolved her discomfort. She is healthy and has no allergies and no surgical history. She was referred by her general dentist for third molar extraction. What would you like to do next* (Fig. 1.5)*?*
  I would review the medical/surgical history and follow-up with questions; for example, does she play any contact sports and how often does she have these flare ups? Which antibiotics has she used to treat this issue? Does she have any TMD symptoms? I would conduct a complete head and neck exam. This would include evaluating her maximal incisal opening, the overlying tissue of the region of the third molars, probing depths on the distal of the second molars, overall hygiene, and condition of the adjacent teeth.
- *She plays field hockey for her high school team. No joint complaints. The last flare up was 3 months ago, but she doesn't recall the frequency. She was prescribed penicillin VK by her dentist. The evaluation shows erythema distal to teeth 17 and 32 with a probing of 6 mm distal to 32 and 5 mm of #17. The adjacent teeth are in good condition.*
- *Can you describe what you see on the orthopantogram?*
  Teeth 1, 16, 17, and 32 are full bony impacted wisdom teeth. All teeth appear two-thirds in development. No intrabony pathology is appreciated. Teeth 17 and 32 have enlarged follicular sacs. This is a diagnostically unacceptable radiograph, as it is missing the complete head of the condyles and ramus. It does show the

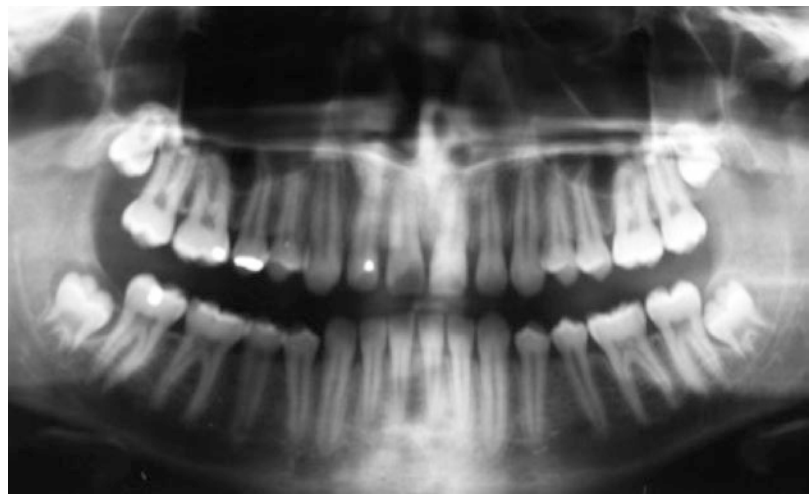

Fig. 1.5 Orthopantogram for case. (Image courtesy of Dr. Damian Findlay)

third molars in question and other vital structures. However, I would recommend taking a second orthopantogram, which includes the temporomandibular joint anatomy.

- *Why do you think she is having pain that comes and goes?*
  She likely has bouts of pericoronitis.
- *Would you remove these third molars or watch them?*
  As she has a history of pain, clinical signs of pericoronitis, periodontal probing greater than 5 mm, and a history of contact sports, I would recommend removal at this time.
- *If there was no history of pain, would you still consider removal?*
  Yes, to optimize the periodontal health of her second molars. There is also evidence that patients under 25 have a much lower rate of complications and improved recovery time. As she is 18 years old, mandibular growth has likely ceased; therefore, I would not foresee adequate arch space with further eruption. Also, it is unlikely that the teeth will change position due to her age.
- *What would your sequence be? How would you remove tooth #1?*
  I would extract the mandibular thirds first followed by the maxillary thirds to prevent blood entering the field from above. After achieving adequate local anesthesia, I would make a sharp crestal flap from the mesial of tooth #2 extending onto the maxillary tuberosity. A periosteal elevator would be used to carefully elevate the flap. I would remove the bone covering the crown to allow for adequate visualization up to the CEJ of tooth #1. I would apply pressure apically with my retractor to the flap in the region apical and distal to tooth #1. I would carefully luxate tooth #1 to ensure mobility and retrieve with a forcep. I would smoothen the bone with a rasp, curette the socket from granulation or dental follicle, and irrigate the site with copious irrigation. I would then reapproximate the tissue with 3-0 chromic gut suture to ensure primary closure.
- *You look at your tooth and notice one of the roots is incomplete, comparing the adjacent roots and your radiography it would be fair to estimate 1 mm of root remains, what would you do next?*
  I would explore the socket and see if the root is mobile or easily visualized. If it is easily accessed, I would attempt retrieval. If there is confirmation that the root tip has been displaced into the sinus or infratemporal fossa, then I would consider leaving the root (if the root is less than 3 mm, non-infected) to prevent damage to proximal vital structures. I would make a note in the chart as well as inform the patient. I would get baseline imaging at 6 months and then at one year.
- *You are paged to the ED for evaluation of a 56-year-old healthy female with mild dysphagia 3 hours s/p extraction of teeth 17 and 18 with complaint of difficulty breathing and swallowing. Her oxygen saturation is stable at 98% on room air. Exam reveals a well-developed well-nourished female in no acute distress with stable vital signs. Oral exam reveals a somewhat firm sublingual swelling adjacent to the extraction site #17. Past medical history is significant for high blood pressure that is treated with Lisinopril. NKDA. What do you want to do next?*
  Review a complete past medical history and further clarification for potential familial history of coagulopathies or recent street drug use.
- *This is all negative, now what?*
  Obtain a CT of the neck with contrast. I would also order CBC and coagulation studies.
- *CBC shows white count in high normal range and coagulation studies come back as normal. The CT scan shows the area of concern* (Fig. 1.6). *What is the most likely diagnosis?*
  Sublingual hematoma secondary to violation of the lingual cortex during extraction.
- *How would you manage this?*
  If stable, then watchful waiting is appropriate with serial CT neck with contrast scans every 6 hours to evaluate for expansion. If no expansion, no surgical intervention would be required. If actively expanding, I would intubate for airway protection. Transfer to the operating room where a lingual flap would be raised for evacuation of the hematoma and identification of bleeding source. If the source

cannot be identified, interventional radiology should be consulted to aid in identification and possible embolization.

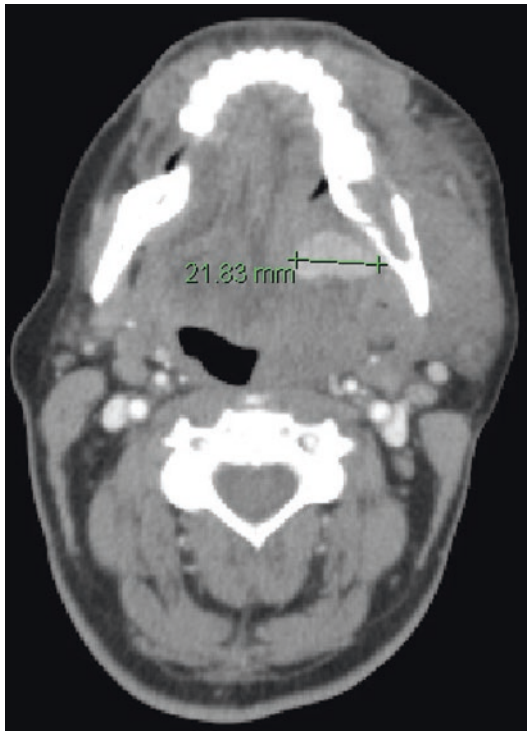

Fig. 1.6 Complication of tooth extraction. (Image Courtesy of Dr. Robert Reti)

Trigeminal Nerve Injury

Nerve Terminology

Endoneurium – connective tissue sheath that surrounds group of fibers forming a fascicle.

Perineurium – connective tissue surrounding a bundle of fascicles within a nerve.

Epineurium – outermost layer of a peripheral nerve, surrounding multiple fascicles and blood vessels (Fig. 1.7).

Classification of Nerve Injuries

- The rate of permanent injury to the lingual nerve from third molar surgery ranges between 0.04% and 0.6%, whereas for the IAN it ranges between 0.1% and 1% [4, 5, 10].
- The incidence of persistent nerve impairment of the IAN 1 year after BSSO surgery is reported to be 33% [11].
- IAN has a greater chance of spontaneous recovery (bony canal acts as a conduit for guided regeneration).
- Seddon in 1942 classified severity of nerve motor nerve injuries based on histology (Dr. Cohen actually first used the terms neuropraxia, axonotmesis, and neurotmesis).
- Seddon classification of peripheral nerve damage is the most commonly used for catego-

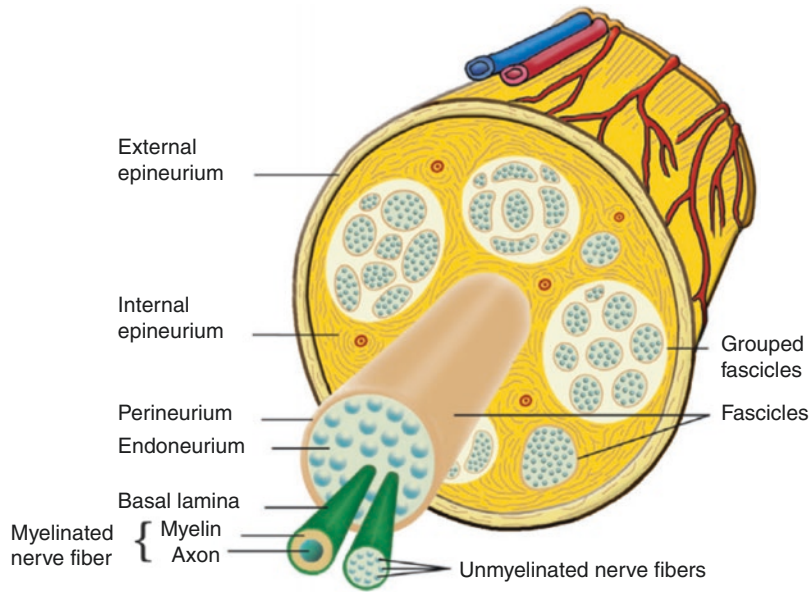

Fig. 1.7 Nerve anatomy. (Reprinted with permission from Winn [14])

rized into three groups: neuropraxias, axonotmesis, or neurotmesis. Sunderland's classification basis the injury on level of anatomic injury and expands on Seddon's classification to five degrees. The classification system aids in directing treatment (Table 1.2).
- Nerve recovery progresses slowly at 1 mm/day or 1 in/month.
- More recently the Medical Research Scale developed for brachial plexus injury monitoring has been modified to allow comparison between studies (Table 1.3).
- Simple to use, only three assessments, all of which can be done with a cotton plier: 1) pain (deep or superficial), 2) touch, and 3) 2-point discrimination (Table 1.4).

Pain Terms

- Allodynia – pain from a non-painful stimulus.
- Anesthesia – absence of any sensation.
- Anesthesia dolorosa – deafferentation pain is pain felt in an area, which is completely anesthetic to touch.
- Hyperalgesia – increased response to stimulation that is normally painful.
- Hyperpathia – prolonged pain following a repetitive noxious stimulus that lingers beyond expected duration.
- Hypoalgesia – diminished response to a normally painful stimulus.
- Hypoesthesia – decreased sensitivity to stimulation.

Table 1.2 Seddon and Sunderland classification

Classification of nerve injury				
Seddon	Sunderland	Description	Treatment	Outcomes
Neuropraxia	1	Temporary disturbance in nerve conduction, resembles common effect of anesthesia Axon continuity preserved Caused by nerve trunk traction or compression Type I (<24 hours): Mild manipulation, compression, traction Type II (<1 week): Moderate manipulation, compression, traction Type III (<1–2 monthos): Severe manipulation, compression, traction	No treatment	Spontaneous recovery, hours to 3 months
Axonotmesis	2	Loss of axonal continuity Endoneurium and perineurium intact Forceful compression or nerve traction greater than 25 g Wallerian degeneration distal to injury	Surgery only if foreign body	Possible spontaneous recovery takes 2–4 months
	3	Endoneurium and axonal loss of continuity Perineurium intact Severe crush, puncture, chemical, thermal trauma, or needle track injury	Microsurgery if no improvement for 3–4 months	Possible spontaneous recovery takes 3–4 months, unlikely complete
	4	Loss of endoneurium, perineurium Epineurium intact Extreme crush, thermal injury, intraneural local anesthetic injection, or caustic substances	Microsurgery if no improvement for 3–4 months	
Neurotmesis	5	Complete transection, interruption with or without neuroma formation	Requires microsurgery	No spontaneous recovery
Neuroma	6	Mackinnon used sixth degree to describe a neuroma in continuity	Requires microsurgery	No spontaneous recovery

Table 1.3 Modified Medical Research Council Scale

Modified Medical Research Council Scale	
Grade	Description
S0	No sensation
S1	Deep cutaneous pain in an autonomous zone
S2	Some superficial pain and touch sensation
S2+	Superficial pain and touch plus hyperesthesia
S3	Superficial pain and touch sensation without hyperesthesia and static 2 point discrimination >15 mm (useful sensory function)
S3+	Same as S3 with good stimulus localization and static 2 point discrimination 7–15 mm
S4	Same as S3 but static 2 point discrimination 2–6 mm (complete sensory recovery)

Table 1.4 Normal two-point discrimination distances

Test area	Average normal threshold distance (mm)	Upper normal limit (mm)
Upper lip (skin)	4.5	8.0
Upper lip (mucosal)	3.0	6.0
Lower lip (mucosal)	3.5	6.5
Lower lip (skin)	5.0	9.0
Chin	9.0	18.0
Tongue (tip)	3.0	4.5
Tongue (dorsum)	5.0	12.0

- Paresthesia – abnormal sensation, whether spontaneous or evoked and is not unpleasant.
- Tinel sign – tingling or "pins and needles" sensation elicited upon tapping on the distribution of the nerve. Thought originally to be an effect of regenerating nerves and also may be misinterpreted as neuroma formation.
- Wallerian degeneration – distal degeneration of the axon and its myelin sheath after injury may result from passive wasting of the distal axonal fragment due to lack of nutrient supply.

Workup

Patient assessment

CC:/HPI:/PMHx:

- Date of injury, type of procedure, type of pain (VAS), changes in taste (parageusia), characteristics of "numbness" progression (better or worse), interference in daily life (e.g., lipstick, shaving, and tooth brushing), speech, chewing, intimacy, and consult with previous surgeon.
- If no insulting surgery, concern for pathology such as metastatic tumor, osteomyelitis, central nervous origin, etc.
- Time frame needs to state first 3 months critical for intervention, by 12 months distal nerve tissue too damaged and ganglion cell death decreases likelihood of recovery.
- Patient to be followed every 2–4 weeks, if no improvement in subsequent visit, after 3 months do not expect improvement in future visits.
- When performing neurosensory testing, always test the affected side and compare to contralateral non-injured side if available.

Neurosensory Testing (NST)

- The area of altered sensation is delineated with the marching needle technique. A 27-gauge needle is marched in 1–2 mm increments from unaltered side to altered side until patient denotes sharp to dull in all directions, and then is marked with a skin pen.
- Compare normal side to abnormal side during NST testing. A score of 8 or less correct responses on the abnormal side is considered impaired (scale out of 10).

Level A – Spatiotemporal Perception

- A-α and A-β fibers.
- Moving brush stroke identification – cotton swab, Semmes-Weinstein monofilament, or camel brush hair.
- Two-point discrimination – caliper and Boley Gauge, cotton pliers or Disk-Criminator®. In general, the normal range for the IAN is 4 mm

and 3 mm for lingual nerve. Anything greater than 6.5 mm is considered abnormal.
- Stimulus localization – touch patient with tip of a cotton stick and ask patient to localize the stimulated area with their finger. 1–3 mm off examiner point is considered normal.
- If testing judged normal, no further testing required.

Level B – Static Light Touch

- A-β fibers.
- Touch skin with end of a cotton tip applicator; if able to detect, then normal, and if can feel only when skin indented, this is an increased threshold which is abnormal.
- Semmes-Weinstein monofilaments or von Frey hairs – touch skin to just create bend in filament on the normal side. Compare this value of fiber on the abnormal side.

Level C – Nociception

- A-δ and C fibers.
- 27-gauge needle without indentation of skin should evoke painful response.
- May discriminate A-δ with heated gutta percha vs. cold from ethyl chloride for C fibers.

Diagnostic Nerve Blocks – if patient complains of altered sensation and abnormal NST, a nerve block may be given to establish if pain is from injured peripheral nerve or central source. If no relief given, likelihood of nerve repair relieving pain is unlikely.

Nerve Repair
- Preoperative imaging such as CBCT or an orthopantogram can give insight into foreign body, retained root, hardware, or bony damage. They do not give information on the nerve integrity.
- Indications for nerve repair:
  - Observed nerve transection
  - Complete postoperative anesthesia
  - Persistent anesthesia >1 month without improvement
  - Presence or development of dysesthesia
  - Paresthesia without improvement >3 months
  - Foreign body in canal
  - Patient unable to tolerate hypoesthesia
- External neurolysis (decompression) – first step to microsurgical repair, involves exposing nerve from soft tissue bed without disruption of epineurium. May be only surgical maneuver required if mild sensory disturbances and without neuroma.
- Neuroma excision – resect 3 mm proximal and distal. Examine fascicles under magnification for opacity and architecture and check for scarification by pressing on the nerve with micro forceps. Adequacy may also be tested by frozen sections 1 mm cross-section biopsies.
- Direct neurorrhaphy – 4–6 circumferential epineural sutures with 7.0–9.0 non-ophthalmic nylon sutures. Lingual nerve gap of 1 cm and IAN gap of 5 mm possible for direct repair (without need for interpositional graft). Minimal tension of 25 g or less to prevent axonal gapping and prevent axon downgrowth to the distal nerve.
- Nerve grafting – requires 25% longer graft than defect due to shrinkage. Sites include sural, greater auricular and the antebrachial cutaneous nerves, dorsal cutaneous branch of the ulnar nerve, medial antebrachial cutaneous, superficial branch of the radial, and other nerves of the cervical plexus (Table 1.5). Most common autografts are sural and greater auricular due to ease of harvest and minimal postoperative morbidity. Important to orient the nerve graft in a functional direction, proximal-proximal, and distal-distal.
- Processed allograft AxoGen Avance® is a non-immunogenic alternative that provides a scaffold for nerve tissue to grow. Provides unlimited length and no donor site morbidity.
- Entubulation – best for gaps <10 mm. Polyglycolic acid conduits start to break down in 3 months and are resorbed by 8 months. Vein and artery grafts have mixed success but have been used. Collagen type I tubes available in 1–3 cm length.

Table 1.5 Nerve anatomy

Nerve anatomy				
Nerve	Fascicles	Diameter (mm)	Length harvest	Morbidity
IAN	18–21 in third molar region and 12 in the area of mental foramen	2.4	N/A	N/A
Lingual	15–18	3.2	N/A	N/A
Sural	11–12	2.1	20–30 cm Found below and posterior to lateral malleolus between the gastrocnemius tendons	Anesthesia of heel and lateral foot, temporary gait disturbance
Greater Auricular	8–9	1.5	2–4 cm Found by drawing line that bisects a line from the mastoid process to mandible	Anesthesia lateral neck, posterior mandible, and earlobe; smaller diameter may require cable graft

Prognosis

- Overall success rate of around 50%.
- 70% of patients with painful neuromas are helped regardless of surgical technique.
- All patients require sensory education after nerve repair.
- Hypoesthetic nerve injuries have a higher success rate than hyperesthetic injuries.
- Delays >6 months have poorer outcomes.

Coronectomy [12]

- Partial tooth removal leaving roots behind to prevent inadvertent IAN damage.
- Contradictions include:
  1. Horizontal impaction with tooth along length of nerve, risk sectioning higher than complete removal.
  2. Inability to access or removal all enamel layer.
  3. Infection of roots.
  4. Plan for distalization of second molar.
  5. Mobility of roots.
- Surgical technique requires removal of all enamel and root remnant 3 mm below the alveolar crestal bone.
- Antibiotics are of surgeon's preference and get rid of the similar results with and without.
- Primary closure has not shown increased success.
- Roots migrate about 30% of the time and can be appreciated in first 3 months as an apparent radiolucency below the roots with coronal migration.
- It should be noted that other techniques to reduce nerve damage include orthodontic extrusion (if nerve does not perforate roots) and sequential coronal reduction.

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Temporomandibular Joint Dysfunction

2

Rishad Shaikh, Damian Findlay, and Robert Reti

Anatomy

- The temporomandibular joint (TMJ) is a ginglymoarthrodial joint with translational movement in the superior joint space and rotational movement in the inferior joint space (Fig. 2.1).
- The capsular ligament or joint capsule is a functional ligament that surrounds the joint (attaching to the temporal bone and surrounds the condylar head/neck circumferentially).
- The capsular ligament is lined by the synovium, which functions to provide nutrition and immunosurveillance and lubricates the joint.
- The other two functional ligaments are the collateral ligaments and the temporomandibular ligaments.
- The accessory ligaments are the sphenomandibular and the stylomandibular ligaments.
- The articular disk is composed of fibrocartilage. It has three zones (anterior band, intermediate band, and posterior band). Posterior to the disk are the retrodiscal tissues, which are highly vascular and innervated.
- Primary joint movement is determined by the muscles of mastication (masseter, lateral pterygoid, medial pterygoid, and temporalis) and the inframandibular accessory muscles serve to impact mandibular function secondarily.
- The vascular supply of the TMJ is primarily from branches of the superficial temporal, maxillary, and masseteric arteries.
- The nerve supply of the TMJ is predominantly from branches of the auriculotemporal with contributions from the masseteric and posterior deep temporal nerve.

Myofascial Pain Dysfunction (MPD)

Definition – non-articular TMJ disorder that manifests itself as dull regional masticatory myalgia that worsens with function and can lead to a decreased range of motion. It can involve the muscles of mastication and any combination of the supramandibular and inframandibular muscle groups. This is the most common TMJ disorder.

Etiologies

- Parafunctional habits such as bruxism, nail biting, clenching, or gum chewing.
- Life stressors.
- Apertognathia and/or overjet greater than 6 mm.
- Lack of posterior dentition leading to muscle hyperactivity.

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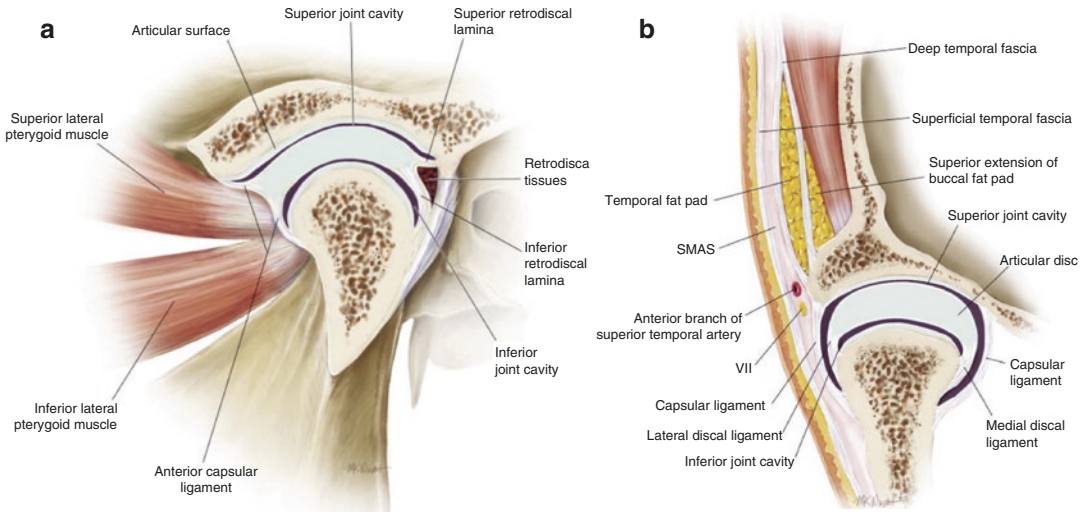

Fig. 2.1 Temporomandibular joint anatomy. (**a**) Lateral view. (**b**) Sagittal view. (Reprinted with Permission from Kadenami and Patel [9])

Clinical Manifestations

- Jaw pain with tenderness of the muscles of mastication and/or supramandibular and infrahyoid muscles.
- May see wear facets of the dentition.
- Scalloping of the tongue.
- Morsicatio buccarum, laborium, or linguarum.
- Patients may complain of sore teeth.
- Decreased range of motion.
- Buccal exostoses (Wolff's law states that bone responds to the pressure exerted on it by an osteoblastic response).
- Patients often will complain of pain on the side of their face as opposed to pointing to the preauricular region. Pain is usually diffuse and involves the muscles of mastication (DDx of MPD-trigeminal neuralgia, atypical facial pain, fibromyalgia).

Treatments

- NSAIDS to reduce pain and inflammation (e.g., ibuprofen 600 mg QID × 2 weeks, naproxen 500 mg BID × 2 weeks, Mobic 7.5–15 mg daily for 2 weeks)
- Occlusal appliances
- Soft diet
- Muscle relaxants:
  - Cyclobenzaprine 5–10 mg daily QHS, baclofen 5–10 mg TID (Some advocate for prescribing these medications TID. There is concern for dizziness/sedation, which is why some surgeons choose to prescribe it QHS.)
- Warm compresses
- Occlusal equilibration
- Trigger point injections
- Botox intramuscular injections
- Replacing the posterior dentition
- Physical therapy

Degenerative Joint Disease

Definition – a chronic inflammatory arthritis within the TMJ resulting in degradation of articular cartilage with remodeling of the subchondral bone.

Non-inflammatory Degenerative Joint Disease (aka Osteoarthritis)

- Due to an imbalance between catabolic and anabolic processes. This leads to expression of catabolic cytokines (TNF-alpha, IL-1, IL-6), initiating liberation of collagenases and proteases that result in degradation of the articular

cartilage. Osteoarthritis of the TMJ can be preceded by internal derangement and trauma and can also develop in patients that have had orthognathic surgery.

Inflammatory Arthritis

- Joint destruction due to an inflammatory arthritic process (e.g., rheumatoid arthritis (RA), juvenile rheumatoid arthritis, psoriatic arthritis, gout, pseudogout, ankylosing spondylitis, reactive arthritis).

Treatment

- Depends on the extent and the level of life disruption. May include medications, physical therapy, or steroids or disease-modifying drugs.
- For mild cases failing conservative treatments, consider arthrocentesis and arthroscopic procedures.
- More advanced cases may require arthroplasty or total joint replacement.

Internal Derangement of the Temporomandibular Joint

Definition – disorder of the TMJ in which the articular disk is in an abnormal position as it relates to the condyle and fossa when the teeth are in occlusion. Malposition of the disk may lead to pain, instability, decreased range of motion, and abnormal mobility of the mandible.

Etiologies

- Trauma
- Joint laxity
- Parafunctional habits
- Altered joint lubrication system
- Anchored disk phenomenon (disk adhesion to articular fossa)
- MPD

Diagnosis

- Look for decreased maximal incisal opening (MIO), deviation, deflection, palpable clicks (reciprocal), and crepitus. Patients often will complain of pain in the preauricular region as opposed to pointing to the side of the face.
- Diagnosis by MRI-T1 and T2. Disk is normally displaced in an anteromedial vector. Can see osseous changes and abnormal contours of the disk.
- Disk displacement with reduction – patient opens the mouth with an accompanying click that is produced when the condyle passes over the posterior portion of the disk. During opening, the disk returns to its normal anatomical position in relation to the fossa and condylar head. During closing, a second click can be appreciated as the condyle passes back over the thickened posterior portion of the disk.
- Disk displacement without reduction – patient attempts to open but the condyle cannot pass over the posterior band of the disk. May see deflection to the ipsilateral side and decreased excursion to the contralateral side. This results in limitation of opening.
- Wilkes classification classifies the degree of internal derangement and provides guidance in relation to treatment options (Table 2.1).

Table 2.1 Wilkes classification of internal derangement

Wilkes classification [1]			
Stages	Clinical findings	Radiographic findings	Surgical findings
Stage I	Painless clicking No pain or locking	Anterior disk displacement noted. Disk contour remains normal with no osseous changes	Normal disk noted and displaced anteromedially
Stage II	Occasional painful clicking with intermittent locking	Anterior disk displacement noted with reduction on opening Mild disk deformity with no osseous changes	The disk appears thickened and displaced anteromedially.

(continued)

Table 2.1 (continued)

Wilkes classification [1]			
Stages	Clinical findings	Radiographic findings	Surgical findings
Stage III	Frequent painful clicking with severe limitation in range of motion Joint tenderness noted	Anterior disk displacement noted without reduction Moderate disk deformity with no osseous changes	The disk is deformed and displaced anteromedially Adhesions may be appreciated
Stage IV	Restricted range of motion with chronic pain and joint crepitus	Anterior disk displacement noted without reduction Marked disk deformity with osseous changes	The disk is perforated with noted osseous changes of the condylar head and the fossa
Stage V	Joint pain and crepitus	Disk is displaced Marked disk deformity with severe osseous changes	The disk is perforated with noted severe osseous changes of the condylar head and the fossa

Treatment

- Conservative treatment as previously mentioned (if appropriate).
- Intra-articular injections with a local anesthetic/steroid mixture.
- Those unresponsive would benefit from arthrocentesis with or without arthroscopy, arthroplasty with repositioning, or meniscectomy with or without graft/replacement, or modified condylotomy.
- Postoperative management – physical therapy/range of motion exercises.

Disorders of Hypomobility and Hypermobility

Hypomobility can be due to intra-articular factors or extra-articular factors (pseudoankylosis).

Fig. 2.2 Ankylotic mass extending from the medial aspect of the ramus to the mandibular fossa over a previously placed prosthetic temporomandibular joint. (Image courtesy of Dr. Damian Findlay)

Extra-Articular Causes

- Muscle fibrosis secondary to radiation, myofascial pain, tumors, infection, hysteric trismus, myositis ossificans.
- Fractures involving the condyle, zygomatic arch, or coronoid process.

True ankylosis (Fig. 2.2) – intra-articular fusion within the joint space resulting in hypomobility:

- Can be bony, fibrous, or fibro-osseous.
- Can be complete vs. incomplete.
- Can be caused by trauma, infection, otitis media, rheumatoid arthritis, psoriatic arthritis, prolonged immobilization, and previous TMJ or orthognathic surgery.
- Based on radiographic findings, two commonly accepted classifications have been adopted. Topazian based on three classes and Swahney has four classes (Table 2.2).

Workup for Ankylosis

- Clinical exam – decreased MIO, inability to appreciate translation of the condylar head.
- Orthopantogram – can see a radiodense mass, overall bony morphology, and coronoid hypertrophy.

Table 2.2 Sawhney and Topazian classifications of ankylosis

Classification of ankylosis [2]	
Sawhney (1986)	Topazian (1984)
Type 1 – flattened condylar head with close approximation to joint space Type 2 – flattened condyle close to glenoid fossa, bony fusion on outer aspect of articular surface. No fusion of the medial joint space Type 3 – bony block bridging the mandibular ramus and zygomatic arch Type 4 – wider bony block bridges the mandibular ramus and zygomatic arch, completely replacing the architecture of the joint	Stage 1 – only condyle involved Stage 2 – extends to sigmoid notch Stage 3 – entire condyle, sigmoid notch, and coronoid

- CT with contrast – defines the extent of the heterotopic bone/ankylotic mass. It also delineates the relationship of the mass to vital structures (foramen ovale, foramen spinosum, carotid canal, jugular foramen, pterygoid plexus). CT also aids in fabrication of a custom TMJ prosthesis in the setting of immediate reconstruction.

Treatment Options – requires excision of the mass with reconstruction. The goal of MIO is 35 mm and greater. In an adult, the reconstruction is more commonly achieved with a prosthetic joint, which is described later in text (other options include costochondral graft (CCG) or fibula free flap).

The Seven-Step KABAN Protocol [3]
Dr. Kaban described a protocol for the treatment of TMJ ankylosis in pediatric patients:

- Aggressive resection of the fibrous and/or bony ankylotic mass.
- Coronoidectomy on the affected side and measure MIO intraoperatively.
- Coronoidectomy on the contralateral side if you cannot achieve an MIO >35 mm and/or to the point of dislocation of the unaffected TMJ.
- Lining of the TMJ with a temporalis myofascial flap or the native disk (if salvageable).
- Reconstruction of the ramus condyle unit with either distraction osteogenesis (DO) (activate 2–4 days) or CCG and rigid fixation (10 days of MMF (Maxillary-Mandibular Fixation). If DO is used to reconstruct the ramus condyle unit, reshape the native bone narrowed and rounded. A corticotomy is then created distally to serve as transport disk. The distraction is set at 1 mm/day. Mobilization begins the day of the operation. In patients who undergo CCG reconstruction, mobilization begins after 10 days of MMF. DO takes advantage of the fibrocartilaginous cap that forms on the advancing front of the distracted bone heading toward the fossa.
- Early mobilization of the jaw.
- Aggressive physiotherapy.

Treatment Options for Fibrous Ankylosis
- Can be treated more conservatively.
  - Lysis of adhesions and fibrosis.
  - Diskectomy.

Postoperative Management
- Aggressive physical therapy is paramount in the treatment.
- Frequent follow-up.
- Consider radiation therapy (20 Gray in 10 fractions) to prevent recurrence and consider when using autogenous grafting, as the risk of recurrence is higher.

Costochondral Graft
- The CCG is commonly used in the growing child. It offers many advantages including ease of adaptation and remodeling, low morbidity at the harvest site, low rate of infections, and reduced relative cost. It does, however, increase operating time. In adults 12–17 cm of rib can be harvested and 7–10 cm in children within the borders of the lateral edge of the latissimus dorsi and costochondral junction.
- Ribs 4–7 may be harvested as they have a direct cartilaginous connection to the sternum. Rib 6 is the most commonly harvested as the incision falls in the inframammary crease creating a better cosmetic outcome (fusion of the rectus and pectoralis major forms an avascular plane.) It is common practice to harvest the right rib, as it is least likely to be confused with cardiogenic pain. Many advocate the rib

contralateral to the side of the defect to allow appropriate curvature of the harvested rib.

Rib Harvest Technique [4]

- A sharp incision is made in the inframammary crease (5 cm long).
- Dissection is carried through the subcutaneous tissue, fascia, and the plane between the pectoralis major and rectus abdominis.
- Two fingers are used to straddle the fifth and sixth intercostal space to prevent slipping of instruments. A sharp incision is cut through the periosteum down to the outer cortex of the rib.
- A molt periosteal now can be used to dissect in a subperiosteal plane around the rib. Some surgeons used the Doyen rib stripper, but its usage is known to be associated with parietal pleural tears.
- A sharp blade is used to make the cartilaginous incision. In children it is important to harvest no more than 3 cm (no less than 1 cm) to avoid overgrowth of the rib and to prevent separation of the cartilaginous cap.
- The rib is pulled laterally and a protected rib cutter is now used to section the length of desired rib.
- Check for pleural tears by filling the cavity with normal saline and have the anesthesiologist perform a Valsalva maneuver to check for bubble formation.
- The periosteal sleeve is now closed with 3-0 polyglactin (this may promote de novo regeneration of the missing rib in the child patient).
- The fascia between the rectus and pectoralis major is closed with a 3-0 resorbable suture, followed by subcutaneous tissue and finally skin.
- Post-operatively a chest X-ray is ordered to rule out a missed pneumothorax or hemothorax. The patient may return to normal activity post-op day 7, but any strenuous activity is withheld for 6 weeks.

Complications

- *Cartilaginous Cap Has Separated from Harvested Rib* – this is a highly debated question and the opinion of the authorities appears to be diverse. One approach is to drill a hole through the width of the rib and tie a non-resorbable suture to secure the cap. Another approach is to simply harvest the second rib above and start fresh. The rib directly above is preserved to prevent a cosmetic defect.
- *Pneumothorax* – occurs when air is trapped between the visceral and parietal pleural cavity. The condition develops when there is a one-way valve allowing air to enter and not escape. This condition can rapidly progress to respiratory insufficiency and cardiovascular collapse. Clinically the patients will have labored (tachypneic) breathing, chest pain, tachycardia, hyperresonance of chest wall on the affected side with diminished breath sounds. Late findings include cyanosis, distension of neck veins, tracheal deviation, and a decreased level of consciousness. Radiographically can appreciate tracheal deviation, loss of pleural lines, and loss of vascular markings (Fig. 2.3). Treatment firstly is 100% oxygen therapy to reduce the alveolar concentration of nitrogen, effectively increasing the difference in concentration of oxygen between tissue capillary and pneumothorax space, leading to rapid absorption by the surrounding vasculature. A pneumothorax 10% or less in size can be left to reabsorb and serial chest X-rays are indicated. If it does not resolve

Fig. 2.3 Right sided pneumothorax. (Reprinted with permission from Fontaine and Page [5])

in 1 week, a tube thoracostomy is required. Estimation is provided by using a crude method by using a correlation that a 2.5-cm margin of gas peripheral to the collapsing lung corresponds to a pneumothorax of about 30%. Complete collapse of the lung is a 100% pneumothorax. If immediate pressure release is required, needle decompression can be done by placing an IV catheter at the second intercostal space along the mid-clavicular line and listen for rush of air. This procedure will normally buy time for tube thoracostomy. Tube thoracostomy requires a 2–3 cm incision that is marked at the fifth intercostal space just above the top of the sixth rib. Local anesthetic is infiltrated in the skin and tissues. A proximal end of a thoracotomy tub is clamped and advanced over the sixth rib, avoiding the neurovascular bundle on the inferior border of the fifth rib. The tube is placed on water-sealed suction drainage.

- *Pleural Tear* – air bubbles may be appreciated during the Valsalva maneuver indicative of a pleural tear. A suction catheter is placed into the wound and a purse string suture through the tear. The suction catheter is removed under suction while tightening the purse string simultaneously.

Hypermobility/Dislocation

Mandibular subluxation resulting in an inability to close from the patient's maximal incisal open position. This results in the condylar head being anterior to the articular eminence causing what is known as an open lock.

Etiologies

- Excessive yawning
- Excessive opening/prolonged opening (e.g., dental appointment)
- Seizure disorder
- Intubation
- Tardive dyskinesia
- Phenothiazine treatment – causes involuntary oromandibular movements
- Connective tissue disorders (e.g., Ehlers-Danlos and Marfan syndromes)

Acute Treatment

- Reduction by bimanual mandibular manipulation in a downward and posterior vector. Consider sedation beforehand.
- Wrap the head with a Barton bandage after reduction to limit jaw movements for a week (this allows stretched tissues to heal).

Treatment for Chronic Dislocation

- Noninvasive measures include intra-articular injections of a sclerosing agent such as alcohol or autogenous blood in the superior joint space.
- Botox has also been used in the lateral pterygoid.
- LeClerc/Dautrey procedures (zygomatic arch osteotomies), eminectomy, lengthening the articular eminence with a bone graft (calvarium, symphysis, ramus).

MRI Imaging of the Joint

- Ordering an MRI should be done with T1- and T2-weighted images in 3 mm serial cuts in the coronal, sagittal, and axial views for both open and closed mouths.
- A normal MRI will have the junction of the posterior band and the posterior attachment at the 12' O clock position in a closed mouth.

T1 Imaging (Fig. 2.4)

- Fat is bright and will appear white.
- Better for anatomy evaluation.
- The marrow fat in the condyle will have a high T1 signal intensity. An easy way to identify a T1-weighted image is if the condyle is white and the gyri of the brain do not show white banding or the orbits appear gray.
- On both T1- and T2-weighted image, the disk and cortical bone will appear black due to low proton density.
- Of note, in avascular necrosis, T1 marrow will be black and T2 will be bright due to necrosis.

T2 Imaging (Figs. 2.4 and 2.5a)

- Water is bright and fat is dark.
- Brain appears gray.

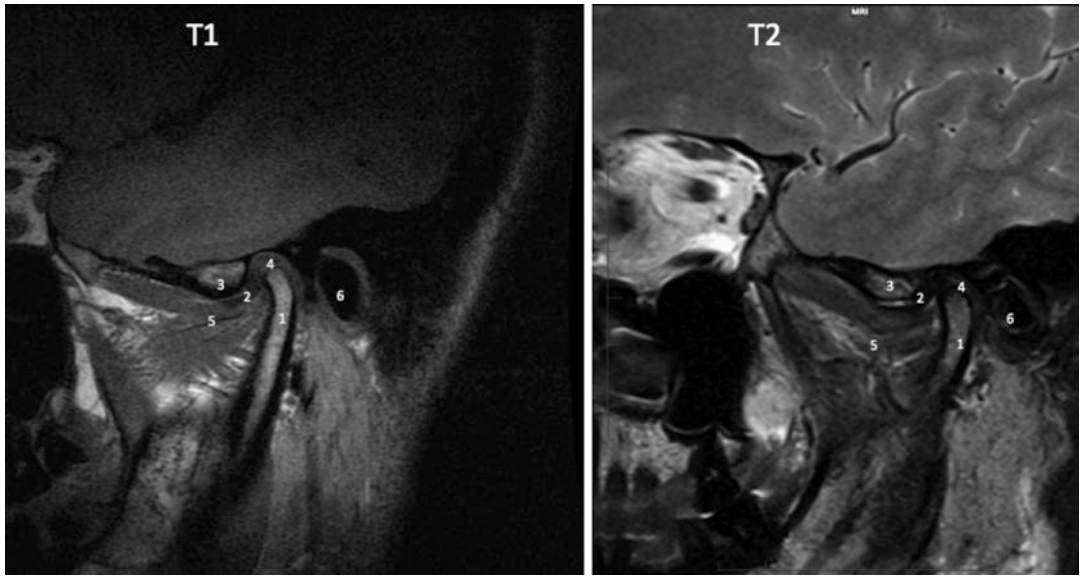

Fig. 2.4 (1) Condyle, (2) disk, (3) articular eminence, (4) posterior attachment, (5) lateral pterygoid, (6) auditory canal. (Image courtesy of Dr. Robert Reti)

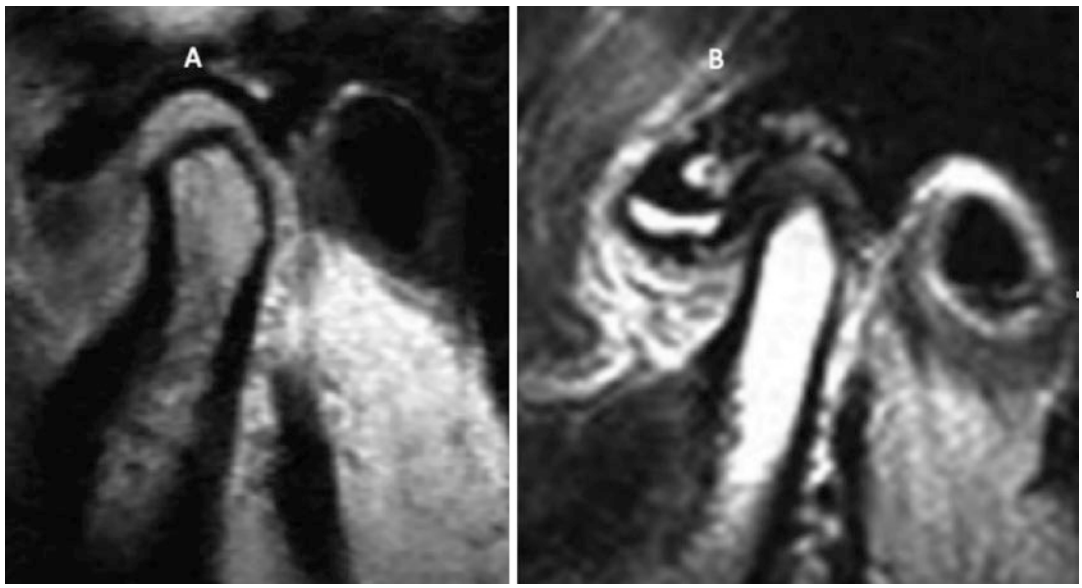

Fig. 2.5 (**a**) Example T1-weighted image sagittal view of TMJ in a closed mouth position with anterior disk position. (**b**) T2-weighted sagittal view of the TMJ in a closed mouth position with an effusion of the superior disk space. (Image courtesy of Dr. Robert Reti)

- Better to look for effusions and pathology (trauma/pathologies normally accompanied by edema) (Fig. 2.5b).
- The bone marrow is less bright (hence the condyle looks gray).
- Easy to identify whether you see a bright signal from gyri of the brain.

Approach to the Facial Pain/ Temporomandibular Joint Section

CC – Always ask the patient to expound on the chief complaint.

- *HPI* (HPI – Use the OLD CARTS acronym)
- *O*nset – when did the issue start? Was there a history of trauma?
- *L*ocation – where is the issue anatomically? For example, have the patient point to the region of discomfort.
- *D*uration – how long has the pain or decrease in opening been going on?
- *C*haracter – describe the character of the pain (throbbing, sharp, or dull).
- *A*ggravating/associated symptoms – is there anything that makes it worse? Do you have headaches, bruxism, clenching, gum chewing, nail biting, tinnitus, neck pain, or ear pain? Does your bed partner report any nocturnal bruxing? History of open or closed locks? Does your bite feel normal?
- *R*elieving – is there anything that makes the issue better?
- *T*iming – has this happened before? Any recent increase in life stressors? Does the pain improve during the day (nocturnal bruxism discomfort regularly improves during the day) or in the evening (arthritic joints tend to have more pain with continued function)?
- *S*everity – on a scale from 1 to 10, how severe are the symptoms? Is function impaired? Is there difficulty with mastication? Is there difficulty with speech due to pain? How has this affected your quality of life?

Physical Exam/Workup

- *Inspection* – look for gross asymmetry of the face (chin point and preauricular region). Look for signs of occlusal trauma such as wear facets, abfractive lesions, broken/worn restorations, exposed dentin, and missing teeth. Loss of posterior teeth can lead to MPD and overloading of the TMJ, which can cause intra-articular degenerative changes. Cheek bite marks or tongue scalloping. Look for premature contacts.
- *Palpate* – palpate the muscles of mastication (temporalis, masseter, pterygoids) and cervical musculature (SCM and trapezius). Palpate in the preauricular region to assess for masses and if movement of the condylar head can be appreciated. The condylar head may not move in cases of mechanical obstruction (i.e., ankylosis or neoplasm involving the TMJ).
- *Assess the Mandibular Gait* – check for maximal incisal opening (normal ~42–55 mm), lateral excursive (normal ~10–12 mm), and protrusive movements (normal ~8–11 mm). Look for deflection and deviation (possible signs of internal derangement) and the length of opening on occurrence.
- *Other Physical Exam Maneuvers*
  - Can you elicit Mahan's sign? Working side is loaded by placing tongue blades on the contralateral canines. If there is ipsilateral preauricular pain, then there is an internal derangement of the ipsilateral joint.
  - Joint auscultation to assess for clicks and crepitus.
- *Radiographic Imaging*
  - Orthopantogram – is it of diagnostic quality? Can both TMJs be visualized? Are the condyles in the fossae? Are there degenerative changes of the condylar head? Is there loss of joint spacing? Subcortical cysts? Chondromatosis (joint mice)? Subchondral eburnations (sclerosis)? Osteophytes? Are there radiodense changes or coronoid hypertrophy indicative of ankylosis? Is there condylar hyperplasia, hypoplasia, or agenesis? Are there any signs of hemiman-

dibular hypertrophy or condylar hyperplasia? Is there adequate penetration to visualize structures clearly? Look for fractures, third molars, caries, periodontitis, and sinus pathology.
- TMJ MRI – get T1- and T2-weighted (non-contrast) open and closed mouth views to assess disk position with function, disk integrity, and condition of the condyles. T1 gives better detail of joint anatomy. T2 useful for inflammatory changes and effusions. Look for the position of the disk and whether there is deformation. Remember in T1 fat is bright, T2 water is bright. Can look at the brain in T2 and note the brightness of the gyri and periorbital tissues.
- TMJ arthrogram – plain film of the TMJ that uses contrast. Good to visualize the position of the disk and good to assess for perforations.
- CT with contrast of the TMJs – look for ankylotic masses, neoplasms, mechanical obstruction, or infectious causes of trismus. Contrast helps to delineate the proximity of blood vessels to an ankylotic mass or if there is a collection that could be indicative of an infection (i.e., temporal space infection leading to trismus).

Arthrocentesis

Indications are for acute closed lock, previous surgery with continued discomfort, TMJ arthralgia, Wilke's classification 1, 2, and 3.

- Contraindications – ankylosis, overlying skin infection, and inability to appreciate the regional anatomy (i.e., obese patients).
- Can be done under local anesthesia or sedation.

Arthrocentesis Technique

- Use a marking pen to draw out the canthaltragal line (aka Holmlund-Hellsing line): First point is 10 mm ahead of the line and 2 mm below. Second point is 20 mm ahead (10 mm anterior to the first line) and 10 mm below. First point corresponds to the deepest point of the glenoid fossa and second point corresponds to the height of the articular eminence.
- Prepare skin with antiseptic solution.
- Use local anesthetic without epinephrine to anesthetize the area. This allows early evaluation if concern for traumatic versus anesthetic palsy of facial nerve. Additionally, if planning for diagnostic arthroscopy, epinephrine may mask erythema, rendering findings inaccurate.
- Manipulate the jaw to open the joint space.
- Insufflate superior disk space with a 27-gauge needle with lactated ringers.
- Using an 18-gauge needle, aim the needle at a 45-degree angle superiorly and anteriorly to reach the lateral aspect of the zygomatic arch, then walk the needle off the bone to enter the superior joint space. This will be your anterior port. (Joint entry with needle on average is 25 mm from skin.) Average superior joint space is around 3 cc.
- Place posterior port in similar manner with 18-gauge needle (of note a Shepard cannula can also be used which has an entry and exit port).
- Irrigate with lactated ringers (at least 100 ml). Lavaging the joint can break up adhesions, which can allow the disk to recapture into its premorbid position. This also irrigates out inflammatory mediators.
- Remove anterior port and inject a single agent or combination of steroid (Kenalog 40 mg/ml), hyaluronic acid (10 mg/ml), local anesthesia (bupivacaine 0.5% with 1:200 K epi), and morphine (10 mg/ml).
- Manipulate joint under anesthesia and check opening under sedation.
- Postoperative management includes aggressive range of motion exercises, NSAIDS, splints.

Disk Reposition Procedure

- Surgical procedure to manually reposition the disk into its premorbid position.
- Indications are failure of conservative therapy, Wilkes 2–5.

Preauricular Approach/Disk Reposition Technique

- Incision is marked in the preauricular crease (may consider the Al-Kayat extension to increase access).
- The incision is made through the skin and subcutaneous tissues for the entire length.
- Attention is then directed to the superior portion of the incision. Dissect through temporoparietal fascia (TP) and auricularis anterior muscle down to the temporalis fascia layer (which is recognized by the glistening white color). The TP fascia is attenuated in this region and not as thick as its superior counterpart (Galea). Remember the temporal branch of the facial nerve runs within the TP fascia anywhere from 8 mm to 35 mm (average 20 mm) from the bony anterior extent of the external auditory meatus. The remaining intervening tissues are dissected down to the level of the temporalis fascia using a nerve monitor/stimulator to avoid the course of the nerve (Fig. 2.6).
- Palpate the zygomatic arch. Incise through the attached periosteum. Dissect subperiosteally until you appreciate the joint capsule.
- Insufflate the joint with local anesthesia or saline. Make an incision into the joint capsule to enter superior joint space.
- Mobilize the disk. Assess for perforations (repair if small perforations/remove disk if the perforation is large). Disk can be plicated in a posterolateral vector to the disk capsule or temporalis fascia with non-resorbable suture or a Mitek® anchor.
- Close in layers.

Complications

Otitis Externa – Infection of external auditory canal. Patient will complain of pain on movement or pressure of ear. Otoscopy will reveal edematous EAC with possible discharge. Treatment includes topical fluoroquinolone otic products (to cover pseudomonas – most common bacteria implicated in otitis externa).

Otitis Media – inflammation of the middle ear structures. Patient will complain of ear pain, difficulty hearing, and fever. Otoscopy shows full or bulging tympanic membrane or possible purulence (if there is perforation of tympanic membrane). Treatment includes antibiotics such as amoxicillin. Consider consult with ENT for myringotomy tubes.

Broken Instrument During Arthroscopy/Arthrocentesis – if you are able to visualize the fragment, and having arthroscopic training, attempt removal arthroscopically. If you cannot visualize, then obtain radiographs in multiple planes for identification. If these failed or not trained, convert to an open approach.

TMJ Rupture/Hemotympanum – otoscopy to examine for TM rupture or hemotympanum. Consult ENT for intra-op examination if this is

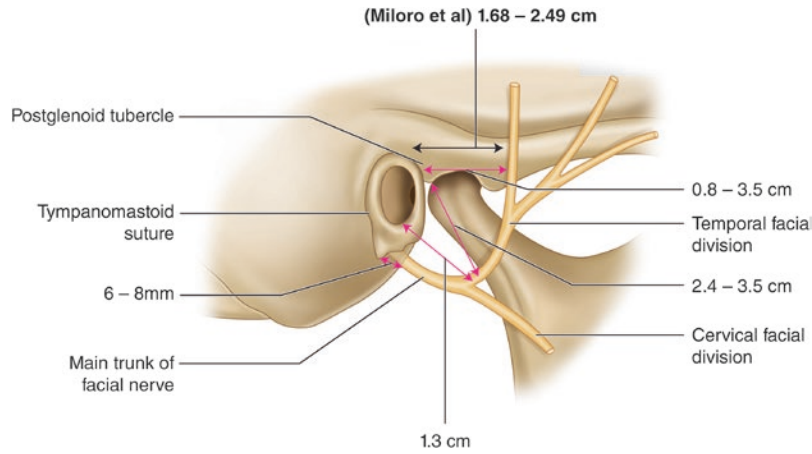

Fig. 2.6 Facial nerve as measured from the lowest point of the external bony auditory canal. Bifurcation of facial nerve: 1.5–2.8 cm. Facial nerve crossing zygomatic arch: 0.8–3.5 cm (average 20 mm). (Reprinted with permission from Miloro M, Redinger S, Peddington D, Kolodge T. JOMS 2007; 65(12):2466–2469)

noted. If EAC is damaged, place an antibiotic impregnated sponge dressing. This is sutured to maintain opening of the EAC, thereby, preventing stenosis. Some physicians will place on antibiotic-hydrocortisone suspension for 14 days post-op and monitor for granulation tissue formation. This granulation tissue can be removed with bipolar cautery or silver nitrate.

Violation of the Middle Cranial Fossa – keep in mind that the fossa is approximately only 0.9 mm thick. If a large perforation is noted, an intraoperative neurosurgical consult is recommended (as it may be able to be treated immediately). If you suspect CSF leak postoperatively, then obtain a CT scan/MRI. A tracer study should also be taken. (Neurosurgery should be consulted and should advise on the desired imaging.) The patient is placed on bed rest, with the head of the bed raised greater than 30 degrees. Some advocate administration of antibiotics such as cotrimoxazole as this is bactericidal and enters CSF. The overwhelming majority of small leaks spontaneously heal within 1 week.

Damage to the Temporal Branch of the Facial Nerve – the temporal branch of the facial nerve on average is 2 cm anterior to the bony external auditory canal. The classic study of Al-Kyat and Bramley identified a range of 0.8 cm to 3.5 cm [6]. The temporal branch of the facial nerve innervates the frontalis, orbicularis, and corrugator supercilii. Most injuries resolve in 3–6 months and, therefore, observation is warranted. Treatment should be reserved for those who are symptomatic. Ophthalmologic consult is indicated. Lubrication and taping of the eye at night are necessary to prevent keratoconjunctivitis. Physical therapy with electrical stimulation may aid in maintaining muscle tone while awaiting recovery. Gold weights implants can be placed in the upper eyelid for more permanent defects.

Auriculotemporal Nerve Syndrome (Frey Syndrome) – signs and symptoms include gustatory sweating, flushing, and warmth over the temporal and preauricular areas. It results when there is auriculotemporal nerve damage and occurs most commonly with arthroscopy. It usually is temporary and will resolve within 6 months.

**Author's Note*. The patient is to be evaluated with the Minor test (starch-iodine). A solution of 3 g iodine, 20 g castor oil, and 200 ml absolute alcohol is applied to both preauricular regions of the face. Gustatory sweating is elicited by having the patient chew on a lemon drop. A positive test is conversion of the yellow mixture to a dark blue. Case reports have shown that 16–80 IU of botulinum A subcutaneous injection has resulted in resolution within 1 week. Other treatments are application of scopolamine ointment (anticholinergic properties) and surgical transection of the innervation.

Bleeding During Condylotomy – during the condylotomy, the concern for bleeding is from the internal maxillary artery (IMA) and its branches. The IMA runs 3 mm medial from the mid-sigmoid notch and 20 mm below the condylar head. A commonly damaged vessel, as the cut is made through the sigmoid notch, is the masseteric artery.

Bleeding During Diskectomy – many times during a diskectomy, the bleeding may be also originating from the retrodiscal tissues or the lateral pterygoid muscle. The most commonly damaged vascular structure is the middle meningeal artery. It is found on average 31 mm medial the zygomatic arch and an average of 2.4 mm anterior from the height of the glenoid fossa. The first step to managing bleeding is to establish visualization. Attempt to identify any vessels for cauterization or ligation. If no obvious source, then apply firm pressure with a moistened gauze packed tightly into the wound. Additional hemostatic measures include thrombin-soaked gauze, flowable hemostatic agents, collagen sponges, or tissue adhesives. The inferior border of the mandible is then displaced superiorly to aid in pressure hemostasis (holding pressure for at least 5 minutes). Interventional radiology for embolization is warranted immediately if bleeding is not controlled by local hemostatic measures.

**Author's Note.* Some surgeons advocate carotid artery cut down for uncontrollable bleeding. Some question its efficacy due to contralateral circulation. In this approach, the neck incision is extended (a horizontal incision 5 cm in length) 2 cm below the inferior border of the

mandible, over the sternocleidomastoid muscle (SCM). The SCM is retracted posteriorly, and with blunt dissection parallel to the vessels, the carotid sheath should be identified. The SCM is carefully dissected from the sheath and the sheath is carefully entered. The internal jugular vein should be retracted posteriorly to reveal the common carotid. Dissection to the bifurcation aids in identification. The hypoglossal nerve will cross the arteries above this bifurcation and should be identified to prevent damage. Ligation should be above the facial branch, third of the anterior branches. Blood flow has been found to be reduced by 73%, when ligated at this position [7].

Total TMJ Joint Replacement

Total joint replacement (TJR) indications:

- Failed previous TMD surgeries
- Severe arthritic joint
- Loss of vertical mandibular height and occlusal relationship
- Pathology
- Ankylosis – either bony or fibrotic
- Condylar agenesis

Two Approved TJR Prosthetics in the USA

1. Biomet®
   - Stocked with multiple sizes
   - Chromium cobalt alloy for condylar component and ultra-high molecular weight polyethylene for fossa component.
   - Pseudotranslation possible (if unilateral placement due to push of contralateral TMJ).
   - Chromium cobalt mandibular prosthesis is offered in three sizes (45 mm, 50 mm, and 55 mm) and in three styles (standard, narrow, and offset).
   - Chromium cobalt may contain nickel (a consideration in those with a nickel allergy).
2. TMJ Concepts®
   - Custom made w/CT scan and stereolithography.
   - Pure titanium for condylar component.
   - Pure titanium with ultra-high molecular weight polyethylene for the fossa component.

Surgical Technique for TJR

- Requires a preauricular and submandibular/retromandibular approach.

Preauricular Approach

- Standard preauricular approach to joint capsule (see above).
- Make an incision in the periosteum of the lateral aspect of the condylar head, in a T shape fashion, to expose the lateral aspect of the condyle. Of note, the anatomy may be distorted due to an ankylotic mass and, therefore, recognizable anatomical landmarks should be used as a reference for the dissection.
- Dissect subperiosteally to expose the anterior and posterior regions of the condylar neck.
- Pack site and direct attention to the submandibular region.

Submandibular Approach

- Mark mandible 2 cm below inferior aspect of the mandible.
- Inject vasoconstrictor.
- Make an incision approximately 6 cm long.
- Dissect through skin and subcutaneous tissue to the level of the platysma.
- Undermine skin flap in all directions.
- Sharp dissection through platysma exposing superficial layer of the deep cervical fascia. Dissect through this layer with the aid of nerve stimulator/monitor testing for marginal mandibular nerve, which is within or deep to the fascia.
- (Don't forget Dingman and Grabb [8] study – 19% of the time, the marginal mandibular nerve passed below the inferior border of mandible until it crossed facial artery 1 cm below the inferior border of the mandible).
- Marginal mandibular nerve has two branches 61% of the time and 21% it is a single branch.
- Dissect out facial artery and vein; isolate and clamp and tie vessels.
  - Hayes-Martin maneuver – ligation of facial vein (posterior to facial artery) at the lower

border of the mandible aiding in reflection of the superficial layer of the deep cervical fascia preserving the marginal mandibular nerve.
- Divide the pterygomasseteric sling along the inferior border of the mandible (the most avascular portion of sling). Redirect attention to the preauricular region.

Condylar Resection (Condylectomy)
- Condyle retractors placed to isolate the neck of the condyle (may not be possible in large ankylotic masses).
- Resect exposed condyle (a minimum of 15 mm of clearance for condyle and fossa component) if additional condyle neck requires removal, may place bone clamp on inferior border and displace ramus superiorly, further exposing condyle neck into preauricular/endaural incision.
- Inadequate removal may lead to impingement of ramus remnant on fossa prosthesis when MMF placed.

Fossa Preparation
- Removal all soft tissues from tympanic plate to remnant articular eminence.
- TMJ Concepts® – if necessary, reproduce any fossa contouring noted on preoperative model. TMJ concepts will require verification of seating by using the fossa-seating tool.
- BIOMET® stock joint requires manipulation of a specially designed diamond rasp or burr to modify the articular eminence. This allows positioning of fossa component. The surgeon must choose the appropriate fossa from sizers to ensure tripod stability. Note, the articulating surface of the fossa component stays constant and the amount of screw hole positions over the arch increases with size.
- Secure fossa component (make sure to apply firm pressure with fossa seating tool from TMJ concepts).
- Place only two screws for securing the prosthesis to allow check for the range of motion/interferences and to avoid damage to bone stock if repositioning is required.

Condyle Component
- Place patient in MMF.
- Biomet®, choose correct mandibular component from the sizers.
- Contour bone of the lateral ramus (rarely needed with TMJ concepts due to it having a custom fit) to allow passive fit of BIOMET sizer.
- Secure with two screws at this time.

Final Screw Securement
- Cover open wound sites, enter oral cavity, and remove MMF. (Consider paralysis at this time for freedom of movement).
- Ensure ROM is at least 32–35 mm.
  - If cannot achieve ROM, perform coronoidectomy (first ipsilateral and if not bilateral).
  - Note: If this is an ankylotic case, a coronoidectomy is required per Kaban protocol.
- Place final screws, at least four screws for fossa component and six in ramus.
- Irrigate sites and close.
- Consider fat graft around fossa to prevent ankylosis.

Post-op
- Post-op radiographs to confirm position and alignment.
- Post-op exercises and soft diet.
- Consider physical therapy for 4–6 weeks.

TMJ Case

**Authors Note.* There are many ways to treat TMD. The goal is to explain the way you will be treating this patient. Do not deviate from your algorithm or explain how other surgeons would approach this. The goal of this portion is to guide you down a path to a surgical procedure. Be prepared to talk about open joint procedures, which could include disk manipulation or total joint replacement.

A 35-year-old female presents to your office with a chief complaint of diffuse, increasing left