Chapter 19

SALIVARY GLAND AND DUCT INJURIES

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INTRODUCTION

Traumatic injury severe enough to disrupt the submandibular or parotid gland is often associated with severe, life-threatening vascular and skeletal injuries. These injuries frequently occur in patients with concomitant trauma, including cervical spine injury, penetrating neck wounds, and severe soft tissue trauma. Furthermore, salivary gland and duct injuries represent a small percentage of overall soft tissue trauma. Lewis and Knottenbelt conducted a retrospective study of 15,419 patients in a trauma unit, finding that only 0.21% had salivary gland or duct injury.[1] Due to their infrequent occurrence and subtle signs on presentation, injuries involving the major salivary glands are frequently overlooked or underestimated.[2]

Penetrating trauma, blunt trauma, and blast injuries cause the majority of salivary gland trauma.[3] Sharp, penetrating trauma may lead to injury of deeper anatomic structures as well. Such trauma may result in injury to the salivary tissue, duct, and the facial and hypoglossal nerves. For example, submandibular gland trauma may be accompanied by injury to the marginal branch of the facial nerve or the facial artery. Parotid gland injury may also occur in the presence of a penetrating neck wound, facial nerve injury, or damage to the carotid sheath. Because of their anatomic location, the parotid gland and duct are exposed to injury in battlefield trauma scenarios involving gunshot wounds and improvised explosive devices (IEDs). The head and neck surgeon must be aware of such injuries because failure to recognize and treat them may lead to otherwise preventable complications such as sialocele, cutaneous fistula, or salivary duct cysts. Thorough assessment and timely intervention of these injuries can reduce the morbidity associated with such trauma. This chapter explores the role of the head and neck surgeon in evaluating and treating glandular and duct injuries.

RELEVANT ANATOMY

The Parotid Gland

The paired parotid glands are the largest of the salivary glands and are located within the parotid space, which extends from the external auditory canal and mastoid tip superiorly to the angle of the mandible inferiorly.[4] The glands are situated superficial to the posterior edge of the masseter muscle and are confined within the superficial layers of the deep cervical fascia.[4] The outermost layer of fascia, known as the superficial musculoaponeurotic system, divides the subcutaneous fat into two distinct layers: a superficial layer with fibrous septa running to the dermis and a deep layer that overlies and adheres to the investing fascia of the parotid gland.[5] The parotid gland is intimately adherent to the investing fascia, which can be used as a landmark during parotid dissection. Additionally, the parotid gland is interspersed with fat. Because of this, on computed tomography (CT), the attenuation of normal parotid gland tissue is lower than that of surrounding muscle but greater than that of fat. On magnetic resonance imagery (MRI), the gland has an intermediate to high signal on T1-weighted imaging and a low to intermediate signal on T2-weighted imaging.

Each gland is divided into deep and superficial lobes by the anatomic plane in which the branches of the facial nerve course. The facial nerve exits the facial canal via the stylomastoid foramen and passes forward to enter the posterior surface of the gland.[6] During its course, the facial nerve crosses the styloid process, retromandibular vein, and external carotid artery before dividing into its five terminal branches behind the neck of the mandible.[7] Each of the five branches (temporal, zygomatic, buccal, marginal mandibular, and cervical) innervates different muscle groups that control facial expression. These branches fan out as they travel through the parotid gland, so that trauma to any part of the gland carries the risk of trauma to the facial nerve (Figure 19-1). In most cases, as long as traumatic lesions do not breach the investing fascia, the facial nerve remains intact.

The parotid duct (Stensen duct) is approximately 7 cm in length and receives ductules from both lobes before emerging from the anterior border of the gland.[8] It follows an anterior course superficial to the masseter muscle and in close proximity to the transverse facial artery and buccal branch of the facial nerve.[9] It pierces the buccinator to open into the oral mucous membrane opposite the upper second molar tooth.[10] Trauma to the duct requires timely repair, because infection may spread retrograde to the buccal space in the short term and may lead to sialocele, cutaneous fistula, or salivary duct cyst in the long term.[11] These complications may occur as a result of infection, and their risk is increased when the duct injury is not recognized or not repaired.

The Submandibular Glands

The submandibular glands are paired glands that are largely confined to the submandibular space, located inferior to the mylohyoid muscle and superior to the hyoid bone, with a small portion of the

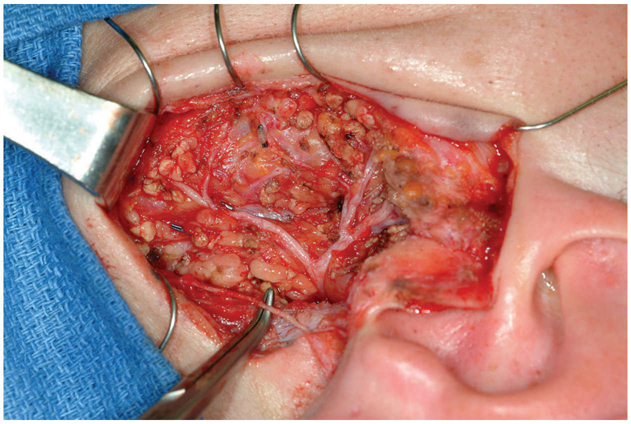

Figure 19-1. Facial nerve dissection demonstrating the pes anserinus and the upper and lower divisions of the facial nerve. Also note preservation of the posterior branch of the great auricular nerve.

gland extending cranially along the posterior border of the mylohyoid.[12] The submandibular glands contain less fat than the parotid glands, leading to a higher attenuation on CT. On MRI, the glands have a lower signal on T1-weighted images and a higher signal on T2-weighted images. The glands lie in a relatively protected position, largely deep to the mandible, and share this space with the anterior belly of the digastric muscle, fat, lymph nodes, the inferior portion of the hypoglossal nerve, and the facial artery and vein.[13]

To reach the glands from a transcervical approach, the overlying skin, subcutaneous tissue, and platysma muscle must be traversed.[14] Once the subplatysmal plane is reached, the marginal mandibular branch of the facial nerve, which innervates the lower lip and angle of the mouth, is vulnerable to injury. The nerve courses just lateral and superior to the gland and can have a single or multiple branches.[15] In approximately 80% of cases, the nerve courses superiorly to the mandible, making it less susceptible to injury with submandibular trauma.[16] However, there is great variability in the course of the nerve and extreme care should be taken when operating within 2 cm of the bony mandible.[16] The marginal mandibular nerve overlies the facial vein, which runs perpendicular to the mandible.[17] This vein is often sacrificed on surgical approach to gain access to the submandibular gland and is easily injured with trauma to the area.[18]

Both the facial artery and vein lie lateral and posterior to the posterior pole of the gland. This region, known as the vascular pole, is where most facial vessels enter the parenchyma of the gland.[17] The anterior belly of the digastric muscle lies deep to the facial vein and immediately superficial to the mylohyoid muscle, which can be easily distinguished by its fibers that run from posterosuperior to anteroinferior.[18] The mylohyoid divides the gland into anterior and posterior portions and must be gently retracted anteriorly to access the entire gland and the Wharton duct. The duct exits the gland at its anterior edge, where it is involved in an interesting relationship with the lingual nerve, which supplies sensory innervation to the tongue. The lingual nerve runs medial to the submandibular gland and travels deep but parallel to the course of the Wharton duct initially. The duct then courses superiorly over the nerve to run medial to it. Distally, the duct crosses the nerve again as it follows an anterior path to the sublingual papilla on the floor of mouth, while the nerve continues in a superior trajectory to innervate the tongue.

The hypoglossal nerve, which supplies motor innervation to the ipsilateral side of the tongue, is the next important structure encountered, running inferior and medial to the lower third of the gland under the posterior belly of the digastric muscle. Because of the complex anatomy, traumatic injury to the submandibular region can lead to a number of problems, including hemorrhage, infection, lower facial palsy, tongue palsy, and hypoesthesia.

The Sublingual Glands

The sublingual glands are found within the areolar tissue between the mucosa of the floor of the mouth and the mylohyoid muscle.[19] These glands lack a capsule or fascial sheath. The sublingual glands consist of a grouping of 15 to 30 small, elongated glands, each with a short duct (Rivinus ducts) that opens to the plica sublingualis. One or more ducts may join to form the Bartholin duct, which may empty into Wharton's duct or take an independent path and open next to the caruncula sublingualis. Injury to the ducts of either type of sublingual gland can cause scar tissue formation and contracture that can seal and obstruct the gland, resulting in sialocele or ranula.[19] Sublingual glands may not be visualized on CT due to their small size. On MRI, the T1-weighted signal is lower than the surrounding fat and the T2-weighted signal is higher.

PHYSICAL EXAMINATION AND DIAGNOSIS

Parotid and submandibular duct injuries are often subtle, thus requiring a high index of suspicion in the polytrauma patient. Facial trauma involving forces resulting in fractures of the facial skeleton may result in associated salivary gland injuries. In fact, it is estimated that 21% of patients with penetrating trauma to the parotid region experience injury to the parotid duct.[20] Thus, salivary gland and duct injury should be routinely assessed in patients with fractures of the zygoma, maxilla, and mandible. The wound should be meticulously inspected for any foreign bodies during initial examination. Salivary gland and duct injury should be considered in any patient with concomitant facial nerve weakness, or in the presence of penetrating injury of the cheek or floor of the mouth. In the case of parotid duct injury, the buccal branch is the most commonly affected division of the facial nerve, because it lies inferior and lateral to the duct. In the case of submandibular duct injury, the marginal branch of the facial nerve and the hypoglossal nerve are most commonly affected.

The clinician should assess for salivary leakage arising from the wound. Any penetrating injury along an imaginary line drawn from the tragus to the oral commissure may result in injury to the Stensen duct or the parotid gland parenchyma. Stevenson et al developed a classification that divides the parotid gland into three distinct regions: region A is the area of the parotid gland that lies posterior to the masseter muscle; region B is the area that lies superficial and courses through to the masseter muscle; and region C is the area where the Stensen duct lies medial to the masseter muscle and enters the oral cavity opposite the second maxillary molar. This classification is clinically useful because injuries involving the duct (regions B and C) demonstrate a higher complication rate than injuries of the parotid parenchyma itself.[21]

Pooling of saliva within the wound should raise suspicion of glandular injury. In such cases, the integrity of the adjacent duct should be carefully assessed. The integrity of the parotid and submandibular duct may be assessed by cannulating the papilla intraorally. This may be performed with either lacrimal probes or a small bore (eg, 20 or 24 gauge) angiocatheter. Care should be taken when cannulating the duct to avoid iatrogenic injury. Alternatively, manual expression of saliva from the salivary papilla may be employed, although this is less reliable. Antisialagogue medications such as glycopyrrolate or atropine should be avoided if this technique is used. In cases of diagnostic uncertainty, methylene blue dye may be injected into the duct to assess its integrity or assist in identification of the proximal end of the transected duct. Caution is advised when employing this technique because excessive extravasation of dye from the lacerated duct may complicate repair due to discoloration of the surgical field. Saline is effective in the identification of ductal injury in place of dye and eliminates discoloration of the surgical field.

BLUNT VERSUS PENETRATING TRAUMA

Most salivary gland injuries result from penetrating trauma to the face or neck. Blunt trauma may result in less obvious salivary gland trauma, leading to a delay of diagnosis. Contusions, hematomas, swelling, and pseudocyst formation are examples of injuries secondary to blunt trauma. Shetty and Rink found an 80% incidence of residual salivary gland dysfunction in patients who had sustained blunt trauma to the parotid gland.[22] Injury to the facial nerve and salivary ducts is infrequent, and if either is present at the time of injury, they are often temporary in the context of blunt head and neck trauma. Penetrating trauma carries a higher incidence of duct and facial nerve injury.[9] Types of salivary gland injuries are categorized based upon mechanism of injury (blunt, penetrating); location (parotid, submandibular); and presence of salivary parenchyma injury with or without ductal injury.

DIAGNOSTIC STUDIES

Imaging studies in the head and neck trauma patient generally include CT with iodinated contrast of the head and neck. CT may also identify associated injuries such as facial fractures and carotid sheath injuries. MRI and plain films are less helpful in the acute trauma evaluation of salivary gland and duct injuries; however, plain film imaging may be useful when a foreign body is suspected and CT imaging is not available. CT angiography and MR angiography are useful when vascular injuries are suspected, although their availability maybe limited in theater operations. Sialography can be useful in evaluating salivary duct injuries but may be challenging to perform in trauma patients, especially those with multiple traumatic injuries. Additionally, injection of contrast or dye may lead to spillage into the wound or fluid collection in the soft tissue, which may complicate soft tissue repair.

Salivary gland endoscopy is an evolving technique that may help in localizing or diagnosing salivary duct injuries. It requires endoscopic equipment, which may not be available in a theater hospital. Such equipment may be available in an otolaryngology department when the patient has been evacuated from the theater of operations for evaluation and definitive management.

MANAGEMENT

In the polytrauma patient, treating life-threatening injuries, establishing a secure airway, and controlling hemorrhage are the highest priorities. In patients with massive soft tissue loss, complex closures or flaps should be avoided in the immediate setting. The basic principles applied to wound care apply to management of salivary gland injuries. Removal of foreign material, meticulous cleansing, sterile technique, gentle tissue handling and debridement, and tension-free closure of lacerations ensure optimal outcomes. Lewis and Knottenbelt performed a prospective study enrolling 19 patients who sustained parotid gland injury that were managed with conservative, nonoperative treatment. In this series, 53% of patients developed late complications, including fistulas and sialoceles, when gland injury was not addressed acutely. All complications were managed without surgery and led to subsequent resolution of the symptoms[1]; however, recovery was prolonged in patients who sustained complications as a result of their initial injuries.

Due to their close proximity, injuries to the facial nerve frequently accompany parotid and submandibular duct injury. Thus, a thorough cranial nerve examination is essential in patients who sustain penetrating or blunt trauma to the head and neck region. Traditionally, branches of the facial nerve that are anterior to a vertically oriented imaginary line drawn from the lateral canthus of the eye inferiorly are not repaired. Conversely, repair either by direct neurorrhaphy or grafting techniques may be considered in certain patients whose facial nerve injury lies posterior to a vertical line drawn from the lateral canthus. Immediate repair or reconstruction of injured facial nerves may be delayed in patients who have sustained massive facial trauma. In such cases, facial nerve ends may be identified and tagged for future intervention. Wounds should be thoroughly cleansed, with removal of foreign bodies as indicated. Attention should then be directed to assessment of the salivary duct's patency, functionality, and integrity.

TRAUMA TO THE PAROTID GLAND AND DUCT

In situations of penetrating trauma, gland and duct repair should be performed within the first 24 to 72 hours following the injury, if feasible. For duct injury, a direct end-to-end reanastomosis is preferred.[9] This method requires identification of the distal and proximal ends of the parotid duct. In order to repair the duct, the surgeon must first identify the distal and proximal stumps. This may be accomplished via intraoral cannulation as described previously. Once the two ends have been identified, direct end-to-end anastomosis may be performed. Duct loss should not exceed 1 cm; primary reanastomosis of gaps larger than 1 cm will lead to excessive tension on the repair and an increased incidence of postoperative stenosis and failure. Additionally, the distal end of the parotid duct may be difficult to identify due to soft tissue trauma. In such circumstances, the proximal portion should be identified, then cannualized with either lacrimal probes or an angiocatheter, with subsequent marsupialization into the oral cavity. Magnification with operating loupes or an operating microscope is valuable in identification and repair of the severed duct. Performing a suture repair of a duct laceration over a small stent is recommended. A temporary stent such as an angiocatheter is then placed into the remnant duct that communicates into the oral cavity. This will ensure duct patency during healing.[23]

If the distal segment of the duct is nonviable, duct rerouting of the proximal portion of the remaining duct is a viable option. The proximal segment is cannulated with marsupialization of the duct into the buccal mucosa. As in reanastomosis procedures, a temporary stent should be left in place to assure proper wound healing and facilitate salivary flow.[23] Ductal ligation historically has been described in the acute management of salivary duct injury, though it is utilized only when repair is impossible or impractical.

Any injury of the parotid gland parenchyma is treated with suturing and primary closure of the parotid fascia. Postoperative treatment should include antibiotic prophylaxis, external pressure via compression dressings, and antisialogogues. Any intraoral duct catheter that is placed at the time of repair should be secured to the adjacent buccal mucosa and remain in place for at least 7 to 10 days. The wound should be serially monitored for complications such as wound infection, sialocele, and fistula because early detection and intervention portend favorable outcomes. Historically, surgeons have performed Jacobson's neurectomy (cranial nerve IX) in an effort to diminish salivary flow and promote atrophy of the gland, although this is rarely performed today.

TRAUMA TO THE SUBMANDIBULAR GLAND AND DUCT

Isolated traumatic injury to the submandibular gland is rare, which is attributed to the gland's protected location behind the mandible. Most submandibular gland injuries are seen in association with penetrating wounds of the neck and floor of the mouth. Common symptoms of submandibular duct injury include painful swelling, dysphagia, and respiratory difficulties. In situations of blunt trauma, these symptoms are frequently delayed in onset. Management strategies that apply to the parotid gland may also be adapted to management of submandibular gland and duct injuries. Blunt trauma is typically managed effectively with conservative therapy involving aspiration if a sialocele occurs. Placement of a pressure dressing may also be helpful. In situations of penetrating trauma, integrity of the submandibular duct should be assessed. If injury to the duct is discovered, it should be repaired either by direct, end-to-end reanastomosis, or duct rerouting as previously described. Conversely, excision of the gland may be considered, particularly if the parenchyma of the gland is damaged.

COMPLICATIONS

Failure to identify and treat salivary gland and duct injuries during the acute phase of trauma management often results in posttraumatic complications, leading to significant morbidity, impaired wound healing, and patient discomfort. Complications resulting from salivary gland and duct injuries include posttraumatic salivary fistula, wound infection, and sialoceles. Fortunately, most cases respond to conservative therapy. Salivary pseudocyst (sialocele) formation is a late complication that may occur after unrecognized injury or as postoperative sequelae of attempted ductal repair. Sialoceles typically develop 7 to 14 days after injury of the affected salivary gland. Suspicion of parenchymal or duct injury with formation of a sialocele should be raised if the patient experiences episodic swelling or increasing pain and swelling while eating. In contrast to a salivary gland abscess, erythema and warmth are absent. Pseudocysts may be further delineated with soft tissue CT imaging.

Initial management of sialoceles typically involves a conservative approach, although more aggressive techniques may be employed if the initial treatment fails. Conservative management consists of serial fine needle aspiration, antisialagogues, and compression. Aspirated fluid is frequently sent for amylase levels to confirm the diagnosis. Anticholinergics such as scopolamine or glycopyrrolate are often added to reduce saliva production during the healing phase. Duct injuries are slower to respond to conservative management than parenchymal injuries. Torre-Leon et al described placement of a temporary angiocatheter into a recurrent sialocele with resolution.[3] Sialoendoscopy is an emerging technique employed in situations where patients continue to experience recurrent sialoceles despite conservative management. Sialoendoscopy has proven most useful in assessing duct injury following the acute period, where duct injury may have been missed, or to assess the results of treatment in the postoperative period following duct repair.[24]

Submandibular and parotid gland fistulas are typically managed with serial aspiration, antisialagogues, restricting oral intake, and compression.[25] Delayed salivary drainage emanating from a nonhealing wound is indicative of a salivary fistula.[26] Sialoendoscopy may also be used in identifying the site of duct injury. Botulinum toxin injection into the affected gland in the treatment of sialoceles and salivary fistulas is frequently utilized as an adjunct to conservative therapy.[27] Botulinum toxin type A is produced by *Clostridium botulinum*, a Gram-positive, anaerobic spore-forming bacillus. The toxin produces chemical denervation by acting on the presynaptic receptor of cholinergic autonomic nerves, blocking the release of acetylcholine into the synaptic cleft. Typically, between 100 and 150 IU of botulinum toxin type A is injected into the affected gland. To avoid injections into the masseter muscle, patients are instructed to clench their teeth. Under aseptic technique, a hollow electrode needle connected to an electromyography device is used to precisely guide the injection. Injections may also be guided by ultrasonography. Typically, serial injections are required every 3 months to reduce salivary production.[28] Breuer and colleagues reported successful management of parotid gland fistulas in two patients by injecting botulinum toxin into the gland.[29] Thus, a combination approach involving serial aspirations, compression, restriction of oral intake, intravenous hydration, antibiotic therapy, antisialagogues, and serial botulinum injections is recommended.

In situations of chronic complications refractory to conservative methods, ligation of the salivary duct or surgical removal of the affected gland is recommended, although rarely necessary.[30] Stenosis of the salivary duct due to complications related to acute repair or failure to manage the laceration at the time of injury may lead to chronic sialoceles. In this situation, sialography with dilation may be used in circumstances of mild stenosis; however, severe stenosis often requires ligation of the duct.[31] Reduction of salivary gland function and glandular atrophy is common following salivary gland injury.

SUMMARY

Although uncommon, trauma to the parotid and submandibular duct and gland can result in serious sequelae. Complications from salivary gland and duct injury frequently occur if the injuries are undetected at the time of initial evaluation. A thorough knowledge of the local anatomy and a high degree of suspicion for injury are key factors in diagnosing and treating these injuries in a timely fashion. Facial nerve injury frequently accompanies salivary gland and duct injury and should be routinely assessed on initial examination. Parotid and submandibular duct injuries are best repaired early (within 72 hours) of the time of injury. Direct end-to-end anastomosis of the severed duct yields the best outcome. Duct rerouting procedures are indicated if the distal segment is not repairable, although this method carries a higher incidence of duct stenosis and failure. Adjunctive measures may be helpful, including restriction of oral intake, antisialagogues, antibiotic prophylaxis, and compression. Salivary fistulas and sialoceles are common complications resulting from salivary parenchymal and duct injuries. Fortunately, these complications often respond to conservative therapy. Botulinum toxin A injection acts to chemically denervate saliva production and is a useful adjunct for treatment in the setting of salivary fistulas and sialocele. The primary goals of treatment are to restore patients to their premorbid condition and restore salivary function.

CASE PRESENTATIONS

Case Study 19-1

Presentation

A 25-year-old male soldier was evaluated at the theater hospital in Afghanistan. He had sustained facial and neck trauma secondary to an IED blast. His initial trauma survey revealed left facial and penetrating neck injuries. His neurological exam revealed no facial movement on the left side. The patient arrived at Bagram Air Base on the day of his injury.

Preoperative Workup/Radiology

CT was performed prior to arrival to the operating room, revealing a large soft tissue injury but no evidence of bony fractures.

Operative Plan/Timing of Surgery

Patients who sustain massive penetrating facial and neck trauma with loss of facial movement warrant both neck exploration and facial nerve exploration (Figure 19-2a). If patients are hemodynamically stable, imaging studies such as CT are recommended to aid in preoperative planning.

Operation

The patient was intubated and transferred to the operating room for neck exploration, panendoscopy, and facial nerve exploration and repair by interposition nerve graft. The neck was explored and found to have a hematoma, likely from injury to the external jugular vein, but otherwise negative for vascular, neurologic, pharyngeal, airway, or esophageal trauma. Direct laryngoscopy, esophagoscopy, and bronchoscopy revealed no further injury. Upon surgical exploration of the large left facial wound, traumatic left facial nerve transaction was noted just at the pes anserinus. The parotid duct was intact. The wound was cleaned and debrided of devitalized tissue. The transected ends of

Figure 19-2. (**a**) Large left facial laceration meeting indication for facial nerve exploration as well as parotid duct exploration.

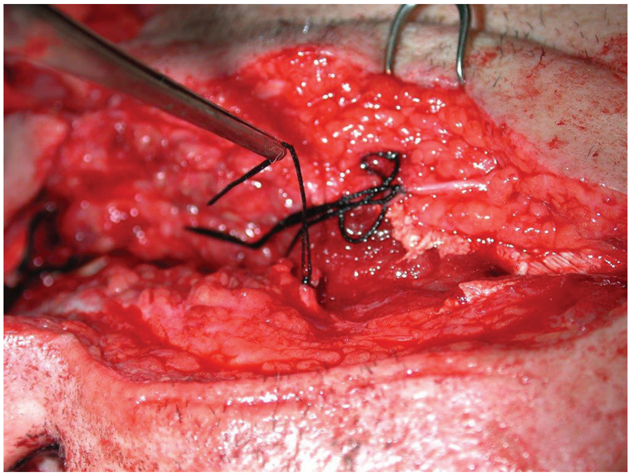

Figure 19-2. (**b**) Isolation of the transected ends of the facial nerve.

the facial nerve were freshened (Figure 19- 2b). During the neck exploration, the left greater auricular nerve was harvested and a 2- to 3-cm interposition graft was sewn in place using 9-0 nylon suture (Figure 19-2c). The facial lacerations were closed in layers with Prolene (Ethicon Inc, West Somerville, NJ) suture on the face. The neck exploration wound, which was extended from the postauricular portion of the facial laceration to below the angle of the mandible, was also closed in layers with staples on the skin. A postauricular Penrose drain was secured with silk suture to allow drainage from the facial and neck regions (Figure 19-2d). One year later, the patient was doing well, with House-Brackmann grade II to III facial motion on the left side.

Figure 19-2. (**c**) Left greater auricular nerve transposition graft in place.

Complications

None.

Lessons Learned

Because this patient was able to receive definitive evaluation and facial nerve repair in the deployed theater hospital, the potential for recovery of facial nerve function was preserved. This case report emphasizes the importance of wound exploration and anatomic identification of the integrity of the facial nerve. If the facial nerve is transected, immediate repair of the facial nerve should be performed by either direct end-to-end reanastomosis or nerve grafting techniques as described above. Of note, the patient did not develop a postoperative wound infection, sialocele, or hematoma.

Case Study 19-2

Presentation

An active duty male service member sustained a gunshot wound to the neck, with the bullet severing the upper division of the facial nerve. The patient received emergency care in the deployed trauma theater hospital, including neck exploration and stabilization. He was evacuated through the aeromedical transport services from the deployed location through Europe and arrived stateside in stable condition. Upon arrival stateside, he was transported to Walter Reed Army Medical Center. Upon evaluation by the otolaryngology trauma service at Walter Reed, clinical examination revealed weakness of the lower facial nerve division with some movement. The upper division was without any motion.

Figure 19-2. (**d**) Neck and facial wounds closed.

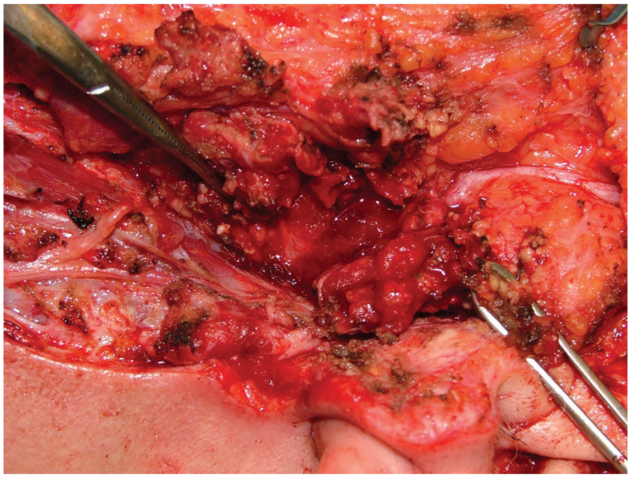

Figure 19-3. (**a**) Facial nerve defect.

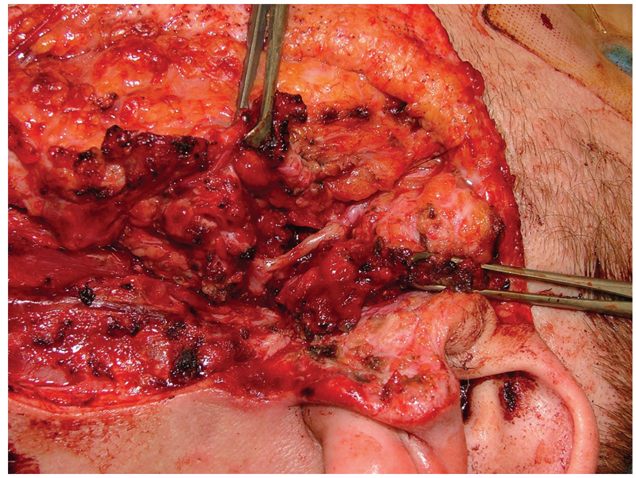

Figure 19-3. (**b**) Great auricular nerve interposition graft sutured in place.

Preoperative Workup/Radiology

As described, the patient underwent neck exploration and stabilization in theater and was then evacuated to Walter Reed Army Medical Center within 1 week of his injury.

Operative Plan/Timing of Surgery

Due to the need for stabilization of other potentially life-threatening injuries, facial nerve exploration with repair was delayed until the patient reached a definitive tertiary medical center.

Operation

A classic parotidectomy incision was made, with identification of the facial nerve proximally and identification of both the upper and lower divisions. Because there were no appropriate facial lacerations, facial exploration occurred via a preauricular and cervical approach, revealing an intact lower division and a 1.5-cm defect in the upper division (Figure 19-3a). The defect was repaired with a great auricular nerve interposition graft using an operating microscope and 8-0 nylon suture (Figure 19-3b). A NeuraGen tubule was placed around the interposition graft (Figure 19-3c). The wound was closed in typical layered closure with a drain in place.

Complications

None.

Lessons Learned

Follow-up is not available for this patient. However, if traumatic injuries to the facial nerve are identified and repaired as soon as possible, even later than 72 hours from the initial injury, results similar to those seen with immediate repairs may be expected. The timing of repair can be impacted by the ability to stabilize a patient secondary to other injuries, transport of the patient during stabilization, late recognition of the injury, or lack of clinical ability to perform facial nerve evaluation due to other injuries or sedation. It is important to recognize the injury and perform

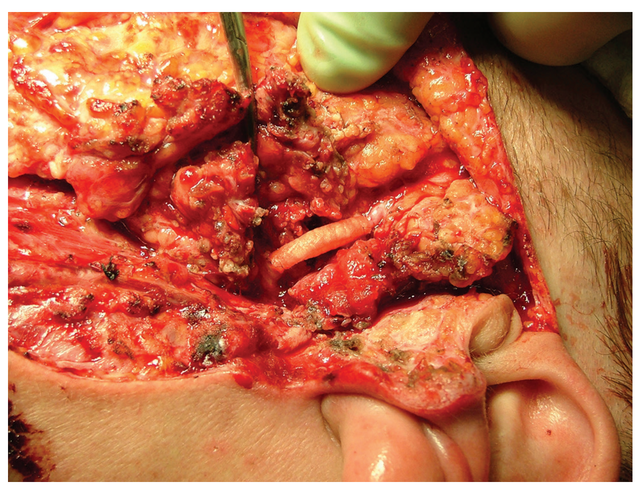

Figure 19-3. (**c**) NeuraGen Nerve Guide (Integra Life Sciences Corporation, Plainsboro, NJ) tubule placed around the interposition graft.

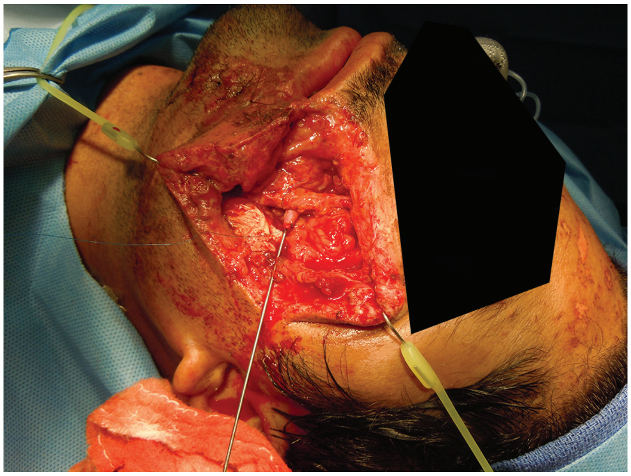

Figure 19-4. (**a**) Lacrimal probe placed in injured parotid duct.

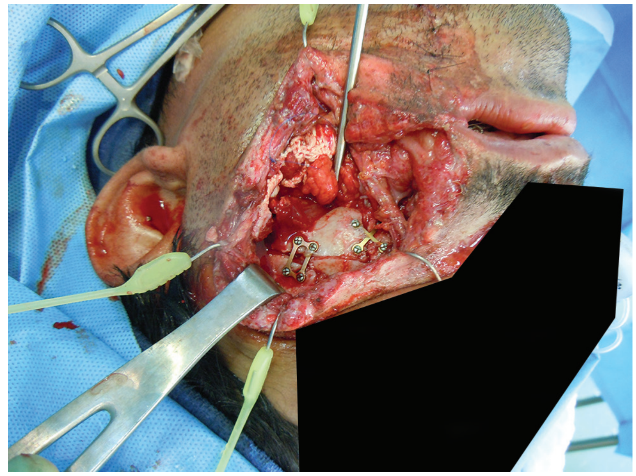

Figure 19-4. (**b**) Injury with open reduction and internal fixation of zygoma fractures, showing tissue loss.

an appropriate repair as soon as the patient is clinically stable to maximize potential successful return of facial function.

Case Study 19-3

Presentation

A 27-year-old male sustained facial injuries secondary to an IED blast and vehicle rollover. Multiple injuries were noted upon examination, including nasal, maxillary, zygoma, and mandible fractures. Left parotid gland wounds were identified upon examination. The patient arrived at the theater hospital in Afghanistan hemodynamically stable on the day of his injury. His neurologic exam was notable for absence of facial movement on the left.

Preoperative Workup/Radiology

CT of the face and neck revealed a large periparotid soft tissue defect with associated mandibular and zygomaticomaxillary complex fractures.

Operative Plan/Timing of Surgery

The patient was stable and was taken to the operating room on day 2 after his injury for open reduction and internal fixation of facial fractures, wound exploration, and parotid duct identification and repair.

Operation

The patient underwent maxilla-mandibular fixation and open reduction with internal fixation of his mandible and zygoma fractures. Multiple facial lacerations were repaired. The largest left facial laceration was noted to have large amounts of dead muscle, and active saliva draining from the proximal segment of the parotid duct upon wound compression and inspection for a salivary leak. There was a large defect of the parotid duct. Exploration of the facial wound revealed loss of facial muscles, parotid tissue, and facial nerve fibers. There was no facial motion elicited upon maximal stimulation. The parotid duct was cannulated with a lacrimal probe initially through the wound bed during the wound exploration (Figure 19-4a). The Stensen duct was cannulated through the intraoral opening located near the maxillary second molar with a fine wire exiting within the wound bed from the distal parotid duct segment. The proximal segment was found

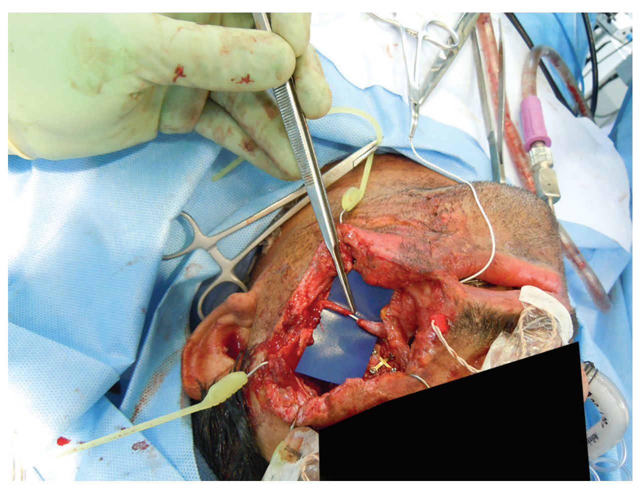

Figure 19-4. (**c**) Wire cannulating both distal and proximal duct segments.

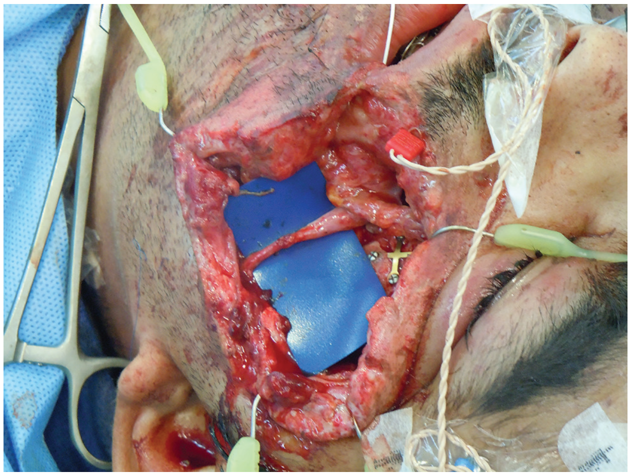

Figure 19-4. (**d**) Left parotid duct repaired.

and released from the surrounding structures so that no tethering was noted (Figure 19-4b). Both segments were then cannulated over the wire (Figure 19-4c) and sutured together with 7-0 Prolene circumferentially. The wound was debrided of dead tissue. Adjacent soft tissue and muscle were used to cover and protect the duct repair (Figure 19-4d). Multilayer closure of the wound with a Penrose drain was performed. A stent was left in place to prevent stenosis.

Complications

None.

Lessons Learned

Due to significant loss of facial musculature, soft tissue, and the facial nerve branches beyond the upper and lower divisions, the facial nerve was not reconstructed at the time of the parotid duct repair. Traditionally, branches of the facial nerve that are anterior to a vertically oriented imaginary line drawn from the lateral canthus of the eye inferiorly are not repaired. Given this patient's massive facial soft tissue injuries and tissue loss extending medial to the lateral canthus, acute repair of the facial nerve was not attempted. However, distal nerve segments identified during exploration and debridement of the wound may be tagged for future intervention. Attention was then directed to repair of the patient's salivary duct injury and soft tissue repair. Patient transfer to a stateside tertiary care facility will allow appropriate delayed reconstruction and rehabilitation.

REFERENCES

1. Lewis G, Knottenbelt JD. Parotid duct injury: is immediate surgical repair necessary? *Injury*. 1991;22:407–409.
2. Parekh D, Glezerson G, Stewart M, Esser J, Lawson HH. Post-traumatic parotid fistulae and sialoceles: a prospective study of conservative management in 51 cases. *Ann Surg*. 1989;209:105–111.
3. Torre-Leon C, Canario Q, Garrton M. A novel approach in the treatment of a posttraumatic sialocele. *Otolaryngol Head Neck Surg*. 2013;148:529–530.
4. Kanekar SG, Mannion K, Zacharia T, Showalter M. Parotid space: anatomic imaging. *Otolaryngol Clin North Am*. 2012;45:1253–1272.
5. Ramsaroop L1, Singh B, Allopi L, Moodley J, Partab P, Satyapal KS. The surgical anatomy of the parotid fascia. *Surg Radiol Anat*. 2006;28:33–37.
6. Saylam C, Ucerler H, Orhan M, Ozek C. Anatomic landmarks of the buccal branches of the facial nerve. *Surg Radiol Anat*. 2006;28:462–467.
7. Pather N, Osman M. Landmarks of the facial nerve: implications for parotidectomy. *Surg Radiol Anat*. 2006;28:170–175.
8. Stringer MD, Mirjalili SA, Meredith SJ, Muirhead JC. Redefining the surface anatomy of the parotid duct: an in vivo ultrasound study. *Plast Reconstr Surg*. 2012;130:1032–1037.
9. Steinberg MJ, Herrera AF. Management of parotid duct injuries. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2005;99:136–141.
10. Flint PW. *Cummings Otolaryngology—Head & Neck Surgery*. Philadelphia, PA: Mosby/Elsevier; 2010.

11. Harrison M, Page MP. Submandibular gland injury and delayed airway compromise caused by a seat belt. *Am J Otolaryngol*. 2010;31:209–211.

12. Myers E, Carrau RL, eds. *Operative Otolaryngology: Head and Neck Surgery*. Philadelphia, PA: Saunders/Elsevier; 2008.

13. Dingman RO, Grabb WC. Surgical anatomy of the mandibular ramus of the facial nerve based on the dissection of 100 facial halves. *Plast Reconstr Surg Transplant Bull.* 1962;29:266–272.

14. Potgieter W1, Meiring JH, Boon JM, Pretorius E, Pretorius JP, Becker PJ. Mandibular landmarks as an aid in minimizing injury to the marginal mandibular branch: a metric and geometric anatomical study. *Clin Anat*. 2005;18:171–178.

15. Guerrissi JO, Taborda G. Endoscopic excision of the submandibular gland by an intraoral approach. *J Craniofac Surg.* 2001;12:299–303.

16. Beahm DD, Peleaz L, Nuss DW, et al. Surgical approaches to the submandibular gland: a review of literature. *Int J Surg.* 2009;7:503–509.

17. Harrison JD. Modern management and pathophysiology of ranula: literature review. *Head Neck*. 2010;32:1310–1320.

18. Iida S, Kogo M, Tominaga G, Matsuya T. Plunging ranula as a complication of intraoral removal of a submandibular sialolith. *Br J Oral Maxillofac Surg*. 2001;39:214–216.

19. McGurk M, Eyeson J, Thomas B, Harrison JD. Conservative treatment of oral ranula by excision with minimal excision of the sublingual gland: histological support for a traumatic etiology. *J Oral Maxillofac Surg*. 2008;66:2050–2057.

20. Gordin EA, Daniero JJ, Krein H, Boon MS. Parotid gland trauma. *Facial Plast Surg*. 2010;26:504–510.

21. Sickel J. Current controversies in maxillofacial trauma of parotid gland and duct injuries. *Oral Maxillofac Surg Clin*. 2009;21:243–246.

22. Shetty DK, Rink B. Effects of direct blunt trauma on the salivary glands. *Deutsch Zahn Mund Kieferheik*. 1974;62:148–157.

23. Van Sickels JE. Management of parotid gland and duct injuries. *Oral Maxillofac Surg Clin North Am*. 2009;21(2):243–246.

24. Nahlieli O, Abramson A, Shacham R, Puterman MB, Baruchin AM. Endoscopic treatment of salivary gland injuries due to facial rejuvenation procedures. *Laryngoscope*. 2008;118(5):763–767.

25. Landau R, Stewart M. Conservative management of post-traumatic parotid fistulae and sialoceles: a prospective study. *Br J Surg*. 1985;72:42–44.

26. Capaccio P, Paglia M, Minorati D, Manzo R, Ottaviani F. Diagnosis and therapeutic management of iatrogenic parotid sialocele. *Ann Otol Rhinol Laryngol*. 2004;113(7):562–564.

27. Arnaud S, Batifol D, Goudot P, Yachouh J. Nonsurgical management of traumatic injuries of the parotid gland and duct using type A botulinum toxin. *Plast Reconstr Surg*. 2006;117(7):2426–2430.

28. Lim YC, Choi EC. Treatment of an acute salivary fistula after parotid surgery: botulinum toxin type A injection as primary treatment. *Eur Arch Otorhinolaryngol*. 2008;265:243–245.

29. Breuer T, Ferrazzini A, Grossenbacher R. Botulinum toxin A as a treatment of traumatic salivary gland fistulas. *HNO*. 2006;54:385–390.

30. Tachmes L, Woloszyn T, Marini C, et al. Parotid gland and facial nerve trauma: a retrospective review. *J Trauma*. 1990;30:1395–1398.

31. Epker BN, Burnette JC. Trauma to the parotid gland and duct: primary treatment and management of complications. *J Oral Surg*. 1970;28:657–670.