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The Surgical Treatment of Reinforced Steel Bar Injury Penetrating the Skull Base and Maxilla-Mandibular Area

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Abstract: Penetrating injuries with reinforced screwed steel bar in the skull base represent a unique challenge for oral maxillofacial surgeons. Management of these injuries is complicated by associated injuries and the proximity to vital neurovascular structures. A 35-year-old man was admitted to our hospital because of injury due to a downward fall upon a reinforced steel rod. Radiologic studies of the skull base revealed that the steel bar traversed the temporomandibular space between the left cervical spine and the mastoid process to the space between the inner side of the left mandibular ramus and the maxilla. We performed osteotomy of the left mastoid process tip and the left mandibular ramus to take out the steel bar from the maxilla and repaired the left mandible with internal fixation. Appropriate preoperative planning, including three-dimensional computed tomographic images, is integral in the surgical approach for the safe removal of such objects.

Key Words: Steel bar, skull base, penetrating injury, maxilla

Penetrating trauma to the paranasal sinuses and the skull base by retained foreign bodies represents a unique challenge for head and neck surgeons.[1,2] Management of these cases is complicated by risks for intraoperative iatrogenic injury associated with the proximity to vital neurovascular structures. The steel bar blocking complex bone structure sometimes brought out more difficulty in treatment. In this article, the surgical management of a foreign body projectile retained within the maxilla-mandibular area and the skull base was described to discuss and contribute our clinical experience to these occasions.

Patient History and Examination

A 35-year-old man was working on a 3-m–high scaffold for a tunnel construction when the scaffold broke and he fell down. His neck was penetrated by an upright reinforced steel bar from behind. In the emergency department, he was found to be cardiovascularly stable and conscious, maintaining his airway adequately with no hemorrhage or major secretions from the mouth. He was able to answer questions in a weak voice and had limited jaw opening. His neck movement and posture were also limited by the long reinforced steel bar (Fig. 1). At presentation, the patient's blood pressure was 110/60 mm Hg, his pulse rate was 92 beats per minute, and his body temperature was 36.8.

The patient was transported to the computed tomographic (CT) scanner after immobilization of the cervical spine. The 16-mm–thick whorled steel bar had penetrated from the back of the neck to the anterior wall of the left maxillary sinus, displacing the first cervical vertebra medially and the left mandibular ramus laterally, ending at the subcutaneous tissues of the infraorbital area. A portion of the left common carotid artery overshadowed by the steel bar was obliterated and could not be visualized on CT (see Fig. 2). Additional risk and uncertainty were added to the operation by multiple image artifacts created by the large metal foreign body. The portion of the steel bar within the skull base could not be detected clearly on CT or other x-ray images. Radiologic studies of the skull base revealed that the steel bar traversed the temporomandibular space between the left cervical spine and the mastoid process to the space between the inner side of the left mandibular ramus and the maxilla.

Operation

Antibiotics were administered to cover for wound microbial contaminants. The patient was then immediately taken to the operating theater. After consultation with specialists from the neurosurgery and orthopedic departments, an oral and maxillofacial surgeon was selected to lead the operation, with an orthopedic surgeon as

FIGURE 1. Steel bar inserted in the medial aspect of the left mastoid process.

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FIGURE 2. The three-dimensional reconstruction CT image of the patient showing the direction and the position of the steel bar in the skull base and the maxilla (the metal foreign body resulted in numerous image artifacts).

assistant. After conscious fiber-optic nasal intubation and disinfection of the operative site, the steel bar was bundled in sterilized gauze to enhance surgical asepsis, and the incision line was designed along the course of the steel bar.

First, an incision was made from the point of penetration extending forward along the steel bar to the posterior border of the left mandible. The sternocleidomastoid muscle was resected to gain maximal exposure of the steel bar. The steel bar was confined rigidly within the surrounding bones and did not move when we tried shifting it a little. Its posterior segment was held firmly by the mastoid process and the first cervical transverse process, and the anterior segment was locked by the mandible and the maxilla. The tip of the mastoid process was resected, and a small osteotome was used to loosen the posterior segment. However, the steel bar was stuck too firmly for direct removal despite repeated attempts.

Any friction between the rough, threaded surface of the reinforced steel bar and the soft tissues would potentially injure neighboring vital structures deep into the bar. Considering the fact that the big foreign body was lodged in a complicated narrow space occupied by many vitally important cranial nerves and cervical vessels, we decided that the safest way to remove the steel bar was by rotating it laterally, avoiding friction against the deep cervical sheath. Osteotomy of the left mandible would then be performed after placement of screw perforations for subsequent rigid internal fixation with Association for Osteosynthesis/Association for the Study of Internal Fixation titanium plates (2.0 mm mini-fracture plate, Synthes, West Chester, PA).

The separated left mandibular ramus could then be reflected upward, and the steel bar was loosened slightly. As planned, the deep soft tissue was protected from frictional injury by removing the bar with an outward rotation, instead of tracking it posteriorly. Bleeding from the pterygoid venous plexus was readily controlled with Surgicel (Ethicon, Inc, Somerville, NJ) and sutures. The embedded section of the steel bar was 18 cm long.

After wound irrigation, rinsing, and debridement with saline, the surgical site was observed for several minutes to ensure that no bleeding points were present. Occlusal repositioning was achieved through internal fixation of the mandible with Association for Osteosynthesis titanium plates (2.0 mm mini-fracture plate) screwed into the predrilled holes. A vacuum drainage system was applied before layered suturing of the soft tissue.

The Postoperative Course

The patient was observed in the intensive care unit for 24 hours and recovered without complications. He was discharged 7 days after the operation with only left facial palsy. Prophylactic antibiotics were administered postoperatively during the hospital stay, to guard against infection from the polluted steel bar. He was monitored for bleeding from potentially injured vessels.

When he was discharged, we suspected that his left facial nerve trunk may have been severed and planned a second operation after healing of the surgical wound. At the 1-month follow-up examination, we found few signs of facial nerve recovery but decided to schedule another follow-up examination at 3 months, by which time there was complete resolution of the left facial palsy.

DISCUSSION

A retained steel bar in the sinuses or the skull base is an uncommon phenomenon. Management principles are extrapolated from other conditions because prospective and controlled research is difficult to perform on such rare cases.[1] The clinical scenario will often dictate medical management because of the unique attributes of each case. The steel bar was inserted from the back of the neck through a path between the medial aspect of the mastoid process and the lateral aspect of the atlas transverse process, where many important vessels and nerves pass through, such as the vertebral artery, the internal carotid artery, the jugular vein, the facial nerve trunk, the vagus nerve, the glossopharyngeal nerve, and other vital structures.[3] The steel bar extended anteriorly through the medial aspect of the mandibular ramus, terminating at the anterior maxilla. The high potential risk for bleeding from the pterygoid plexus of veins and injury to other adjacent vessels made for a very dangerous surgical procedure to remove the steel bar.[4] The patient presented with edema in the left suborbital area, and although the preoperative examination did not reveal active bleeding points at the entry site and there was no detectable adjacent hematoma or expression of cerebrospinal fluid, we could not exclude the possibility that the steel bar may have been compressing an injured vessel and that there was slow seeping hemorrhage without overt bleeding, under reduced vascular pressure. Rupture of the internal carotid artery could also lead to cerebral ischemia or infarction, resulting in severe complications such as hemiplegia, disturbance of consciousness, or even death.[3] The surgical operation for this case had to be designed correctly to avoid iatrogenic and intraoperative vessel injury.

The posterior portion of the steel bar was embedded firmly between the mastoid process and the atlas vertebra, whereas the anterior portion was held rigidly between the maxilla and the mandible. To avoid injuring the cervical artery, the only method of freeing the posterior portion of the bar was to surgically excise a section of the mastoid process, even if there was risk for facial nerve injury.

The jugular vein is the main venous pathway to the brain.[5] Complications of unilateral ligation of the internal jugular vein include backflow disturbance of the cerebral veins,[6] increased intracranial pressure, venous sinus thrombosis,[7] and other vascular disturbances resulting from retrograde venous blood flow,[8] in addition to insufficient collateral circulation at the convergence of the sigmoid and transverse venous sinuses, which has a reported incidence of 10% to 43%.[9] The patient was stabilized and kept under preoperative observation for 5 hours to ensure that there was a well-developed contralateral (right side) sigmoid sinus circulation permitting left side ligation during the operation.

In conclusion, penetrating injuries with reinforced screwed steel bar in the maxilla and the skull base are uncommon but life-threatening injuries. Appropriate imaging studies include CT scan of the head with or without angiography. Although neurosurgical and otolaryngologic approaches are commonly used to extract these foreign bodies from the face and the skull base,[1] the oral maxillofacial approach sometimes might be the best if the cranial or the nasal cavity is not involved. The challenging clinical problems mainly focus on how to avoid potential complications such as cranial nerve injury, cerebral ischemia or infarction, infection, and hemorrhage. If there are postoperative symptoms of nerve injury, it is required for close follow-up to ensure no signs of nerve regeneration before the next nerve-repair operation.

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An Alternative Clinical Approach to Achieve Greater Anterior Than Posterior Maxillary Expansion in Cleft Lip and Palate Patients

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Abstract: Cleft lip and palate patients commonly present maxillary constriction, particularly in the anterior region. The aim of this case report was to describe an alternative clinical approach that used a smaller Hyrax screw unconventionally positioned to achieve greater anterior than posterior expansion in patients with complete unilateral cleft lip and palate. The idea presented here is to take advantage of a reduced dimension screw to position it anteriorly. When only anterior expansion was needed (patient 1), the appliance was soldered to the first premolar bands and associated to a transpalatal arch cemented to the first molars. However, when overall expansion was required (patient 2), the screw was positioned anteriorly, but soldered to the first molar bands. Intercanine, premolar, and first molar widths were measured on dental casts with a digital caliper. Pre-expansion and postexpansion radiographs and tomographies were also evaluated. A significant anterior expansion and no intermolar width increase were registered in the first patient. Although patient 2 also presented a greater anterior than posterior expansion, a noteworthy expansion occurred at the molar region. The alternative approach to expand the maxilla in cleft patients reported here caused greater anterior than posterior expansion when the Mini-Hyrax was associated to a transpalatal arch, and its reduced dimension also minimized discomfort and facilitated hygiene.

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Cleft lip and palate (CLP) is one of the most frequent craniofacial anomalies worldwide. It affects approximately 1 in every 700 live births[1] and compromises the quality of life of more than 7.5 million children.[2] These patients commonly present a significant maxillary transverse deficiency with a collapsed cleft segment.[3] They usually need a rapid maxillary expansion (RME) to correct the constricted maxillary arch. However, RME may be more challenging in CLP patients because of the missing midpalate, the greater anatomical deformity on the anterior region of the maxilla and the higher relapse tendency.[4,5]

Most CLP patients present a narrower anterior than posterior maxillary arch frequently showing a crossbite in both canine and premolar areas and a normal occlusal transverse molar relationship.[6] Therefore, an important treatment objective in these cases is to achieve greater anterior than posterior maxillary expansion.[7] However, the traditional Haas[8] and Hyrax[9] expanders exert parallel forces to the alveolar bones and the maxillary complex, which generates similar amounts of anterior and posterior alveolar expansion. Thus, RME on CLP patients using a Haas or a Hyrax expander must be frequently interrupted before the full correction of the anterior transverse deficiency in order to avoid the occurrence of a posterior buccal crossbite.[10]

Previous attempts to develop an expander that affected mostly the anterior region of the maxilla have been reported.[10–13] However, their efficacy remains uncertain, and most of these modified rapid maxillary expanders compromised oral hygiene because of their acrylic pads.[14,15] Therefore, the purpose of this article was to describe an alternative clinical approach to achieve greater anterior than posterior maxillary expansion and that might also facilitate oral hygiene during RME.

Patient 1

A 13-year-old boy presenting unilateral CLP sought orthodontic care at the Pontifical Catholic University of Minas Gerais (Belo Horizonte, Brazil) to improve masticatory function and dental aesthetics. Intraoral evaluation showed an anteriorly collapsed maxillary arch with severe constriction at the canine and first premolar area (Figs. 1A, B). The amount of expansion required at the maxillary anterior region was greater than that at the posterior. Ideally,