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Case Report

Complex reconstruction of facial deformity and function after severe gunshot injury: one case report

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Abstract: In this report, we described clinical outcomes of a multi-stage surgery integrating multiple techniques in restoration of facial morphology and function of a 17-year-old boy with severe gunshot injuries. This multi-stage surgery was applied in treatment of one rare case of gunshot-caused complicated facial deformities involving most parts of the face (labrum, left nose wing, nasal columella, nasal septum, maxillary alveolar process, hard palate, soft palate, bilateral maxillary bones, left zygoma, suborbital bone defects) and clinical efficacy upon restoring facial form and function were retrospectively evaluated. The patient was diagnosed with massive facial defects and deformities caused by gunshot, which led to feeding difficulty, severe articulation disorders and serious facial disfigurement. To reconstruct facial form and restore functions of mastication and articulation, multiple examinations and surgical procedures including mirror imaging, rapid prototyping technique, porous titanium implants, microscopic surgical technique, dental implants, osteomyocutaneous flap, muscular flap, shifting and repairing of adjacent tissue flaps and free bone graft reconstruction were undertaken. Postoperatively, reconstruction of severe facial disfigurement and restoring basic functions including articulation and feeding for the first time and relatively sound clinical outcomes have been obtained, which may add clinical evidence to the treatment of similar cases of severe facial deformities.

Keywords: Gunshot wound, tissue defects, repair, reconstruction

Introduction

Human face includes multiple important sense organs and it assembles the openings of respiratory and gastrointestinal tracts. Therefore, facial injuries are likely to cause facial defects, disfigurement, severe mastication and articulation disorders, psychological trauma and even life-threatening danger [1-4]. Consequently, it is an extremely challenging task to treat maxillofacial gunshot injuries. It not only involves with saving patients' life, but also correlates with both functional and morphologic effects. A boy aged 17 years, who was severely injured with gunshot-caused maxillofacial fractures, was admitted to our hospital in 2011. Upon admission, he presented with serious functional defects and facial disfigurement of his midface. After an intensive consultation by a multidisciplinary team of plastic, transplant and ear, nose and throat surgeons, a novel multi-stage surgery integrating a variety of techniques was applied. Following surgical treatment, he not only restored mastication and articulation functions, but also basically reconstructed facial form.

Methods

General data

The male patient was aged 17 years old. His face was severely injured by a gunshot attack with a near distance of 3-5 cm on September 17, 2011. He fell onto the ground immediately after the gunshot. His midface was severely damaged, which resulted in excessive eversion, destructive defects and massive hemorrhage. He presented with mild respiration difficulty. No signs of coma, unconsciousness or fecal and urinary incontinence were observed. Two hours later, he referred to Lufeng People's Hospital

Figure 1. Patient after debridement.

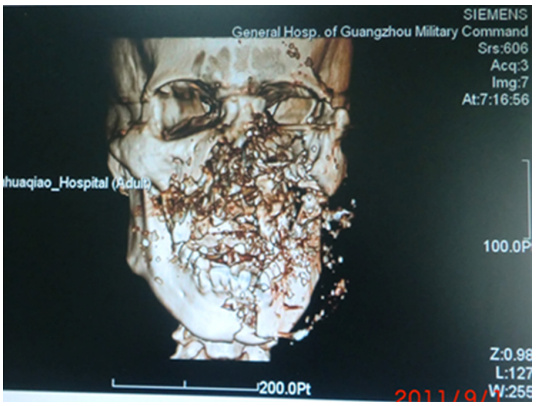

Figure 2. 3D CT scan depicting the extent of midfacial bone defect, including the entire maxilla, nasal bone and zygomatic bones.

and treated with intravenous infusion, blood transfusion, stanch treatment and urgent tracheotomy. On September 18, he was transferred to our hospital for subsequent examinations and treatment. He presented with mental confusion and was uncooperative during the examination. His blood pressure decreased to 90/60 mmHg. His midface was severely injured accompanied with destructive tissue defects and massive hemorrhage from the wound (**Figure 1**). CT scans of this patient revealed the signs of comminuted fracture of bilateral maxillary bones, left zygomatic and zygomatic arch fracture, left suborbital defects, maxillary A5-B5 teeth loss, alveolar bone loss, comminuted fracture accompanied with bone defects of the mandibular bone (**Figure 2**). Hundreds of metal foreign bodies still remained in his face.

Clinical diagnosis

1. Severe facial gunshot wound

1.1 Comminuted fracture accompanied with bone defects of bilateral maxillary bones.

1.2 Left zygomatic and zygomatic arch fracture accompanied with partial bone defects.

1.3 Comminuted fracture accompanied with bone defects of A5-B5 alveolar bones.

1.4 A5-B5 teeth loss.

1.5 Labrum, left nose wing, nasal columella and nasal septum defects.

1.6 Comminuted fracture of hard palate accompanied with basis nasi, palatal mucosa and hard palate defects.

1.7 A substantial amount of metal foreign bodies were detected in the midface.

1.8 Comminuted fracture of the mandibular bone.

2. Gunshot wound in the left eye

2.1 Gunshot wound in the left eyeball.

2.2 Comminuted fracture of the left suborbital bone.

2.3 Blindness in the left eye.

3. Post-tracheotomy

4. Craniocerebral injury to be subsequently diagnosed

5. Hypovolemic shock

6. Psychogenic psychonosema

7. Tongue avulsion

Surgical procedures

Upon the admission day, the patient was subject to facial wound debridement (**Figure 3**), restoration of mandibular fracture, fixation combined with mandibular ligation and extraction of metal foreign bodies. Intraoperatively, his blood pressure repeatedly declined to 65/50 and 40/35 mmHg due to excessive hemorrhage, elevated by intravenous infusion and blood transfusion. Postoperatively, he received intensive anti-infection and support therapies. He was discharged when stage I wound was observed.

Figure 3. Patient after suturing surgery.

After multi-round of consultations, a three-stage surgery integrating varying techniques was established to specifically repair and reconstruct severe tissue defects caused by gunshot. At 6 months after injury, he presented with excessive defects involving soft and hard tissues in the midface, contracted scars, apparent down-shifting of the left eyeball due to suborbital defects, complete collapse of middle and head parts of the nose. His mouth and nasal cavities were directly connected resulting from complex defects involving labrum, alveolar process, bilateral maxillary bone, left zygoma, hard palate and basis nasi (**Figures 4**, **5**). He had difficulty in mastication and feeding, could not speak clearly. His facial appearance was totally destroyed. Considering the severity of tissue defects and facial deformity, reconstruction procedures would be extremely complicated and challenging.

The whole surgery was divided into three stages. Stage I: microscopic vascular anastomosis was adopted to transfer free osteomyocutaneous flaps and reconstruct bilateral alveolar process, maxillary bones and labrum defects, which basically separated the mouth and nasal cavities. Intraoperatively, titanium graft was utilized to reconstruct suborbital bone and restore normal position of the left eye. Stage II: it aimed to reconstruct the exterior surface of nasal columella using living flaps after stage I surgery. Costal cartilage was utilized to support the nasal columella cartilage and costal cartilage transplantation was performed to restore the height of nose. Meantime, tongue flaps were created to repair labral defects. Stage III: zygomatic graft and dental implants were employed to implant grafts into the living osteomyocutaneous flaps. Maxillary dentition was repaired considering the remnant bilateral molars to restore mastication function and the appearance of oral cavity. Besides, we decided to simultaneously perform left nose wing, endoscopic choanal plasty, and labral repairing.

Rapid prototyping technique: prior to operation, the patient underwent 3D spiral CT scan (**Figure 2**). 3D reconstruction, 3D image partition, extraction of target tissues and STL file storage were conducted by using Magics software package. Instant module shaper was employed to print the midface model after gunshot, which precisely reflected the extent and size of facial bone defects. The wax model of muscle-bone flaps were created in the simulated defect area on this created model (**Figure 6**). Based on the created model and wax shape, osteomyocutaneous flaps were designed. The required fibula length and arc and the length, width and thickness of soft tissues of osteomyocutaneous free flaps were calculated. CT arteriography (CTA) was performed to evaluate the vascular structure of facial artery and vein, and jugular vein. Doppler ultrasound was conducted to detect the right fibular artery and vein and radial artery and vein and observe whether muscular flap and muscle-bone flap defects and variation occurred.

Based upon the original model, CAD/CAM combined with computer mirror imaging was utilized to print the symmetrical final model on the right side. AO titanium implants were applied in the final model with a thickness of 0.5 mm. Individualized titanium mesh, made from reticular materials with a diameter of 2.5 mm, was employed to reconstruct left suborbital bones to restore its normal morphology, as shown in the figure below.

On March 27, 2012, the patient underwent tracheotomy under general anesthesia, recon-

Figure 4. Frontal appearance of the patient at 6 months after injury.

Figure 5. Lateral appearance of the patient at 6 months after injury.

struction of left suborbital bone, implantation of prepared titanium mesh, transferring of free muscular flaps of iliac bone and reconstruction of bilateral maxillary bones and labral defects. However, he presented with vascular crisis on the 2nd day after surgery and had signs of muscular flap necrosis of iliac bone postoperatively. Both reconstruction of left suborbital bone and titanium mesh implantation were successfully performed. The down-shifting and collapse of left eyeball were significantly improved after surgery. Muscular flap necrosis of iliac bone was subject to repeated debridement at postoperative 2 weeks. On May 9, 2012, the boy

Figure 6. 3D CT scan and computer-designed model.

Figure 7. Patient after reconstruction with forearm flaps.

underwent flap transplantation from his left forearm. Intraoperatively, a conventional 20-hole AO compression plate was utilized to fix the posterior margin of bilateral remnant maxillary bones. Forearm flaps were made into column shape and sutured with bilateral remnant maxillary bones. Surgical incisions were well healed and all flaps survived successfully, as illustrated in **Figure 7**.

At 3-week after survival of forearm flaps, arterial occlusion of skin flaps was performed by pressing the occlusion artery twice daily, 5 min for each time and gradually extended to 1 h. No ischemic signs, such as swelling, empurple and paleness, were observed in the forearm flaps after arterial occlusion. Vascularized fibular osteocutaneous free flaps were created based on the original designed model. On July 13, 2012, the patient received transferring of fibular osteocutaneous free flaps under general anesthesia and reconstruction of soft and hard tissue defects in midface. During the surgery, column-shaped forearm flaps were cut open and used as inner layer of nasal mucosa. Fibular osteocutaneous free flaps were trans-

Figure 8. Patient after nasal columella plasty and rhinoplasty.

planted to the midface and made into an arc shape. Two ends of the fibula were connected to maxillary bone defects, fixed by titanium plate and the blood vessels of fibular osteocutaneous free flaps and the right arteries and veins were subject to anastomosis. All free flaps survived completely post-surgery.

After the survival of fibular osteocutaneous free flaps, the 2nd stage surgery was initiated in March 2013. On March 22, he underwent right nose wing plasty and left nasal angle repairing. On May 6, 2013, the patient received nasal columella plasty and rhinoplasty. Intraoperatively, survived fibular osteocutaneous free flaps were collected from soft tissues of nasal base to construct the exterior of nasal columella. The 7th right costal cartilage was carved into a shape of "7" to form nasal columella graft and implanted into the nose. Aesthetic appearance of the nose was significantly improved after the surgery, as illustrated in **Figure 8**.

In June 2013, he received reconstruction of labral shape and color using tongue flap transplantation and left nostril plasty. Intraoperatively, labral scars and superfluous soft tissues were excised to construct a defect bed for red lips. Pedicle tongue flaps were created from the anterior tongue and transplanted and sutured with the defect site. Soft tissues of the left nostril were removed and transferred to the left nasal base. The silica gel catheter was inserted into the left nasal cavity for smooth breathing. The tongue flaps transplanted in the stage I surgery survived. Three weeks later, the tongue pedicle was cut off and red lip repairing was completed, as seen in **Figure 9**.

Figure 9. Patient after reconstruction of labral shape and color.

The whole surgery endured for over two years. The patient with rarely severe gunshot maxillofacial injuries basically reconstructed the soft and hard tissue defects and his facial appearance was improved (**Figure 9**).

Next, we'll perform left nose wing plasty, left labral repairing, zygomatic bone grafts and tooth implant restoration to recover occlusal function.

Discussion

Gunshot wounds remain a public health concern, with an average of 115,000 firearm-related injuries resulting in 35,200 deaths and 79,400 nonfatal injuries reported annually [5]. Gunshot wound to the face (GSWF), although uncommon [6], pose a significant challenge to trauma and reconstruction surgeons because of the catastrophic functional and aesthetic consequences sustained by the patient [7, 8]. The incidence of facial gunshot injuries climbed up to 8-12%, most of which were attacked by extremely destructive weapons with high ener-

gy and explosive force [9-11]. Facial gunshot wounds result in devastating functional and aesthetic consequences for patients, eventually leading to mental and psychological disorders. The task of treating maxillofacial gunshot wounds is extremely challenging and complex, which not only involves functional recovery including mastication, feeding and articulation, but also should take the aesthetic effects into account and restore the original appearance as possible [12]. Consequently, the emergent treatment, repairing and reconstruction of facial gunshot wounds remain an urgent task for the professionals from the department of maxillofacial surgery.

At present, American Impairment Scale (AIS) grade and Injury Severity Score (ISS) are dominantly employed to assess the severity of injury [13]. However, these evaluation methods fail to apply for the assessment of the severity of multiple complex injuries. Current classification criterion of maxillofacial trauma is too simple to provide a complete assessment of the injury. In addition, the parameters included are not adequate and complete, which underestimate the grading scores and fail to precisely reflect clinical characteristics of cases with multiple and complex maxillofacial trauma. Cheng Yang et al. [14] combined Delphi method and analytic hierarchy process to subdivide the dissection of maxillofacial tissues and establish an objective and quantitative method for assessing the severity of maxillofacial injury. It is easy to follow, accelerates the consensus of reconstruction guidelines and is of great significance for the emergent repairing and reconstruction of maxillofacial wounds in battlefields.

It is an extremely challenging task to repair and reconstruct maxillofacial gunshot wounds, tumor-induced maxillary bone and soft tissue defects in clinical settings. The opinions regarding how to repair severe gunshot wounds and when to perform the surgical reconstruction still greatly vary. Differing from traffic accident and falling injuries, gunshot wounds are characterized as involvement with multiple organs, composite and extremely serious injuries. Early studies proposed the principle of early debridement, delay of suture and then performing repairing and reconstruction. In recent years, scholars put forward a novel method: delayed stage I surgery. After the debridement, antiseptic dressings are filled into the wounds and observed for 1 week. When systemic conditions of the patients stabilize, the reconstruction surgery will be performed. Zhou et al. [15] successfully conducted stage I repairing of mandibular bone defects caused by gunshot using fibular osteomyocutaneous free flaps.

Up to now, prosthesis and free tissue flaps are still the common methods adopted to repair extensive soft and hard tissue defects. Along with the rapid progress of microscopic surgery, digitalization, rapid model establishment and zygomatic and dental implants, the treatment options for repairing the function of maxillary bones become diversified. Sun et al successfully conducted three-segment free fibular flaps combined with endosteal implants and stage I implantation of zygomatic grafts and obtained sound clinical efficacy. In this case, the boy presented with extremely severe facial wounds involving bilateral maxillary bone, zygoma, labrum, nasal columella, nasal septum, palatal mucosa and plate, dentition, alveolar process and extensive tissue defects, which is rarely encountered in clinical practice. After extensive multidisciplinary consultations, multiple novel and conventional techniques including computer-aided design and rapid model establishment to design and create vascularized osteomyocutaneous flaps, skin flaps and free bone implantation, tongue flaps, etc. The complex surgery has been divided into multiple stages and successfully performed based on the clinical efficacy of each stage. Good functional recovery has been achieved and the facial appearance greatly improved. Due to limited experience, the necrosis of free bone flaps occurred during the first attempt, which postponed the time of repairing. Moreover, how to utilize computer-aided technique to accurately repair bilateral maxillary, nasal and labral defects and obtain better functional repair effect remain to be investigated.

Disclosure of conflict of interest

None.

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