SEMON LECTURE - 2005
MODERN MANAGEMENT OF PENETRATING FACIAL TRAUMA

I wish to thank the members of the selection committee for the incredible honour of being granted the Semon Lectureship for 20–.
It is the most important award that I have received in my entire career as an otolaryngologist/ head and neck surgeon.

The field of the treatment of maxillofacial injuries has undergone an amazing evolution over the centuries. Healing of fractures as well as some alleviation of pain was accomplished by the use of immobilization was discovered as early as the first century BC [1.] In the ensuing early centuries the emphasis was on immobilization and very little on fixation. In the 20th and 21st centuries the principal of establishing correct dental occlusion was stressed and the landmark introduction of the arch bar was introduced by Erich [2].

In the early 1940's internal fixation of the fractured facial skeleton began with the use of stainless steel wires by Milton Adams[3]. This technique was the mainstay of internal fiaxtion until the introduction of metal plating systems with screw fixation. In the late 1960's and early 1970's 2 European surgeons, Luhr and Spiessl, working independantly developed the first rudiments of plating system technology[4,5]. The first plates were constructed from stainless steel and vitallium. They were strong but difficult to bend and had the propensity for extrusion. Once these plates were exposed either intraorally or externally the tissues would not heal over them. More recently plates were fashioned using titanium. This metal is much lighter , stronger and more resistant to extrusion. Even if they became exposed there was a tendency for the epithelium to cover them.

This preamble is necessary as a prelude to a discussion of the modern approach to penetrating trauma. Currently the commonest penetrating injuries are those caused be firearms and knives. However, as war and especially terrorism become more prevalent in our society the other types of injury, more commonly seen in the last 2 decades, are from shrapnel.

BALLISTICS:

In order to understand something of the ballistics of wounding some knowledge of the nature and dynamics of weaponry is necessary.

The most commonly encountered penetrating injuries in civilian practice are from firearms usually pistols.

The unit of ammunition is called a cartridge. It is comprised of a cylinder, which is commonly called a “shell”, of various diameters and lengths. This holds the gunpowder. At the end that faces the rear of the weapon is a “cap” which holds a small amount of high explosive that when hit by the hammer of the weapon will cause the gun powder to ignite. At the front end of the cartridge is the bullet, the projectile that traverses the gun barrel and flies toward the target. The force that propels the bullet forward is generated by the rapidly expanding gas produced by the ignited powder.

Weapons are usually named by the “caliber” of the weapon. This assignation is based on the diameter of the bore of the barrel measured in mm or inches. A .22 caliber rifle will have a barrel that is.22 inches in diameter, a 357 magnum will have bore diameter of .375 inches. The name of the inventor of the weapon or the manufacturer or the date of its introduction may also be used in naming the firearm. So Winchester .22 was introduced by Winchester. The Mosberg 30-06 was manufactored by the Mosberg company, has a bore diameter of .30 inches and was introduced in 1906. On the other hand, shot guns are measured in Gauge with the small the number, the larger the diameter of the barrel and the larger the unit of ammunition, Since most shotguns were designed for shooting birds, instead of a bullet, they use buckshot whose diameter depends on the number used to describe it having the same inverse relationship to size that the gauge has for the shotgun. Common sizes of shot for duck hunting will be in the 5 to 7 range and for larger birds like geese or brant in the range of 1 or 2.

WOUND BALLISTICS:

The degree of injury secondary to a gunshot will be proportional to the energy expended in the target according to the formula $KE = \frac{MxV}{2}$ where KE is the kinetic energy imparted to the target tissues, M equals the mass of the bullet and V is the muzzle velocity of the weapon. It is readily apparent from this formula that the muzzle velocity is the most important part of the equation. However if a bullet passes through the target tissue then the energy expended to the target is ½ { $M(V1^2xV^2)$} Where V1 is the entrance velocity and V2 is the exit velocity.

Muzzle velocity is the speed in feet per second of the bullet as it exits the end of the gun barrel.

The vital factors in wounding are:

- Muzzle Velocity
- Distance from the shooter ro the target
- Flight parameters of the bullet
  - weight
  - shape
  - constitution
  - flight path
- Nature of the target tissue

Firearms are divided into two categories: low velocity and high velocity. Whereas low velocity firearms have muzzle velocities less than 1000 ft./sec., high velocity weapons have velocities greater than 2000 ft./sec. With the wounding energy being proportional to the square of the muzzle velocity it is obvious that high velocity weapons produce much more extensive injury than low velocity ones.

Curiously, the weight of a bullet is measured in grains rather than ounces or grams. One grain is equivalent to .002 ounces or .065 grams. Similarly the weight of gun powder used to load the cartridge is also measured in grains. In addition, gun powder comes in a variety of types with such colourful names such as “blue dot”, “red dot”, “win 630", “norma 123" etc. Each powder has individual characteristics such as burning time which in turn effects muzzle velocity.

Most of the gunshot wounds seen in civilian practice are of the low velocity type, usually from a pistol. Common pistols seen in street violence are exemplified by the Smith and Wesson .32 special that has a 125 to 128 grain bullet and a muzzle velocity of 800 ft/sec or the 25 caliber “Saturday night special” that has a 50 grain bullet and a muzzle velocity of 850. ft./sec. As will be explained further, the type of injury caused by low velocity weapons such as these differs markedly in severity compared to those from the high velocity weapons used in armed conflict. The damage created by an AK 47, which is the commonest weapon used by insurgents and terrorist organizations throughout the world is obviously more extensive then that resulting from, for example, a .32 Smith and Wesson handgun. The AK 47 has a muzzle velocity of 2,400 ft/sec and has a bullet weight of 150. The M16 rifle used by the U.S. military has a muzzle velocity of 3200 ft/sec but has a bullet weight of merely 50 grains.

Bullets have differing shape characteristics. The unit of shape is referred to as its”ogive”. The pointedness of the bullet at its front end is designated by an “ogive number”. The more pointed it is the higher the ogive number.

Bullets have a characteristic composition. Most bullets for low velocity weapons are comprised of lead. However any cartridge that has a muzzle velocity above about 1500 ft/sec cannot have any of a lead bullet touch the inner surface of the barrel. The lead core then requires a coating. In the case of military weapons, the bullets have a metal jacket of steel or copper. This is referred to as a full metal jacket. Sporting rifles used to kill game such as deer or elk, have a soft nose bullet with a copper jacket that comes into contact with the inner surface of the barrel but a pointed lead tip. Generally on contact the bullet tip will then cause fragmentation of the bullet and more successfully kill the animal.

The flight path of the bullet may also have an influence on the type of wounding. Most firearms, with the exception of the shotgun, have spiral groves cut into the inner surface of the gun barrel to provide spin to the bullet as it exits the gun barrel. The spin allows the bullet to have a straight flight path. As the distance from the gun barrel to the target increases the bullet tends to tumble. The degree to which that happens is referred to as “yaw”.

THE BULLET WOUND:

There are 2 important effects resulting from the bullet as it traverses the tissues: cavitation and stress waves. Cavitation occurs as the missile passes through the target tissue and damages tissue to a varying degree along its track. With low velocity weapons a small amount of damage is created outside the track. Conversely the high velocity bullet creates a large amount of tissue injury much wider than the track the bullet takes. This temporary cavity reduces in size shortly after missile passes through, but the remaining tissue damage in the case of the high velocity missile will be much wider than the permanent track that the bullet has created. So the axiom is: in cases of a low velocity weapon the permanent damage to the tissues is not too much wider than the permanent track it creates while the damage caused by high velocity weapons is far larger than the permanent tract.

As the bullet passes through the tissue the amount of damage it creates is also dependant upon the specific gravity of the tissues. In low specific gravity tissues such as lung, the damage created from either a low or high velocity missile is much less than high specific gravity tissues such as liver. Another factor in the severity of injury is the so-called secondary missile phenomenon. As the missile passes through a target such as the face it often strikes tissues of high specific gravity such as bone or teeth. The bone fractures and the teeth are dislodged. The shattered bone fragments and teeth develop their own paths with accompanying temporary tracks and temporary and permanent cavities. This effect is compounded further if a soft nosed bullet has been used which in turn will create its own secondary missiles as it fragments.

The injury created in the temporary cavity are due to stress waves. These depend on the kinetic energy expended in the path of the bullet; all of of the energy if the bullet does not leave the body, less so if the bullet exits the body. In the later case the energy expended in the target tissue is called the "residual velocity". The vascular epithelium is particularly sensitive to stress waves, such that if a high velocity missile penetrates the neck, for instance, even if the bullet path is at a distance from the carotid artery the endothelium may be disrupted and later may form a dissecting aneurysm or simply occlude. Angiography is always indicated in such patients.

Contrary to the notion that "hot lead" will sterilize the wound, all bullet wounds are infected. This is due to the so-called "splash-back" effect. As the bullet passes through the skin, it carries with it portions of whatever the victim is wearing, but also literally sucks contaminants on the patients skin into the wound by the negative pressure created by the penetration of the missile through the tissues. In that regard, it is essential to drain bullet wounds to the face and neck except occasionally in the instances of small wounds from a low calibre weapon. In all cases of wounds to the trunk, abdomen or extremities with extensive damage, part of the wound should always be left open and closed by delayed primary closure. The problem of primary closure of wounds created in the field of battle is secondary infection. This finding was prevalent in the Crimean war, World war l and World war ll. In the initial stages of those conflicts the wounds were often closed. The incidence of infection and gangrene was enormous. By leaving such wounds open and closing them by delayed primary closure the incidence of wound infection and gangrene dropped precipitously. By the time of the Viet Nam conflict, the lesson was learned. The American forces' medical officers could be court marshaled for primarily closing a field wound.

Entry and exit wounds vary greatly dependant on the caliber of the weapon, the muzzle velocity and the degree of secondary missile activity within the target. The commonly seen entry and exit wounds from low caliber "Saturday night special" will be close to the same diameter. High caliber weapons have a somewhat small entry wound but commonly have a large exit wound. Combat wounds resulting from rifle shots, grenade launchers, machine guns as well as shrapnel from mortar rounds and IED's produce both devastating entry and particularly massive exit wounds. The permanent tracks and temporary cavities are often enormous.

Shotgun injuries are somewhat idiosyncratic. Shotgun shells are loaded with buckshot of varying sizes starting with a "slug", which is a solid piece of lead to small round balls of lead, brass, or stainless steel whose diameter is assignated by numbers from 000 to 12. The larger the shot number the larger the diameter of the shot .Shotguns come in various sizes or "gauges". They are named according to a formula based on the number of shells that can be filled with round projectiles of equal size that can be derived from 1 pound of lead. This designates the gauge of the gun. For example; in a 12 gauge shotgun the number of shells that can hold 1 pound of lead made into 0.727 inch lead balls when equally divided is 12. The only exception to this rule is the .410 shotgun which is named because the diameter of the gun barrel is .410 of an inch[6]. The muzzle velocity is slightly less than 1000 feet per second.

If a patient is struck by a shotgun blast within 6 meters it produces a high velocity type injury. The injury diminishes with distance between the weapon and the target as well as the size of the shot and the gauge of the weapon. Some of this is dependant on the "choke" of the gun barrel. Spread of the pellet spray is tighter with a "full choke" than a "modified choke".The diameter of the pellet spray from a shotgun is 2.5 cm in diameter at 6 meters and spreads 2.5 cm for every meter traveled. Beyond 6 meters there is no longer a blast effect and any damage is done by the shot pellets. The distance between the gun and the target is highly variable, dependant on the gauge of the gun, the size of the shot and the amount of powder in the shell casing. A larger load called a "magnum"will send the shot further . A 12 gauge shotgun using #9 shot will travel 175 yards whereas the same gun with heavier #00 shot will travel 748 yards. The effective wounding and "stopping range" (in terms of shooting an animal or intruder) is much shorter.

Many shotgun injuries seen in American emergency rooms are self inflicted, either by accident or attempts at suicide . These attempted suicide attempts are often thwarted in that the victim places the muzzle of the gun in the mouth and reaches down to pull the trigger. Since the barrel length of the gun is often around 36 inches long, since this is longer than the average human arm length, most persons will need to turn the head to one side or extend the head on the neck in order to reach the trigger. This usually results in an injury that either blows out the facial tissues laterally often missing the brain , as intended. If the head is extended then the anterior facial tissues are blown apart but with often only a few pellets entering the frontal lobes of the brain.

EARLY MANAGEMENT:

On admission to the emergency room The usual ABC'S of emergency dicta of management; Airway, Breathing and Circulation, are employed. If the airway is at all compromised intubation or emergency cricothyroidotmy must be considered. Most bleeding from the face and neck can be controlled by pressure. However, bleeding from deep in the face and under the skull base may require the placing of packing. Vessels that can be seen bleeding should be immediately clamped with a hemostat and left in place until the patient can be brought to the operating room for definitive therapy. A quick neurological check should ensue, first for level of consciousness and pupillary asymmetry. If indicated by the nature of the injury an emergency CAT scan should be done to rule out a cervical spine fracture. Tetanus prophylaxis is administered immediately.

Once the urgent elements of injury have been addressed then a direct assessment of the wound can be made. If there is any knowledge of the type and caliber of the weapon, this information can be
valuable in anticipating the extent of tissue damage.
The path of the bullet should be plotted. If there is risk of vascular injury, radiological examination should be done either by classical angiography or by CAT Scan or MRI examination. CAT scanning of the head and neck are necessary to help assess the soft tissue and bony damage done by the missile. A further thorough neurological examination must also be done especially if there is suspicion of a cervical spine injury. If the airway needs to be secured,

nasal or oral intubation must be done under fibreoptic guidance avoiding any extension of the neck. No attempt at tracheostomy should be done until the cervical-spine films have been cleared and preformed preferably in the operating room.

WOUND MANAGEMENT - Soft tissues

Th next step in early management is to assess vision and see what can be done with disrupted facial tissues to cover the eye. This may even necessitate the use of a tarsorraphy to cover the cornea until definitive surgical reconstruction of the lids can be done. Careful examination of the facial wound must be done to rule out a CSF leak. Due to the contamination of the wound the barrier between the intracranial space and the deep recesses of the subcranial compartment must be assured. All exposed brain and dura must be covered.

The condition of the patient must be continuously assessed and if any hemodynamic instability or other problem ensues then the next phases of reconstruction can be postponed for the next day or until the patient is stabilized. In most gunshot wounds to the face, unless there are other wounds present in the thorax or abdomen usually the next procedures can be done. Facial nerve reconstruction should be done immediately or, if delayed, no later than 2 to3 days after injury before the distal branches of the nerve loose their stimulability. Even if some instability of the patient occurs the severed branches of the nerves can be rapidly tagged with silk sutures to ease further identification.

If the parotid duct has been severed it should be stented and approximated with 2 or 3 #8-0 sutures. The procedure is quite simple. A small diameter silicone tube like the Gabor tube that is usually used to stent the lacrimal duct serves very well. The metal director on the tube is removed and the tube fitted with a Keith needle. The needle is inserted into Stensen"s duct, threaded along the duct until it protrudes from the cut end of the duct within the wound. The needle is the placed into the proximal end of the duct until the hilum of the gland is reached. The duct is approximated with 2 or 3 #8-0 gut sutures.

The needle is then directed through the parotid tissue and the overlying skin. The silicone tube is pulled through the skin puncture and tied to the other end emanating from the mouth. The soft tissues of the face are then attended to next. Conservative debridement of the wound is essential to preserve viable tissue. Contrary to the rest of the body, the face has a rich blood supply so only non-viable tissue should be removed. Muscle that has been devitalized is purple or black in color, does not bleed and will not contract when stimulated. In low velocity wounds the amount of debridement necessary is usually minimal and often is confined to excision of the bullet tract. High velocity weapons produce considerably more damage because of the large temporary cavity. Debridement is then necessarily carried out wide of the permanent tract. If there is some doubt as to tissue viability it should be preserved especially in some areas that are left open or covered by a skin graft. Care must be taken to identify severed vessels, especially arteries, which will often be in spasm and need to be tied or clipped in order to prevent late hemorrhage. Loose small pieces of bone, shattered teeth and bullet fragments are removed. Larger fragments such as parts of the zygoma or mandible should be reimplanted.

In self inflicted wounds especially those created by a shotgun, the blast will often blow some of the bone and adjacent soft tissue out of the wound cavity but most of the overlying skin although shredded to some degree, will still be viable. Often primary approximation of the remaining skin, after debridement of non-viable tissue, is possible. All attempts should be made to achieve closure of the epithelial cover especially over areas where hardware is used to reconstruct the bone. In some areas, although often not very cosmetic, mucosa can be approximated to skin. Flaps should be avoided initially because of the danger of wound contamination, total or partial flap failure with subsequent flap shrinkage or complete loss.

It is important to remember that because of the natural elasticity of the skin, especially in the young, that there may appear to be missing tissue at the site of injury. The elasticity of the skin of the area will retract the tissue away from the wound. When pushed together, wounds that appear to have missing tissue will be able to be closed without tension. The concept of "centering" of the wound, that is moving the lateral soft tissues of the face and neck toward the middle of the patient's face aids in primary closure. Keeping in mind the concept of facial units as well as the natural skin tension lines of the face and neck, closure should advantage these as much as possible in order to achieve the best aesthetic result.

As stated by Robertson and Manson[7], the patient in the early days following initial treatment, may need to be taken to the operating room periodically to debride the wound of necrotic tissue or drain areas of infection.

These principles fly in the face of the battlefield experience in Afghanistan and Iraq. Combatants evacuated from the area of conflict at which they suffered extensive facial wounds are rapidly Med-evaced by helicopter to a field hospital which is generally relatively close to the field of battle. They are taken to the Emergency Room are triaged, clinically evaluated, scanned and if free of other wounds immediately taken to the operating room where they undergo primary repair. The time between injury and beginning of treatment is often between 1 to 2 hours. The procedure is usually to cleanse and debride the wound, repair facial fractures and close the wound with either a local, regional or free flap. The incidence of infection in their hands is very small. The difference between the military and civilian experience may be accounted for by some of the following factors. The time from injury to definitive surgery in the military is considerably shorter than in the civilian experience. In civilian practice the time from the incident until the time the emergency service vehicles arrive and the patient is imported to the ER is most times prolonged. The admission process in the ER is time consuming, the process of getting the patient to the scanner then getting a the booking time in the OR, and the time it takes to set up for the procedure. The entire process is much more protracted than in the modern military situation. The combatants injured in the field are generally young, healthy and do not suffer from alcohol abuse and poor diet.

WOUND MANAGEMENT - Facial Skeleton

In dealing with the skeletal part of the injury I advocate the "bottom-up" principal where the mandible is addressed first. The dentition form the template of facial bone position especially as it relates to the mandible and maxilla. Wherever possible the normal occlusal relationships of the upper and lower teeth must be established. Even when there are gaps in the dentition or segments of mandible have been blown away from the injury, approximating the remaining mandibular teeth will produce the best result.

With a simple fracture of the mandible the fixation can be accomplished with eyelet wires. The most utilitarian fixation is intermaxillary fixation with Eric arch bars. If there is a significant amount of bone loss then the most expeditious way of managing the problem is to apply arch bars then wire the bar to whatever teeth are available to establish them in correct occlusion. An external appliance is then placed to keep the mandibular fragments in their normal position. Once the wound is controlled and there is adequate soft tissue cover, then a fibular or scapular free flap can be placed to replace the lost mandibular bone. The primary use at the time of injury of a long reconstruction plate to bridge the bony gap is ill-advised because of the frequent incidence of subsequent exposure of the plate due to infection.

Treatment of midfacial fractures begins, once more, with establishing dental occlusion. Fractures of maxilla tend to follow the lines established by Rene Lefort[8] in 1900. Maxillary fractures are generally classified according to the Le Fort system. The fractures in this system are all bilateral in kind. The least severe is the LeFort l, or Guerin fracture which extends horizontally just above the alveolar ridge, through the inferior aspect of the pyriform ridges of the nose and ends up just in front of or though the pterygoid plates inferiorly. The next in severity is The Le Fort ll, or pyramidal fracture, that courses along the maxilla laterally to the nasal frame and into the floors and medial walls of the orbit. It carries back at a variable height along the medial walls of the nose anterior maxilla and through the pterygoid plates. The most severe is the Le Fort lll fracture or craniofacial disjunction. This fracture literally separates the facial skeleton from the cranium. The nose is fractured across the nasion, into the medial orbital walls, along the orbital floors and lateral walls, through the zygomatic arches, infratemporal fossae and across the pterygoid plates[9]. In any situation in facial trauma the types can be, and usually are, mixed: with, for instance a Le Fort 1 fracture on one side and a Le Fort ll or lll on the opposite side. In addition a bullet may shatter a weak bone such as the lateral maxillary wall and go internally through the nose and up into the opposite orbit. This a sort of “hemimaxillary fracture”.

Repair of maxillary fractures is done with mini-plates and sometimes even micro-plates and in exceptional instances with small gauge wire. These titanium plates are light weight and are placed in the buttresses of the face and along the stress lines of the maxilla. Facial symmetry must be kept in mind as these repairs proceed

The nose is often completely disrupted in self-inflicted gunshot wounds. The best opportunity to achieve a satisfactory result is at the first operative procedure. Unfortunately, delayed treatment often yields a cosmetically undesirable outcome that defies repeated attempts at remediation.

As long as an epithelial cover can be achieved, bone grafting and fixation with microplates will yield the best results

When the Zygoma is fractured it should be restored to its normal position and plated. In the self inflicted shotgun injury the Zygoma may be shattered into multiple small pieces. One must resist the urge to insert free bone grafts or alloplasts because of the risk of infection. Small free-floating fragments must be discarded and reconstruction delayed until a future day.

Fractures of the frontal sinus can be managed at a future date unless there is a CSF leak. In such instances only the posterior wall may be fractured with a tear in the frontal lobe dura. Often there is an associated intracranial injury which requires a frontal craniotomy and dural repair reenforced with a facial graft. When there is a fracture of both anterior and posterior walls and the anterior wall fragments are of sufficient size, then the sinus can be cranialized[10] and the frontal lobes will advance to fill in the dead space. With extensive fracturing of the sinus walls, the best solution is The Riedel[11] sinusectomy with removal of all the sinus walls, collapsing the forehead skin against the repaired dura. Cosmetic reconstruction of the resulting forehead defect is delayed until a later time. The essential thing if the fractured sinus is preserved is to ensure adequate drainage of the sinus into the nose.

FRONTAL-ORBITAL FRACTURES

Orbital floor fractures often occur in gunshot wounds to the face especially in the instances of suicide attempts involving a shotgun.The exception to the placement of alloplasts into the wound must be made in the instances of these comminuted fractures of the orbital floor. Avoiding reconstruction at the time of injury will result in diplopia secondary to a severely scarred -in and sometimes even an immobile globe which will be difficult to impossible to later restore to normal function.

One of the most difficult injuries to repair is the fronto-ethmoidal-nasal complex fracture. These injuries generally result in the phenomenon of traumatic telecanthus. The insertions of the medial canthal tendons are blown out laterally giving the appearance of hypertelorism. The eye is generally displaced laterally because of the natural contraction of the orbicularis occuli whose medial termination comprises most of the medial canthal tendon as it inserts into the anterior lacrimal crest. In addition to the lateral displacement the inner canthus, the eye tends to slope down and medially. Furthermore, due to the lack of the usual tethering force of the tone of the orbicularis muscle, the globe tends to be displaced slightly anteriorly. In the normal individual, the width between the apices of the medial canthi is equal to the width of one eye. If only the tendon of one eye is avulsed the intercanthal distance will be greater than normal but the interpalpebral distance in the effected eye will be greater than that of the undisplaced eye. If the problem is bilateral than the distance between the medial and lateral canthi in each eye will be foreshortened.

If the patient is fortunate enough to have some lacrimal bone still attached to the tendon then it can serve as an anchor in the reconstruction. Two small drill holes are made in the bony remnant and a fine wire like a 28 gauge is threaded into the holes, passed through the upper portion of the nasal cavity and nasal septum then fixed to the medial orbital bone of the opposite side. The lacrimal drainage system must be carefully attended to and the placement of a Gabor drainage tube from the lacrimal punctum to the inferior meatus of the nose prior to the definitive canthal repair will greatly aid in this. If there is no bone attached to the medial canthal tendon, the wire pierces the tendon, is passed to the opposite side and anchored to the orbital bone on this side through 2 drill holes. The wire is then passed back through the medial orbital wall of the normal side and nasal cavity then back into the wound and again through the tendon of the injured side. The two ends of the wire can then be twisted into a rosette, as described by Kasanjian[12,13]then tightened until the eye is in the normal position. The button is necessary to prevent the tearing of the wire through the tendon when under tension from the wire suspension. The use of lead plates against the nasal frame to redrape the soft tissues over the canthal area not only lends support to the often severely fractured nose but relieves some of the strain of the wires suspending the canthal tendon[14]. Overcorrection of the eye position is advised, as some degree of relapse is not uncommon.

If the injury involves both tendons then the so-called Hogan “open sky” technique[15,16] is used. Two wires are placed through the tendon of one side, one through the upper part of the tendon and one on the lower part. Each wire then traverses through the ethmoid sinuses, the nasal cavity and through the nasal septum. It continues through the nasal cavity of the opposite side, ethmoids and through the shattered medial orbital wall of the opposite side. Each wire is then pierced through the corresponding point of the medial canthal tendon. The wire above the tendon in each orbit is twisted together with the wire below it, with the surgeon twisting in one medial orbit while the assistant twists the other. Care is taken to maintain a normal intercanthal distance with perhaps a slight over-correction. Lead plates are applied and removed at 3 weeks.

A perfect correction is very hard to achieve and close follow-up is necessary in case the patient would desire to have further correction.

FINAL CLOSURE:

Once the viscera of the face and the skeletal elements have been repaired, the cutaneous wounds are then repaired. It is wise not to use large flaps such as regional or free flaps to replace missing tissue at this time. The frequency of infection and uncertainty of viability of some of the remaining skin cover and subsequent flap shrinkage make vigorous attempts at cosmetic reconstruction highly risky and ill-advised. The hand is forced when there is dural exposure and/or a CSF leak. In such instances a flap should be placed.

Approximation of the remaining skin should be done with small closely placed sutures to avoid excessive scar formation. Some areas will need to be left open especially when there is a question tissue viability.

In conclusion: penetrating wounds to the face can be extremely challenging, especially when there is significant hard and/or soft tissue loss. The advances in reconstructive surgery using the modern techniques of three dimensional imaging and three dimensional modeling, the use of free flaps, and innovations in plate and screw technology have greatly improved functional and aesthetic reconstruction.

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