THE USE OF TITANIUM MESH IN FACIAL CONTOUR RECONSTRUCTION

V. V. Costan¹, Daniela Sulea¹*, A. Nicolau¹, C. I. Drochioi¹, St. Luchian², Otilia Boisteanu¹
“Grigore T. Popa” University of Medicine and Pharmacy Iasi
1. Faculty of Dental Medicine
   Department of Oral and Maxillofacial Surgery
2. Faculty of Medicine
*Corresponding author. E-mail: suleadaniela@gmail.com

THE USE OF TITANIUM MESH IN FACIAL CONTOUR RECONSTRUCTION (Abstract): Bone defects following trauma, or the radical resection of facial tumors are often associated with the loss of soft tissue support. The objectives of facial reconstructive surgery should not only be the restoration of the defect, but also the aesthetic and functional craniofacial rehabilitation with the restoration of facial symmetry. Aim: The purpose of this study is to assess the practicality of titanium mesh panels for reconstructing the craniofacial skeleton. Material and methods: Between January 2015 and December 2017 the authors used titanium mesh for a number of 26 patients including 20 trauma-related cases and six cases of post-ablative defects when titanium mesh was covered using loco-regional flaps. Results: All the facial dimensions were restored. None of the titanium meshes was exposed postoperatively. Conclusions: Titanium mesh has proven to be a useful material for the reconstruction of the craniofacial skeleton, capable of providing a true individualized treatment. Keywords: TITANIUM MESH, CRANIOFACIAL SKELETON, FRACTURE, SYMMETRY.

Posttraumatic defects of the facial skeleton, or bone defects following tumor removal are usually associated with soft tissue support deficit, resulting in facial asymmetry, enophthalmos, lagophthalmos with secondary conjunctivitis, the loss of tooth-bearing segments, and speech impairment (1). All lead to a lower quality of life for the patient. Furthermore, the restoration of the complex architecture of the craniofacial bone frame is a challenging task for the surgeon.

The purpose of the reconstruction is to restore the aesthetic appearance and the lost functions by providing continuity of the bone contours, which ensures support for the soft tissues and allows the restoration of facial symmetry (2).

There are many possibilities for facial bone reconstruction such as titanium plates, bone grafts, composite flaps and titanium mesh. Titanium mesh has proven to be a useful material for the reconstruction of the craniofacial skeleton, capable of providing a true individualized treatment.

MATERIAL AND METHODS
Between January 2015 and December 2017, the authors used titanium mesh for a number of 26 patients including 20 (76.92%) trauma-associated defects and 6 (23.08%) post-ablative defects. In the
trauma-related group there were 6 (23.08%) cases of comminuted mandibular fractures, 3 (11.54%) fractures of the atrophic mandible, 6 (23.08%) cases of complex midface fractures, 3 (11.54%) fractures of the zygomatic complex with comminution of the zygomatic-alveolar crest, and 2 (7.69%) patients with sequelae following nose-orbital-ethmoid (NOE) fractures associated with anterior wall of the frontal sinus fractures. In the 6 (23.08%) patients with post-ablative bone and skin defects following the removal of cheek region basal cell carcinomas, titanium mesh was associated with loco-regional flaps consisting of 3 (11.54%) frontal flaps with a medial pedicle, 2 (7.69%) frontal flaps with a lateral pedicle and one (3.85%) rotated cheek flap.

All the titanium mesh panels were modelled intraoperatively, with the exception of two (7.69%) cases where stereolithographic 3D printed models were used for the pre-operative shaping of the titanium-mesh panels. The resulting modelled titanium meshes were sterilized and used intraoperatively. The mesh was fixed in place with titanium screws using a minimum three-point fixation method for ensuring spatial stability of the material. For the fixation of mandible fractures, the titanium mesh was bent according to the shape of the basilar border so that it would contain all fragments and the adjacent ends of the fracture. More fixation screws were therefore needed for the immobilization of all fragments.

**RESULTS**

All the dimensions of the comminuted and atrophic mandibular fractures were accurately restored. The affected segments were sensibly equal with the opposing side when compared with the help of imagistic methods. The functionality was resumed in the cases of mandibular fractures, with adequate healing, absence of persisting mobility in the line of fracture and resumption of proper mastication and deglutition.

Regarding the restoration of facial bone contours the results were excellent for NOE fracture sequelae cases and good for the other fracture cases, ensuring improved symmetry. The projection of the zygomatic bone and midfacial contours were reconstructed due to the possibility of multiple fragment preservation and fixation. Titanium mesh fixation at the level of the zygomatic-alveolar crest allowed improved stability and possibility to bridge bone defects or comminution to achieve proper fixation in the anatomically reduced position of the zygomatic bone. The facial appearance of patients improved in all cases. There were no complaints of postoperative diplopia or restricted eye movements. An adequate support for the soft tissues was achieved in trauma-related cases.

For defects following the removal of malignant tumors the plasty had excellent results when the defect involved only the inferior orbital margin, anterior wall of the maxillary sinus and the orbital floor. The extension of the defect to the zygomatic bone body increased the complexity of the shaping process for ensuring good postoperative results. Titanium mesh allowed proper reconstruction of the orbital floor, without complaints of postoperative diplopia. Secondary plasties were needed for further fine adjustments regarding the position of the soft tissue coverage in two (7.69%) cases.

When stereolithographic models were used for the pre-bending of the titanium meshes, not only the results were more accurate, but the operative time was shorter.
None of the titanium meshes was exposed postoperatively. The good outcomes of titanium mesh reconstruction are illustrated by the help of a case portraying the treatment of a double angle fracture of an atrophic mandible in an edentulous patient (fig. 1-7).

**Fig. 1.** Patient with bilateral mandibular angle fracture. Note the impossibility of closing the mouth due to bilateral angle fractures.

**Fig. 2.** Lateral view of the patient with bilateral mandibular angle fracture.

**Fig. 3.** Lateral left and right view of 3D reconstruction from Computed Tomography (CT) scan. Note the severe atrophy of the mandibular bone and the edentulous state.
Fig. 4. Aspect of the titanium mesh tray modelled after the inferior border of the mandible

Fig. 5. Intraoperative view of the right and left mandibular angle fracture sites fixated with titanium mesh sheet

Fig. 6. Postoperative frontal view of the patient demonstrating the restored contour of the mandible and the ability to close the mouth.

Fig. 7. Postoperative profile view of the patient demonstrating the restored contour and projection of the mandible and the ability to close the mouth.
DISCUSSION
Titanium is considered the most biocompatible metal due to its resistance to corrosion from bodily fluids, bio-inertness, capacity for osseointegration, and high fatigue limit. Titanium's ability to withstand the harsh bodily environment is a result of the protective oxide film that forms naturally in the presence of oxygen (3, 4). The titanium mesh couples the advantages of the material with the ones offered by the geometry of the mesh itself that is purposely designed to allow simple three-dimensional modelling without compromising the stability and support of the structure (5, 6).

Versatility, adaptability, stability and malleability are only a few of the advantages of the titanium mesh. Modelling it according to the defect and giving the titanium mesh a complex form often needed for the reconstruction, eventually results in a structured shape capable of resisting mechanical stress and providing an individualized treatment (7).

In cases of comminuted fractures of the facial skeleton, titanium mesh allows improved containment and fixation of the multiple bone fragments, reconstructs contours, and even bridges regions of missing bony substance. These objectives could not be fulfilled to the same degree by the simple use of multiple titanium plates. For post-ablative defects, titanium mesh can provide an alternative to more complex, time consuming methods of treatment involving the association of bone grafting or composite flap raising with titanium reconstruction plates.

Although the price for the titanium mesh is higher than individual plates, it is offset by using fewer mesh panels than titanium plates otherwise needed by the same procedure.

One of the disadvantages of using the titanium mesh is that for the placement of the implant, an extraoral access is frequently needed, leaving a visible scar. Additionally, the removal of the mesh, when this is needed, is difficult due to the connective tissue growing around and through the structure of the panel (3). At the same time, this behavior is an advantage when the titanium panels are used for the reconstruction of the sinus walls, preventing the intra-sinus exposure of the titanium mesh.

Although a considerable number of treatment methods exist for comminuted and atrophic mandibular fractures, choosing the best procedure remains a challenge due to the high infection rate, unsatisfactory mandibular shape and loss of bone fragments.

In cases of mandibular fractures with severe atrophy of the mandibular bone, the use of the “classic” titanium reconstruction plates are not indicated since it involves the decollement of the periosteum form a large surface of the bone, which can lead to osteitis/osteomyelitis. Angle fractures of the atrophic mandibles are another therapeutic challenge since the mouth guard fixation with circum-mandibular wires is not effective for this region. In comminuted mandibular fractures, periosteal stripping can lead to decreased vascularity and loss of the intermediate bone fragments. Additionally, it is extremely challenging to provide adequate stability and fixation for the multiple fragments by using simple titanium plates or a reconstruction plate, while also ensuring the correct mandibular body length (8).

In our opinion, the advantage of using the titanium-mesh in cases of comminuted mandibular fractures, is that by modelling
it around the lower border of the body of
the mandible in a “U” shape, and going up
just a few millimeters on the lingual side,
the resistance of the panel is greatly in-
creased while also leaving the lingual peri-
osteum attached on the bone fragments,
ensuring their vascularization and thus a
favorable healing. On the vestibular aspect
of the mandible, the titanium mesh is mo-
deled to the shape and form necessary to
envelop and preserve all the bone fra-
gements. The characteristic design with mu-
ltiple holes makes the reduction and fixation
with screws possible for all the bone fra-
gements. The good results that we obtained
in our study are consistent with the results
of other authors that have used titanium mesh
for the reconstruction of the mandibular
contour due to its semi-ri-
gid fixation pro-
p-
erties and the need for limited periosteal
stripping (7, 8).

Comminuted fractures of the midface
can result in important facial deformation if
not properly reconstructed. The three-
dimensional analysis of CT (Computed
Tomography) or CBCT (Cone Beam Com-
puted Tomography) scans offers important
information regarding the number of fra-
gements, degree of displacement, the pre-

cence of soft tissue entrapment or foreign
bodies (9) and helps select the most appr-
ropriate treatment method (10).

Restoring the face symmetry after zy-
gomatic complex or midface fractures can
be difficult if there is comminution at the
zygomatic-alveolar process. The three-
dimensional modeling of the titanium-mesh
panel and fixing it in such a way to reesta-
ablish a correct and stable vertical dimension
allows an accurate rehabilitation of the
zygomatic geometry, symmetric with the
opposing side. Other authors also underline
the importance of titanium mesh fixation
for achieving improved fixation and indi-

gualized treatment in complex midface
fractures (11). Although the bone frame
support is restored by using the titanium
mesh, it is important to also address the
soft tissues by repositioning sutures fixed
to the periosteum or to the titanium mesh,
placed at the end of the surgery. Omitting
to perform soft tissue rearrangement might
lead to tissue ptosis and an aged facial
appearance (12, 13). Corrective surgery can
be performed later by inserting barbed
threads for soft tissue lift (14), or by autol-
ogous fat transfer in order to restore the
lost volume of the midface (15).

Due to the complex geometry of the re-

gion, comminuted NOE fractures need a
material capable of covering a larger sur-
face. The titanium mesh can stabilize the
smaller bone fragments and by modeling it,
due to its malleability, it ensures an excel-
lent amendment of the region. This is con-
sistent with the favorable results achieved
in our study regarding NOE sequelae
treatment using titanium mesh. Reposition-
ing of the detached medial canthal ligament
by anchorage to the modelled titanium
mesh is also possible and ensures a good
definition of the bony contour in the para-
nasal region and a normal intercanthal
distance (11). In our opinion, an adequate
exposure of the sunken region for the
placement of the titanium mesh could be
the most challenging aspect to minimize
scars and damage to the overlying soft
tissues when addressing sequelae of NOE
fractures.

NOE fractures are frequently associated
with fractures of the anterior wall of the
frontal sinus. The purpose of the treatment
is to protect the intracranial components,
the deterring of cerebrospinal fluid leak,
and the rehabilitation of the facial contour.
The use of titanium mesh in facial contour reconstruction

The management of the comminuted fractures of the frontal sinus is difficult because the bone fragments are too small for fixing them with wires or plates. The titanium mesh is one of the most used material for the anatomic rehabilitation of comminuted frontal sinus fractures generating minimal inflammatory response and imaging artefacts (16).

In many cases of malignant tumors of the midface, the resection often implies a maxillectomy which leads to deformities such as diplopia, depression of the cheek, as well as articulatory, masticatory and swallowing disorders. The timing and method of reconstruction is in relation with the histology and considering the need for postoperative radiotherapy. If a delayed reconstruction is decided, the defect can be initially addressed using an obturator prosthesis and/or an episthmus (17). Frequently, the main treatment for basal cell carcinoma is surgical resection. For this reason, in our case series, the reconstruction was performed at the same time with tumor removal.

Composite flaps or multiple flaps are needed for restoring the complex anatomy of the maxillary bone and for achieving a restoration of both bone and soft tissue. In our opinion, titanium mesh allows a good restoration of midfacial contours following the removal of malignant tumors. The reconstruction implies the shaping of the titanium-mesh panel to rebuild the missing bony architecture, but also ensuring an adequate coverage of the titanium mesh with a soft tissue flap. Considering the extent of the defect, several flaps can be used for the reconstruction. The frontal flap with a medial or lateral pedicle is a good option in the absence of sufficient local tissues for a genian flap coverage. For more extended defects, free flaps are needed to achieve adequate closure (1).

The composite temporo-parietal osteofascial flap is an option for reconstructing bone defects at the level of the zygomatic-maxillary complex and orbital floor. In this case, titanium mesh can be used for fixation of the composite flap, but also for the reconstruction of the skull defect at the donor site (18). When performing the reconstruction of the resected orbital floor, it is important to adequately restore the shape of the inferior wall, but also the correct level of the transition area located at the intersection of the medial orbital wall and the orbital floor. This medial bony strut is considered important in establishing the proper orbital volume and it is usually preserved for best functional results when performing bone decompression surgery for Graves orbitopathy (19, 20, 21).

Although the titanium mesh can be modeled to fit the bone defect perfectly, this objective is arduous to accomplish by the manual intraoperative shaping of the mesh due to the reduced operative access and the long time needed (22). This detriment can be overcome with the help of a stereolithographic model that can be used for the pre-operative shaping of titanium-mesh panels when faced with complex three-dimensionally shaped defects that require increased accuracy and elaborated shaping of the mesh that would be difficult to perform intraoperatively. The titanium meshes pre-modelled to the exact anatomy of the individual’s mirrored healthy side are then sterilized and used intraoperatively.

From our experience, the procedure decreases surgery time and increases the accuracy of the reconstruction. Still, it is stated by some authors that the repeated bending of the material in trying to achieve
the optimal shape could decrease the mechanical strength of the mesh (7). This aspect is of interest when the titanium mesh is used to reconstruct the mandible since the masticatory forces involved in the mandibular region are greater than forces acting in other facial regions. Prospects involve the use of individualized 3D printed titanium mesh trays by direct metal laser sintering that could improve the accuracy of reconstruction even more by eliminating the manual modelling of the titanium mesh (7).

**CONCLUSIONS**

From our study we conclude that the titanium mesh panel is a material capable of providing an individualized treatment for reconstructing the craniofacial skeleton in cases where large defects need to be rectified, for ensuring stability in cases of comminuted fractures and for providing soft tissue support and the rehabilitation of facial symmetry. Furthermore, the use of stereolithographic models warrants the perfect fit of the individualized panels and shortens the operative time.

**REFERENCES**


The use of titanium mesh in facial contour reconstruction


**NEWS**

**ETHYL GLUCURONIDE - A USEFUL BIOMARKER FOR ETHANOL INTAKE IN FORENSIC FIELD**

Alcohol consumption has an important role in most of the forensic deaths, starting with acute alcohol intoxication as a cause of death and going on through many of the fatal accidents (road and occupational) where alcohol intake has its own influence. This is why ethyl alcohol determination in blood specimens is one of the most requested analyses in forensic field. A group of researchers from the Institute of Legal Medicine in Modena (Italy) investigated the role of ethyl glucuronide (EtG) in supporting medico-legal investigations, with the purpose to develop and validate a sensitive procedure for its quantitative determination in order to give a better interpretation of postmortem EtG concentrations in formulating medico-legal conclusions. They analyzed the distribution of this biomarker in different specimens, collected from 21 subjects, : central blood, peripheral blood and liver samples; in 13 of them urine was also available. The specimens were analyzed by liquid chromatography tandem mass spectrometry. EtG levels were higher in the liver samples compared to the blood sampled, and the urine samples (n=13) presented higher EtG levels than the corresponding liver samples, except for 4 cases. Due to the lack of controlled conditions such as the information on the time of alcohol intake and the ingested doses it was difficult to interpret the EtG levels, but the strength of the study was the simultaneous analysis of this metabolite in different matrices from the same subject. (Santunione AL, Verri P, Marchesi F, Rustichelli C, Palazzoli F, Vandelli D, Licata M, Silingardi E, The role of ethyl glucuronide in supporting medico-legal investigations: Analysis of this biomarker in different postmortem specimen from 21 selected autopsy cases, *Journal of Forensic and Legal Medicine* (2017), doi: 10.1016/j.jflm.2017.10.009).