Conference paper

Current Aspects in Reconstructive Surgery for Nasal Cavity and Paranasal Sinus Cancer

V.I. Shtin[1*], V.A. Novikov[1], V.E. Gunther[2], E.I. Choinzonov[1], A.I. Ryabova[1], V.A. Sirkashev[1], P.V. Surkova[1], Yu.F. Yasenchuk[2], S.G. Anikeev[2], R.V. Vasilev[1]

[1] Department of Head and Neck Cancer, Cancer Research Institute of Tomsk Research Medical Center, Tomsk, Russia

[2] Tomsk State University, Research Institute of Medical Materials and Implants with Shape Memory, Tomsk, Russia *shtinv@mail.ru

*Corresponding author: V.I. Shtin, email: shtinv@mail.ru

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Abstract

Tumors of the nasal cavity and paranasal sinuses present a challenge to treat them. A combination of surgery and radiation therapy can improve treatment outcomes in 49-56% of patients with locally advanced nasal cavity and paranasal sinus cancer. The midface reconstruction poses a formidable challenge to the reconstructive surgeon due to the region's complex skeletal and soft-tissue anatomy. The rehabilitation program including the reconstruction of the resected orbital walls using the porous and mesh implants from titanium nickelid (TiNi) was developed at the Cancer Research institute jointly with the Research Institute of Medical Materials. The technique was proven effective, allowing the natural position of the eye and visual function to be preserved in 90% of patients. A long period of reparative processes and risk of developing inflammation in the implant area, as well as the need to decrease length of surgery, contributed to the development of a novel approach to repairing the midface bone structures using the implant based on the microporous wire and TiNi mesh. Eighteen patients with nasal cavity and paranasal sinus cancer were treated using the combined thin implants. The novel technique allowed the time of the implant installation to be reduced to 5-10 minutes. The structure of the implant contributed to prevention of inflammatory processes in 97% of cases. Thus, the natural position of the eyeball and visual function were preserved in 100% of patients. The use of the TiNi implants in reconstructive surgery for patients with nasal cavity and paranasal sinus cancer led to reduced time of surgery and rehabilitation, increased level of social adaptation of patients and improved cosmetic and functional results.

1 Introduction

Unfavourable demographic trends and the complex environmental problems are accompanied by a steady increase in the incidence of cancer. More than 20,000 new cancer cases are diagnosed each year worldwide. Malignant tumors, which affect nasal and paranasal sinus structures, are uncommon, representing of about 0.2% of all cancers. Over the last 10 years, the incidence of nasal cavity and paranasal sinus cancer was increased from 0.55 to 0.64 per 100,000 (13.31%). Expanded possibilities for surgical treatment of nasal cavity and paranasal sinus cancer and the use of the modern radiotherapy techniques allowed the overall and disease-free recurrence rates to be increased, with the 5-year survival rate rangin from 37% to 60%. However, the reconstruction of the midface defects after extended surgical resection is a challenging procedure for the reconstructive surgeon due to the region's complex skeletal and soft-tissue anatomy. At the Cancer Research Institute (Tomsk, Russia), the rehabilitation program, including the reconstruction of the resected bone structures with TiNi implants was developed.

2 Experimental

Two techniques were tested and implemented into clinical practice:

1. Reconstruction of bone structures of the subcranial region with the porous TiNi implants individually fabricatedon the base of thestereolithographic model of the patient's skull
2. Reconstruction of bone structures of the subcranial region using the individuallyfabricated implants from TiNi mesh

These techniques allowed the natural position of the eye and visual function to be preserved in 90 9.4% of cases. However, they also have drawbacks. A long period of reparative processes and risk of the development of inflammation around the implant, as well as the need to reduce length of surgery, contributed to the development of the novel approach to the reconstruction of the midface bone structures. The following main objectives were identified:

– Reconstruction of extensive midface defects;

– Reduction in the period of wound healing around the implant;

– Prevention of the implant displacement and inflammatory complications.

In achieving these objectives, a new prosthetic construction based on the microporous wire and TiNi mesh was used. Based on preoperative planning of the extent of surgical resection using 3D spiral CT findings, we created the microporous

NiTi wire frame in conformity with estimated sizes of the midface bone defects. This frame has predetermined bending angles,(the equivalent of bone structure bends) and possesses a shape memory. The TiNi wide mesh is fixed to the prefabricated individual thin frame using the TiNi thread. This implant is characterized by a lightweight, wireframe function (due to the TiNi frame), the ability of biointegration with adjacent tissue (due to mash fabric, microporous wire frames and threads), and the presence of predetermined shape memory. During surgery, the implant is installed in the preserved bone structures, subperiosteally, if possible, and is fixed with titanium screws. In most cases, we used the three-point support that made the construction the most stable and allowed the physiological position of supported tissues to be achieved.

After tumor resection, surgical reconstruction of midface defects using combined thin implants was performed in 18 patients with stage III-IV nasal cavity and paranasal sinus cancers. Orbital wall defects were reconstructed in 15 patients (Figure 1), and complex defects of the zygomatic bone and orbital walls were repaired in 3 patients (Figure 2). A new approach to the reconstruction of midface defects allowed surgeons to preserve the natural position and function of the eyeball, as well as to preserve the physiological position of soft tissues of the midface.

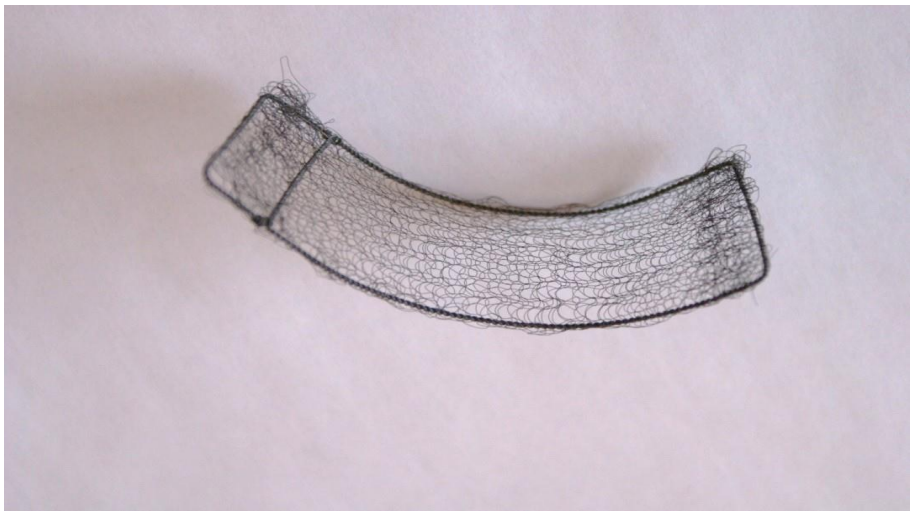

Fig. 1. – Thin combined implant for the reconstructionof the orbital walls

The implant design based on the microporous wire and superelastic TiNi mesh allowed surgeons to reduce the time of reconstruction to 5-10 minutes, resulting in shortening the time of surgery. The structure of the implant has a great integration potential, is capable of changing the shape without fracture on the modeling stage, but finally possesses a customized shape (shape memory). Wound healing time was shortened to 30 - 40 days that is twice less than in the use of porous implants.

Fig. 2. – Thin combined implant for the reconstruction of the zygomatic bone and orbital walls

3 Results and discussion

We present a clinical case of a 24-year-old man with moderately differentiated squamous cell carcinoma of the right maxillary sinus. The patient was treated between November 28, 2011 to December 28, 2011 at the Head and Neck Department of Cancer Research Institute (Figure 3).

The patient was admitted to our clinic with disease progression. In 2010, he received radiation therapy at a total dose of 62 Gy followed by 6 cycles of polychemotherapy (5 fluorouracil, leucovarin, cisplatin).

Physical examination on admission revealed a non-tender and moveable lymph node up to 2 cm in diameter on the right side of the neck. Histological examination (December, 2011) showed lymphoid hyperplasia, the presence of bare nuclei and decay of the nuclei.

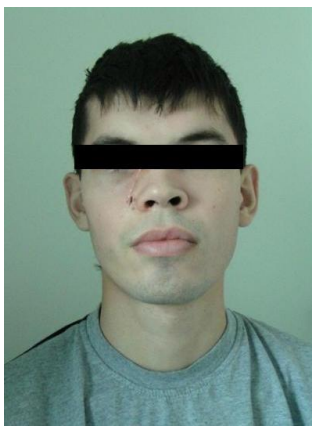

Fig. 3. – Postoperative view of the patient. The orbital walls were reconstructed using the NiTi implant. The natural position and function of the eyeball were preserved

Spiral CT (November, 2011) reveled a partial destruction in the anterior and medial walls of the right maxillary sinus due to a tumor located mainly in the sinus cavity, and the presence of a soft tissue component and air space. The partial defect (3 mm) involving the lateral wall of the maxillary sinus was identified. The tumor involved the right nasal cavity and infiltrated the anterior half of the right turbinates, destroying them. The tumor was adherent to the nasal septum. The tumor infiltrated cells of the ethmoidal labyrinth in the anterior parts, extending to the medial lower quadrant of the right orbit through the destroyed inferior and medial orbital walls. The tumor was partially adherent to the inferior muscle group. The eyeball was intact. The CT image showed tumor infiltration of the medial angle of the orbit, with possible infiltration of the lower eyelid and suborbital region. Soft tissues of the right cheek were compressed in the area of the bone defect of the anterior wall of the maxilla. The nasopharyngeal lumen was unchanged. In the lower parts of the left maxillary sinus, mucosal thickening measuring 28x24 mm in size was identified. Pneumatization of the sphenoid and frontal sinuses was preserved.

The patient underwent resection of the right maxilla (December, 2011). The tumor was located in the medial and inferior orbital walls on the right side, with extension into the upper parts of the maxillary sinus, destructing adjacent parts of the zygomatic bone, anterior and lateral walls of the postoperative cavity. The tumor was removed with resection of adjacent parts of the maxillary bone structures, zygomatic bone and cells of the ethmoidal labyrinth. Hemostasis and coagulation of the walls of postoperative cavity were performed. The right orbital walls were reconstructed with the frame TiNi implant. The procedure to place the implant took 7 minutes.

The tampon was removed from the postoperative cavity on day 9. The postoperative cavity was examined using a rigid endoscope with 45° viewing angle. Wound surface was completely cleansed from necrotic masses. The active growth of granulation tissue was observed. The mesh was fully covered with postoperative granulation tissue.

Sites of the TiNi frame, measuring to 1.5-2 cm and protruding into the wound, were not partially covered with granulation tissue. On the day of hospital discharge (on day 14 after surgery), sites of the frame (up to 1 cm) at the upper edge of the implant's arc were not covered with granulation tissue. No signs of inflammation were seen.

Spiral computed tomography (December, 2011) showed surgical removal of the anterior and medial walls of the right maxillary sinus, frontal bone of the right maxilla, right turbinates, cells of the ethmoidal labyrinth on the right side, and inferior and medial walls of the right orbit with reconstruction with the frame TiNi implant. The implant was placed in the projection of medial, inferior and partially lateral walls of the right

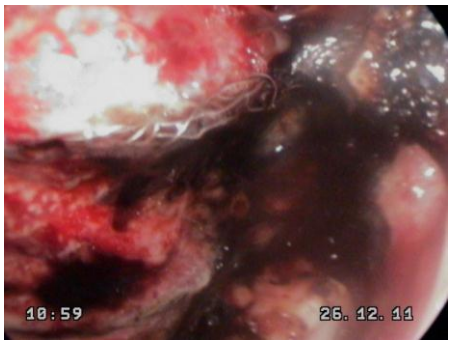

Fig. 4. – The view of the wound surface12 days after surgery. The implant edge (at least 2 cm) not covered with granulation tissue is seen. The remaining parts of the implant have been integrated into recipient tissues

orbit, fitting the removed anatomical structures. Mucosal hyperplasia was seen in the right frontal sinus and in the inferior parts of the right maxillary sinus. A through defect of soft tissues was noted in the medial corner of the right eye. Cystic mucosal thickening measuring 25x22 mm in size was identified in the inferior parts of the left maxillary sinus. The nasopharyngeal lumen was unchanged (Fig. 5, 6).

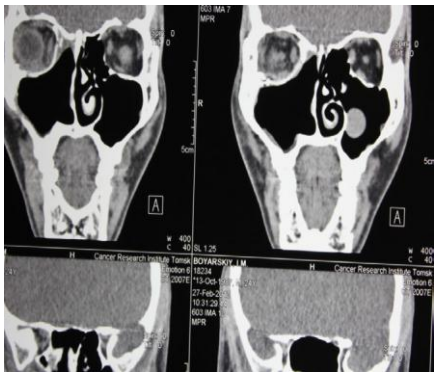

Fig. 5. – Postoperative CT scan of the patient. The implant position fits healthy bone structures

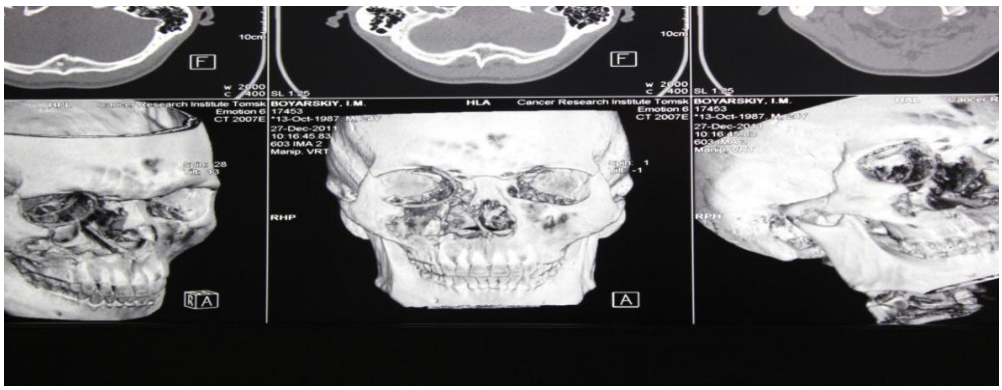

Fig. 6. – 3-D model of the patient after surgery. The implant position fits healthy bone structures

4 Summary

Considering the results obtained, it can be concluded that the use of the TiNi implants for the reconstruction of midface defects in patients with nasal cavity and paranasal sinus cancer leads to reduced time of surgery and rehabilitation, has a positive impact on the quality of life of these patients and improves cosmetic and functional results.

The use of the proposed technique allowed the quality of implantation to be achieved due to reduced time of the implant installation and increased precision of the procedure. Ease of fabrication and installation of the implant made it possible to reconstruct extensive defects of the midface. The structure of the implant promoted its full immersion into the tissues of the recipient area, thus excluding the risk of infection and preventing the development of inflammation in the postoperative period. Wound healing time was shortened to 30-40 days that was twice less than after using the porous implants. Considering all factors above, we can recommend to use the novel technique not only in oncology practice, but also in maxillofacial surgery.

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