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Elimination of Mandibular Defects in Patients with Malignant Neoplasms Using the PoprusTiNi-alloys

A.A. Radkevich[1, 3, 4*], A.A. Gantimurov[2], V.E. Gunther[3, 4]

[1] Research Institute of Medical Problems of the North, Krasnoyarsk, Russia
[2] Municipal Dental Clinic №8, Krasnoyarsk, Russia
[3] Tomsk State University, Tomsk, Russia
[4] Research Institute of Medical Materials and Implants with Shape Memory, Tomsk, Russia

*Corresponding author: A.A. Radkevich, email: radkevich.andrey@yandex.ru

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Abstract

The article presents the clinical observation of 16 patients with malignant neoplasms of the lower jaw. All the patients underwent resection of the mandible with the substitution for the flaws with endoprostheses of porous NiTi. In 10 cases a course of preoperative radiotherapy in a dose of 42-44 gr. was conducted. The results of surgical treatment showed high efficiency of the technology.

1 Introduction

In surgery of tumor lesions of the mandibular bone in connection with the topographic and anatomic features of the oral region, the lower face and neck area some difficulties occur associated with the removal of the extensive malignant neoplasms within the sound tissues due to the patient transfer from the category of a cancer patient in a group of patients with face defects and deformities, the functional disorders on the part of the masticatory apparatus, the temporomandibular joint/s (TMJ), etc. It follows that the radical excision of the pathological tissues often does not lead to full recovery of the patient.

In individuals with malignant tumors in some cases the necessity of applying the combined or complex treatment method – a combination of surgical interference with radiation- and chemotherapy negatively influences on the rehabilitation measures effectiveness. Radiation- and chemotherapy have a negative impact on the reparative processes which greatly increase the risk of the reconstructive operations success, due to that the majority of experts don't carry out the primary bone grafting after the malignant tumors removal.

When choosing the method of operative treatment of tumor and osseous dysplasia it is necessary to consider the nature and type of the pathological process, the peculiarities of its pathologic behavior (the rate of growth, the tendency to recur), localization, prevalence, age, somatic state of the patient as well as one-step or subsequent possibility to restore the anatomical shape and functional features of the damaged bone and facial soft tissues.

Patients' rehabilitation with the lower jaw neoplasms should solve the following problems:

1. The impact on the affected structures (operative, radiation, chemotherapy depending on the lesion nature);
2. Elimination of bone and/or soft tissue defect;
3. Restoration of the functional characteristics of the temporomandibular joint/s and the masticatory apparatus by bone grafting, endoprosthesis replacement or dento-maxillary prosthetics.

In order to restore the anatomical and functional disorders in patients of this category the bone grafting is applied using various kinds of available graft materials [1, 7], replacement of the mandibular bone and temporomandibular joint defects by endoprostheses made of stainless steel, titanium, chrome and cobalt alloy, polymers, ceramics, precious stones (sapphires) and others which do not exhibit the lag effect in terms of loading and unloading [2-4, 8, 14, 15]. However, the results of such operations can't meet the requirements of the patients and clinicians because of the transplant and implant materials resorption and rejection due to non-viability of allogenic and xenogenic tissues, the death of osteocytes in the autografts' thickness, the lack of biomechanical compatibility of the used implants with the body tissues. The use of vascularized grafts in combination with the microsurgical technique is traumatic [5, 9, 13]. Apart from that, the used bone grafts by form don't correspond to the replaceable defect and an artificially created

blood flow in them often becomes unsatisfactory due to microvascular thrombosis during the immediate postoperative period which undoubtedly affects the final outcome. The combinations of the stated techniques [6, 10-12] are not without the above drawbacks.

The researches made in Siberian Physics and Technology Institute (Tomsk) related to the development of obtaining porous materials technology based on nickelid titanium contributed significantly to the implantology development. The most crucial is the alloy TN-10P (porous) creation. The technology of obtaining and processing of the alloy allows to achieve the determined amount of pores and to create an open porous structure in a predetermined range. The implants of this material possess high biological inertness, non-toxic and meet all the requirements of the implants. The biocompatibility of these materials enables them to remain stable in the body while providing reliable fixation to the surrounding tissues by the formation and growth of the tissue structures in the implant pores.

The objective of the work is to increase the efficiency of the surgical treatment of the patients with malignant neoplasms of the mandible based on the new medical technologies development using the endoprostheses of porous nickelid titanium.

2 Experimental

In the scientific research Institute of Medical Materials and Implants with Shape Memory (Tomsk) the endoprosthesis was developed for the simultaneous substitution of the body, the angle and mandibular ramus including the head. This endoprosthesis is a design by configuration corresponding to the anatomical shape of the condylar process of mandible and the mandibular ramus to which the components are fixed which replace the angle and the body of the mandible with right and left variants. This design can be manufactured without a head and in the full version depending on the surgery task. To prevent the implant eruption through the oral cavity mucous membrane or facial soft tissues the body of the latter is covered with fibrous or woven thin-profile nickelid titanium by layer-by-layer winding in 2-3 or more layers (Fig. 1). The sizes and the endoprosthesis configuration are determined individually on the basis of X-ray examinations (computed helical tomography – layer-by-layer and three-dimensional images images).

Fig. 1. Endografts of porous nickelid titanium

The technique of direct endografting for the purpose of the mandibular head, ramus and body replacement. The surgical access to the lesion focus is performed from retromandibular, submandibular areas and the under-chin region or on the part of the oral cavity (depending on the clinical situation). The affected structures of the mandible are removed or the bed is made for the endoprosthesis with the formation of the glenoid cavity and the bone wound surface isolation by tissue nickelid titanium implant or without it. The endoprosthes is inserted in a prepared bed with the head towards the glenoid cavity, another part is fixated to the decorticating surface of the mandible fragment from the external side with the help of fixation devices of nickelid titanium. The masticatory muscles are fixed to the endoprosthesis similarly to the previous method, the fixation of the muscles lowering the mandible is carried out (genioglossal, geniohyoid, mylohyoid muscles, anterior bellies of the digastric muscles if they were severed) to the endoprosthesis body. The wound is sutured layer by layer and drained within 2-3 days.

The technique of delayed endografting for the purpose of the mandibular head, ramus and body replacement. The reahibilitation effectiveness in patients with the absence of the mandibular head, ramus and the lower jaw body defect is associated with the masticatory function restoration. In order to achieve this goal it is necessary the optimal spatial endoprosthesis' location relatively to the maxillary bones and the remaining part of the mandible. Only in this case it is possible to obtain the satisfactory functional result. For this purpose the technology of the rehabilitation measures sequence in this category of patients was developed involving the removal of the pathological tissues (the mandible resection, etc.) in cases if this surgical intervention wasn't performed earlier, determining the centric jaw relation, producing the temporary orthopedic design which fixes the normal position of the remaining part of the lower jaw, performing the reconstructive surgery and the subsequent replacing dentofacial prosthetics.

The peculiarity of the mandible resection in these patients is that after cutting off the muscles from the gross specimen the remaining parts are immersed inside with a thin-profiled knitted fabric structure based on nickelid titanium of "stocking" type and it is left in the surgical wound in this state. The specified measures (actions) during the implant replacement substitution stage allow to distinguish these muscles from the scar' modified tissues and carry out the subsequent fixation to the implant body to restore the function.

The made lower dentofacial prosthesis is fixed in the oral cavity of the patient, after that the surgical intervention is performed consisting of the scar modified tissues dissection in the area according to the previous operation, the soft tissues dissection up to the mucous or submucous layer to form the bed for the endoprosthesis, skeletization and the formation of the decorticating surface from the external edge of the mandible fragment, the fixation of the implant and the muscles according to the previous technology, covering the latter with soft tissues, the wound suturing. In patients with the preserved mandibular heads the endoprosthesis is fixed from the external side of the lower jaw fragments to the decorticating surfaces.

If required, to improve the ratio of the prosthetic bed tissues the subsequent dentofacial prosthetics in the zone of the reconstructed defect was performed individually, 1-3 months after the surgery.

3 Results and discussion

According to the developed technology, 16 patients aged from 53 to 74 years with the lower jaw malignant neoplasms of II и III, A and B stages were treated. The patients underwent the resection of the mandible depending on the indications, the tissues of the oral cavity floor, buccal region and the region of chin. In metastases presence in the lymph nodes in neck was carried out their radical neck dissection. In 10 cases the surgical intervention was preceded by radiation therapy in a dose of 42-44 gr. The mandibular bone flaws were substituted with the endoprostheses of porous nickelid titanium (TiNi). In 10 patients the delayed endoprosthesics, in 6 patients the immediate endoprosthetsis replacements were used. The reasons of the delayed endoprosthesis replacement were the appeals regarding the presence of postoperative body defects and/or the mandibular ramus after the tumors removal in other clinics without their substitution, the unsatisfactory results of bone grafting or endoprosthesics with the use of other implants designs, the primary surgeries on the tumor suppurations and/or the significant tissue necrosis. The characteristics of the replaced defects are shown in Table 1.

Table 1. The characteristics of the replaced defects in patients with the mandibular pathological conditions (n=16)

Defect characteristics	Number of patients
Mandibular ramus, angle and body up to under-chin section excluding the head	2
Mandibular ramus, angle and body up to under-chin section including the head	2
Mandibular angle and the body up to under-chin section	2
Mandibular body in the area of premolar and molar segment	1
Under-chin section of the mandibular body	1

Partial mandibular replacement	3
Mandibular ramus, angle and body including the head and under-chin section of the opposite side	2
Mandibular ramus, angle and body including the head up to premolar and molar segment of the opposite side	2
Complete substitution of the mandible	1

The postoperative tactics regarding the patients by the conventional technique was aimed at early functional load. The postoperative period in all the patients was favorable, without any significant complications. The immediate postoperative period was accompanied by a slight inflammatory reaction in the intervention area which was eliminated by 7-8 days. In 5 people the partial post-radiation tissue necrosis of submandibular and under-chin area in the endoprosthesis projection 2-3 weeks after the surgery was observed which required the removal of devitalized tissues and the elimination of tissue defects by myofasciocutaneous flaps borrowed from the lateral and anterior parts of the neck.

The remote results of treatment (from 1 year to 12 years) showed the absence of the disease recurrence, the normalization of the amount of mouth opening and the functional characteristics of dentoalveolar apparatus. Such events as the implant eruption through the soft tissues in the oral cavity or outward, the fracture and migration of the installed design were not identified.

Fig. 2 shows the X-ray pictures of a 53-year-old patient with the cancer of the mandibular body to the right of III B stage before and 24 months after the surgical treatment.

Fig. 2. The X-ray picture of a patient with a cancerous lesion of the mandible before and after the surgical treatment

4 Summary

Thus, the positive experience of endoprostheses usage of porous nickelid titanium for replacement of different mandibular sections defects including the condylar process made in accordance with the anatomic features of the affected organ allows to make a conclusion about the possibility of full restoration of the lost anatomic and functional characteristics of the dentoalveolar apparatus in this category of patients including their state after the radiation therapy. Due to compliance with the hysteretic behavior of the lost organ and the recipient tissues with the hysteretic behavior of the overall complex endoprosthesis system, the connective tissues on the part of the surrounding implant regions in-grow through the porous implant structure without causing any aggressive body reactions. Osteosynthesis with the devices made of nickelid titanium provides a stable fixation of the endoprosthesis to a mandible fragment and gives the opportunity for early masticatory load. Covering the endoprosthesis body with fibrous or woven thin-profile nickelid titanium by layer-by-layer winding creates the super-elastic system, prevents the implant eruption through the surrounding soft tissues.

Superelastic thin-profile mesh implants fixated on the stumps of the masticatory muscles and the muscles lowering the mandible enable the fixing strength of the latter to the fibrous layer of the prosthesis preventing dissociation, don't impede the muscle contractility and their return to the original position in the process of masticatory apparatus functioning.

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