

Conference paper

## Replacement of Temporomandibular Joint Head Using the Shape Memory Materials

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### Abstract

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In the article the clinical observations of 63 patients with destructive changes of the head of the mandible of various etiologies after its replacement by endoprosthesis based on the porous nickelid titanium were presented. In all cases the obtained result was satisfactory and functional.

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### 1 Introduction

At present, according to the epidemiological studies, the diseases and injuries of temporomandibular joint are found in 14-63 per cent of the population including children and adolescents [4]. The presence of this pathology is often accompanied by pain syndrome, anatomic and functional changes of the masticatory apparatus, aesthetic defects. The appointment of the conservative therapy for the majority of these patients doesn't result in recovery. This category makes up the individuals with the destructive mandible lesions of inflammatory genesis as well as traumatic injuries. All these injuries are characterized by fractures with fragments displacement (including the comminuted ones with the glenoid cavity damage or without it), habitual dislocations of the mandible and other internal joint disorders after the ineffective conservative methods of treatment, deforming temporomandibularosteoarthritis, ankylosis of the temporomandibular articulation, degenerative changes after radiotherapy, anomalies of its development and changes connected with the presence of facial bones' deformity, tumor and tumor-like conditions. In these cases the articular head of the mandible replacement with the complete restoration of the temporomandibular joint functional characteristics is recommended. In this group should be included the

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patients with internal disorders after using the ineffective arthroscopic technologies due to the limited method possibilities.

To restore the mandibular head, a large number of osteoplastic surgeries aimed at the temporomandibular joint reconstruction with the application of autologous and other kinds of allografts as well as their combinations have been recently developed and introduced into the world practice [7, 8, 10-12]. However, these techniques are not able to fully solve the problems faced by the professionals in view of the disease recurrence as the transplanted materials are rejected or resorbed. Besides, the applied grafts don't match the shape of the complex structure of the mandibular condylar process. In this regard, the method of temporomandibular joint endoprosthesis replacement is of particular relevance nowadays. With this purpose many surgeons use the implants of stainless steel, vitallium, titanium, chrome and cobalt alloy, polymers, silicone, ceramics and other materials which do not exhibit the lag effect. [1-3, 5, 6, 9, 13, 14]. It is known that the indicated materials are either rejected or behave like foreign bodies after being placed in tissue defects. This circumstance leads to loosening and displacement of the endoprosthesis as well as the fracture of its fixing part during the process of organism vital activity. The imperfect techniques of connecting the replacement structures with the recipient bone also result in impossible early functional joint load. The usage of titanium plates with screw fastening for this purpose does not ensure the prosthesis stability as this material is not biocompatible, its application method is traumatic and time-consuming.

The problem of the complete connection of the endoprosthesis with the ligament-muscular system is not less relevant as well. The existing design features of endoprostheses, in particular, can't restore the lateral movements of the mandible that leads to the lack of connection of the endoprosthesis head with the lateral pterygoid muscle [2].

Objective: to increase the efficiency of the mandibular head surgical replacement in patients with pathological changes of the temporomandibular joint based on new medical technologies' development using the endoprosthesis of porous nickelid titanium.

## 2 Experimental

In the scientific research Institute of medical materials and implants of shape memory (Tomsk) the endoprosthesis of the mandibular ramus was developed with left and right versions including the head of the temporomandibular joint made of porous and non-porous materials based on nickelid titanium and consisting of superelastic perforated plate to which the permeable porous parts similar in shape and size were fixed. On one side the structure has polished thickening which

corresponds to the mandibular head configuration. To prevent the implant from eruption via the soft tissues, to optimize the configuration as well as the conditions of fusion with the recipient tissues and the fixation of masticatory muscles, the porous part of the endoprosthesis was covered with superelastic mesh thin-profile nickelid titanium made of the 40-60 microns thick yarn by layer-by-layer winding in 2-3 or more layers depending on the operation objectives (Fig. 1). The sizes and the endoprosthesis configuration were determined individually on the basis of X-ray examinations (computed helical tomography - layer-by-layer and three-dimensional images images).



Fig. 1. a - the mandibular head endoprosthesis based on porous nickelid titanium; b - the fixation structures with the shape memory effect; c - the textile thin-profile material based on nickelid titanium

Surgical technique. The access to the lesion focus was performed from retro- and submandibular areas exposing the rear part of the mandibular ramus, the angle and the posterior border of the mandible body. The affected structures of the condylar process were removed by means of osteotomy by cutting towards the corner or there are edge of the ramus. Before removing the osteotomized fragment, the lateral pterygoid muscle was cut off from the last fragment, preliminary having been stitched to use the ligature in subsequent as a conductor. If required, the glenoid cavity was formed with the bone wound surface isolation by the tissue implant made of 40-60 microns thick nickelid titanium and with the cell size less than 240 microns. The endoprosthesis of porous nickelid titanium was inserted in a prepared bed in the optimal infra temporal position with the head

towards the glenoid cavity and it was fixated to the decorticating part of the mandibular ramus external surface with the help of fixation devices of nickelid titanium with shape memory effect. In patients with the ramus deformity and posterior body of the mandible as well as unsatisfactory conditions for effective endoprosthesis fixation, the textile nickelid titanium material was used in addition made of the 40-60 microns thick yarn by circular winding and fixing the interrupted suture. In cases of the neurovascular bundle exposure the latter was moved medially with the preliminary formation of an additional bed. The superelastic mesh thin-profile nickelid titanium implant with a 10-20 mm diameter, 10-25 mm long, made of 40-60 microns thick yarn was fixated on the formed stump of the lateral pterygoid muscle. The muscle tissue along with the implant were stitched by the nickelid titanium yarn by means of which, after the removal of the conductor ligature, the stump of the lateral pterygoid muscle was fixed to the endoprosthesis neck by the interrupted suture. The masticatory and medial pterygoid muscles were stitched together in the area of the lower and rear edge, the wound was sutured layer by layer and drained within 24-48 hours. Postoperative tactics regarding the patients by the conventional technique was aimed at early functional load. In cases of mouth opening limitation during the immediate postoperative period the jaws mechanotherapy was used in 2.5-3 weeks after the surgery.

According to the developed technology, 63 patients of both sexes with pathological conditions aged from 7 to 70 years were treated as shown in Table 1.

Table 1. Distribution of patients in accordance with nosological forms of temporomandibular joint pathology (n=63)

Group of patients	Nosological form	Number of patients
1	Fracture of the mandibular head	10
2	Internal disorders	7
3	Destructive changes of the mandibular head of inflammatory genesis	16
4	Disfynction connected with the mandible deformity	3
5	Unilateral deforming temporomandibularosteoarthrosis	12
6	Bilateral deforming	4

	temporomandibularosteoarthritis	
7	Lateral temporomandibularankylosis	3
8	Bilateral temporomandibularankylosis	6
9	Tumor and tumor-like lesions of the mandibular head	2

The first group included the patients with the mandibular head fractures with fragments displacement, the comminuted and shattered fractures of the condylar process of a mandible; the second group consisted of the patients with the internal disorders characterized by the constant not fitted displacements, ruptures and abruptions of the articular disk; the third group involved the patients with the destructive changes of a mandibular head due to hematogenous osteomyelitis, rheumatoid, gouty arthritis and the arthritis of different etiology; the fourth group was made up by the patients with the congenital and acquired deformities of a mandible combined with the secondary dysfunctional stipulated by the anatomic disorders from the side of temporomandibular joints; in the fifth and sixth groups were the patients with the productive changes of the mandibular head of various genesis; in the seventh and eighth groups were included the patients with the fibrous and bony ankylosis of a temporomandibular articulation including those ankyloses which are combined with the lower micrognathia; the ninth group comprised the patients with benign tumors and cystic lesions of the mandibular head.

During the preoperative period all the patients were performed the clinical examinations including the common blood and urine tests, the biochemical blood parameters were studied, the rheumatoid factor in blood serum was detected, X-ray diagnosis in the form of computed tomography of the temporomandibular joints in open and closed mouth condition was carried out. If required, before the surgical intervention some procedures were performed directed to the normalization of physical body findings. The treatment outcomes were assessed on the basis of clinical observation, the postoperative control of the endoprosthesis standing was carried out by means of the skull X-ray survey in frontal and lateral projections as well as computed tomography during 6, 12, 24, 36, 48, 60 and more months.

### 3 Results and discussion

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 mainly eliminated by 5-8 days, the primary wound healing was determined. The mandible movements were restored with the elimination of inflammation and swelling of tissues in the intervention zone (12-18 days). In 1-1,5 months the patients could take food properly, any negative effects associated with the operation were not marked. During that period in all cases the complete mouth opening, restrictions of lateral movements of the mandible were not determined, palpation revealed the absolute fusion of the implant with the mandibular bone. On examination the patients after 12 months or more they had no complaints, the movements of the mandible were preserved in full, the functional disorders on the part of the temporomandibular joints were not detected. The implants position radiographically was satisfactory, the destructive changes on the part of the recipient bone were not determined. The eruption of the implant through the soft tissues in the oral cavity or outward, the fracture and migration of the installed construction and fixed elements as well as other cases were not observed.

Figure 2, 3 shows the patients radiographs with the temporomandibular joint pathology before and after the endoprosthesis replacement.

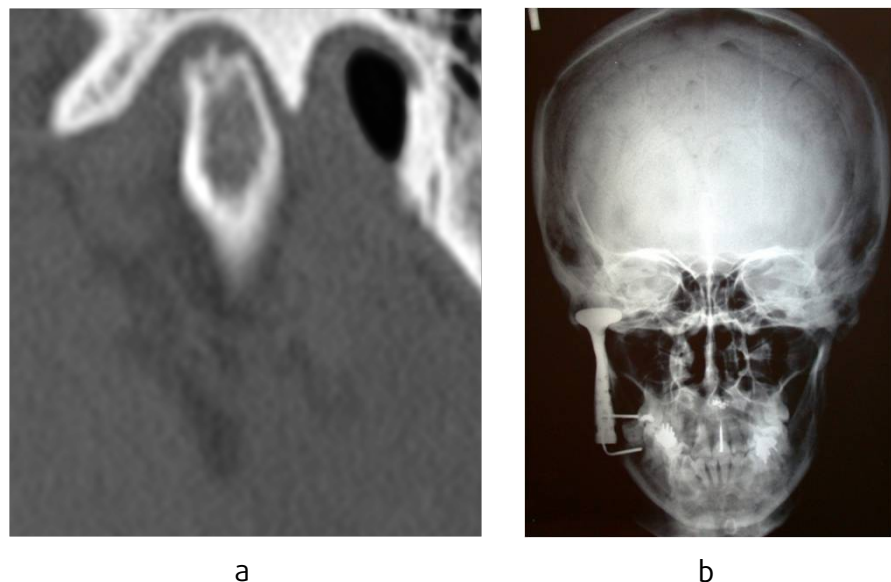


Fig. 2. a – A radiographic picture of the right mandibular head in a 37 year-old patient with destructive temporomandibular osteoarthritis; b – a radiographic picture of the patient 3 years after arthroplasty of the right mandibular head by the endoprosthesis of porous nickelid titanium



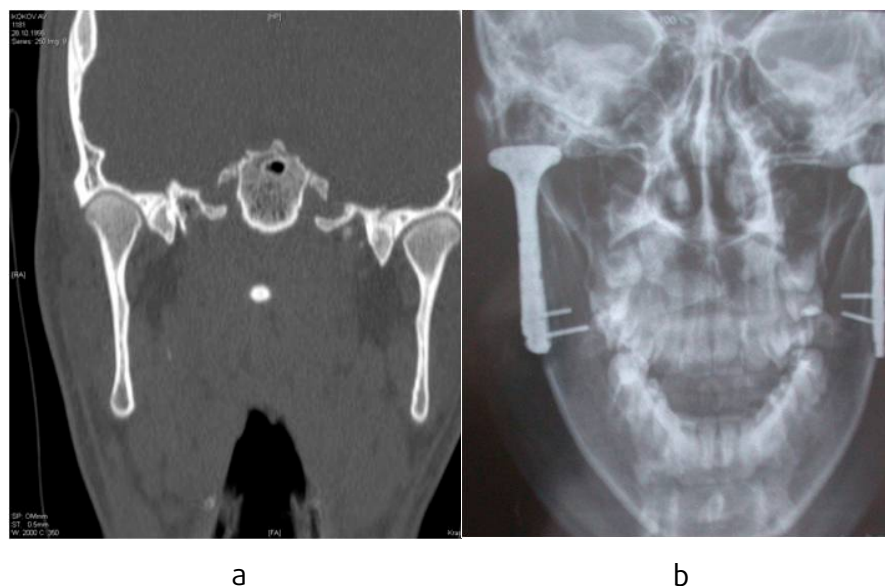


Fig. 3. a – A radiographic picture of a 16 year-old patient with bilateral temporomandibularosteoarthritis; b – a radiographic picture of the same patient 2 years after bilateral endografting of the mandibular heads by the endoprosthesis of porous nickelid titanium

#### 4 Summary

The results of the mandible head replacement analysis in patients with the temporomandibular joint pathology showed high efficiency of the endoprosthesis usage based on porous nickelid titanium. Due to biochemical and biomechanical compatibility of nickelid titanium with the body tissues unlike other materials (not showing the lag effect in terms of loading and unloading), these implants after placement in tissue defects are not rejected and the connective tissues from the recipient areas in-grow through the porous structure of the implanted material without causing any aggressive reactions, forming a single organotypic regenerate with the latest one. The polished part of the endoprosthesis excludes its fusion with the surrounding tissues, thereby maintaining the required amount of movements of the mandible. The fixation constructions with the shape memory effect provide a stable fixation of the endoprosthesis with the bone structures of the mandible and early functional loading, are easy to use, not time-consuming, which undoubtedly has a positive impact on the final outcome. Covering the porous part of the implant with textile thin-profile nickelid titanium creates the optimal conditions for the implanted material with the body tissues' interaction as well as allowing you to vary the configuration of the replaced tissues. The

proposed method of connecting the endoprosthesis with the lateral pterygoid muscle affords to keep the lateral movements of the mandible. Biocompatibility of porous nickelid titanium in combination with textile thin-profile nickelid titanium coating provides the optimal conditions for the muscle with the prosthesis neck fusion.

## References

- [1] Y.V. Shorstov, O.Z. Topolnitsky, A.P. Krasnoydr, Analysis of the results of endoprosthetic treatment of young children presenting with ankylosis of the temporo-mandibular joint and the use of novel technologies for the improvement of its outcome, *Russ. Stomat. Journal.* 3 (2011) 36-39.
- [2] P.N. Mitroshenkov, Reconstruction of the temporo-mandibular articulation by the endoprosthetic technique, *Annals of Plastic, Reconstructive and Aesthetic Surgery.* 1 (2007) 33-42.
- [3] V.N. Antsiferov, N.B. Astashina, G.I. Rogozhnikov et al., Evaluation of the main characteristics of new combined implantation systems for the arthroplasty of the temporomandibular joint, *Fundamental Research.* 1-2 (2013) 20-23.
- [4] R.S. Ibragimova, A.M. Bokaeva, D.E. Fedorov et al., The prevalence of functional disorders of the temporomandibular joint in children, adolescents and young adults, *Vestnik of KazNMU.* 4 (2013) 210-213.
- [5] V.A. Semkin, N.A. Rabukhina, S.I. Volkov. Pathology of the temporomandibular joints, *Practical Medicine [in Russian]*, Moscow, 2011.
- [6] G. Bai, C. Yang, D. He et al., Application of fossa bone graft to stabilize stock total joint prosthesis in temporomandibular joint surgery, *J. Cranio-maxillofac. Surg.* 43 (2015) 1392-1397.
- [7] Y. Liu, J. Li, J. Hu et al., Autogenous coronoid process pedicled on temporal muscle grafts for reconstruction of the mandible condylar in patients with temporomandibular joint ankylosis, *Oral. Surg., Oral. Med., Oral. Pathol., Oral Radiol., Endod.* 109 (2010) 203-210.
- [8] S.M. Balaji, Bifid mandibular condyle with tempromandibular joint ankylosis – a pooled data analysis, *Dent. Traumatol.* 26 (2010) 332-337.
- [9] H. Huang, K. Su, L. Fuh et al., Biomechanical analysis of a temporomandibular joint condylar prosthesis during various clenching tasks, *J. Cranio-maxillofac. Surg.* 43 (2015) 1194-1201.
- [10] A. Khadka, J. Hu, Autogenous grafts for condylar reconstruction in treatment of TMJ ankylosis: current concepts and considerations for the future, *Int. J. Oral. Maxillofac. Surg.* 41 (2012) 94-102.
- [11] J. Ma, H. Jiang, L. Liang, Interpositional arthroplasty versus reconstruction arthroplasty for temporomandibular joint ankylosis: A systematic review and meta-analysis, *J. Craniomaxillofac. Surg.* 43 (2015) 1202-1207.
- [12] K. Pang, S.W. Choi, S. Byun et al., Mandibular condylar-ramal reconstruction using vascularisedcostochondral graft based on the serratus anterior composite flap, *J. Craniomaxillofac. Surg.* 43 (2015) 1184-1193.



- [13] N.D. Roo, L.V. Doorne, A. Troch et al., Quantifying the outcome of surgical treatment of temporomandibular joint ankylosis: A systematic review and meta-analysis, *J. Craniomaxillofac. Surg.* 44 (2016) 6-15.
- [14] A. Ramos, M. Mesnard, The stock alloplastic temporomandibular joint implant can influence the behavior of the opposite native joint: A numerical study, *J. Craniomaxillofac. Surg.* 43 (2015) 1384-1391.