TRAUMATOLOGY

OUR FIRST EXPERIENCE WITH THE USE OF HYDROXYAPATITE PASTE TO IMPROVE THE INTEGRATION OF THE GLENOID COMPONENT OF A REVERSE PROSTHESIS WITH A BONE DEFECT OF THE SCAPULA (CASE REPORT)

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ABSTRACT

The problem of reverse shoulder arthroplasty with various deformities of the glenoid is relevant for modern traumatology and orthopedics. In addition to various defects, the methods of solving which can be eccentric reaming of the glenoid by milling cutters, bone autoplasty, augmentation, the use of individual implants, orthopedic traumatologists have to deal with a decrease in the mineral density of the bone tissue of the scapula.

***The aim of this study** is to demonstrate the possibility of using hydroxyapatite paste together with bone autoplasty in revision shoulder arthroplasty in conditions of a massive defect and reduced glenoid bone density.*

***Discussion.** The article presents a case of surgical treatment of a patient with the consequences of a fracture of the proximal metaepiphysis of the humerus and local osteoporosis of the glenoid by the method of reverse shoulder arthroplasty in combination with the use of hydroxyapatite paste. A detailed description of the operation technique is given.*

***Conclusion.** The described clinical case demonstrates the effectiveness of the technique of using hydroxyapatite preparations for shoulder joint replacement.*

***Key words:** shoulder joint, omarthrosis, reverse arthroplasty, glenoid, hydroxyapatite,* osteoporosis

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НАШ ПЕРВЫЙ ОПЫТ ИСПОЛЬЗОВАНИЯ ГИДРОКСИАПАТИТНОЙ ПАСТЫ ДЛЯ УЛУЧШЕНИЯ ИНТЕГРАЦИИ ГЛЕНОИДАЛЬНОГО КОМПОНЕНТА РЕВЕРСИВНОГО ПРОТЕЗА ПРИ КОСТНОМ ДЕФЕКТЕ ЛОПАТКИ (СЛУЧАЙ ИЗ ПРАКТИКИ)

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РЕЗЮМЕ

Проблема реверсивного эндопротезирования плечевого сустава при различных деформациях гленоида является актуальной для современной травматологии и ортопедии. Кроме различных дефектов, методами решения которых могут быть эксцентричная разработка гленоида фрезами, костная аутопластика, аугментация, применение индивидуальных конструкций, травматологам-ортопедам приходится сталкиваться со снижением минеральной плотности костной ткани лопатки.

***Целью** настоящего исследования является демонстрация возможности применения пасты с гидроксиапатитом совместно с костной аутопластикой при ревизионном эндопротезировании плечевого сустава в условиях массивного дефекта и сниженной плотности костной ткани гленоида.*

***Обсуждение.** В статье представлен случай оперативного лечения пациентки с последствиями перелома проксимального метаэпифиза плечевой кости и локальным остеопорозом гленоида методом реверсивного эндопротезирования в сочетании с применением гидроксиапатитной пасты. Дано подробное описание техники операции.*

***Заключение.** Описываемый клинический случай демонстрирует эффективность методики применения препаратов гидроксиапатита при эндопротезировании плечевого сустава.*

***Ключевые слова:** плечевой сустав, омартроз, реверсивное эндопротезирование, гленоид, гидроксиапатит, остеопороз*

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The problem of reverse shoulder arthroplasty with various deformities of the glenoid is relevant for modern traumatology and orthopedics [1–7]. In addition to various defects, the methods of solving which can be eccentric reaming of the glenoid by milling cutters, bone autoplasty, augmentation, the use of individual implants, orthopedic traumatologists have to deal with a decrease in the mineral density of the bone tissue of the scapula [8–10]. Local osteoporosis of the glenoid surface of the scapula is at least a risk of aseptic instability of the implanted metaglene; also in case of a pronounced decrease in mineral density of the bone tissue of the scapula, stable metaglene placement is not possible at all. In addition to systemic therapy of osteoporosis, the surgical solution of the problem is the use of grafts, special components for more stable fixation (primary-revision metaglene with revision stem, extended screws, etc.), preparations with osteostimulating effect in the form of granules, plates, pastes based on hydroxyapatite [1–7, 11–13].

Synthetic hydroxyapatite with the formula $Ca_{10}(RO_4)_6(OH)_2$ is identical in its chemical properties to the mineral composition of bone tissue – biological hydroxyapatite. Modern science has revealed that blood and intercellular matrix proteins (fibronectin, vitronectin, fibrinogen, osteocalcin, bone sialoproteins, immunoglobulins, albumin, etc.) are absorbed on the surface of bioactive material immediately after its implantation into the tissue environment [14]. In turn, the surface of any implant almost never comes into direct contact with body tissues [14]. The layer of proteins absorbed on the surface of the biomaterial initiates cell adhesion and also provides information transport to cells through cell adhesion receptors – integrins [14]. Fibronectin and vitronectin, which belong to the family of integrins, are involved in the adhesion processes of osteoblasts and their progenitor cells to the surface of calcium-phosphate biomaterials [14]. The morphology, amount and distribution of absorbed substances depend on the physicochemical properties of the biomaterial surface such as electrical charge, chemical composition, roughness, etc. [14]. Hydroxyapatite preparations serve as a gradually resorbable matrix with osteoconductive and osteoinductive properties to which osteoblast precursors attach with subsequent bone growth and formation [14]. Literature data show positive experience of using cement and pastes with hydroxyapatite together with orthopedic implants in order to increase their stability, especially in case of unsatisfactory bone quality [15, 16].

THE AIM OF THE STUDY

To demonstrate the possibility of using hydroxyapatite paste together with bone autoplasty in revision shoulder arthroplasty in conditions of a massive defect and reduced glenoid bone density.

CLINICAL CASE STUDY

Patient K., born in 1949, starting from January 31, 2022 was treated in the adult orthopedics department of the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia with pain and restricted movement of the right shoulder joint. According to the patient and documentation, the injury occurred on December 19, 2017 as a result of a fall on her right shoulder at home. On emergency indications on December 19, 2017 osteosynthesis of a fracture of the neck of the humerus with a plate was performed, in dynamics – lack of fracture union. Anamnestically, pain syndrome was up to 6 points as per the visual analogue scale (VAS); limb function was assessed with a score of 61.7 as per the DASH (Disability of the Arm, Shoulder and Hand) questionnaire. Due to impaired limb function and pain syndrome, the plate was removed 8 months after surgery (Fig. 1).

Due to the formation of pseudoarthrosis defect of the proximal humerus and pronounced impairment of the upper limb function, shoulder hemiarthroplasty was performed on September 23, 2019 (Fig. 2).

Taking into account the initial hypotrophy of the deltoid muscle from inactivity, tendon failure of the supraspinous muscle, the joint was not functional after arthroplasty of the humeral head (impaired function of the upper limb – 53.3 DASH points). In this regard, repeated shoulder arthroplasty with a reverse shoulder system was performed on June 10, 2021 (Fig. 3).

The early postoperative period proceeded without complications, the patient underwent rehabilitation courses and noted improvement of joint function. In the dynamics, the patient noted a feeling of instability in the joint, worsening of the limb function (change in the DASH questionnaire scores from 35.8 to 65.8 points), consulted a doctor and on January 31, 2022 was hospitalized in the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia (Fig. 4).

The patient was further examined at the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia: radiological and computed tomography (CT) data revealed aseptic instability, migration of the entire glenoid component of the endoprosthesis (metaglene with glenosphere), glenoid bone resorption with the formation of a pronounced medializing bone defect. Glenoid bone density was also markedly reduced (with areas with a mean value of about 50 HU), despite the fact that the patient had been previously treated for osteoporosis with antiresorptive therapy (Figure 5).

With regard to the migration of the glenoid component, the volume and type of the medializing defect, and unsatisfactory bone quality parameters in the implantation zone, a decision was made to perform revision reverse arthroplasty using revision metaglene, bone autoplasty, and bioactive paste based on hydroxyapatite to improve osseointegration of metaglene and screws. In order to reduce surgical aggression and prevent an increase in the number of surgical interventions, the surgery for removal of the migrated component and revision arthroplasty were performed in a single stage.

a ***b*** ***c*** ***d*** ***e***

FIG. 1.

Patient K., X-ray picture of the resulting fracture of the humerus, postoperative radiographs of the patient: ***a*** *– X-ray of the fracture of the humerus;* ***b*** *– X-ray of the patient after osteosynthesis;* ***c***–***e*** *– X-ray picture after removal of the plate: the formation of a defect-pseudoarthrosis of the proximal humerus*

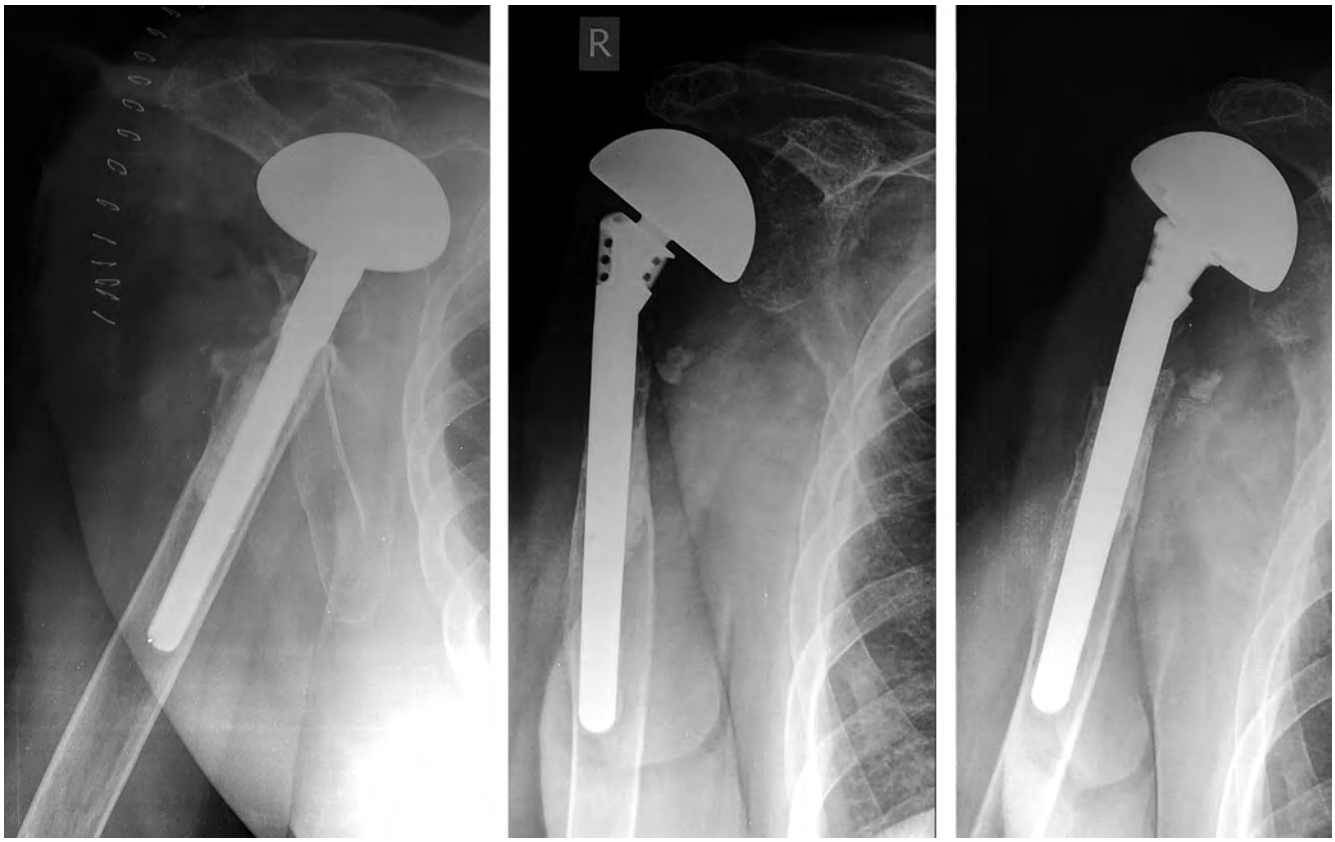
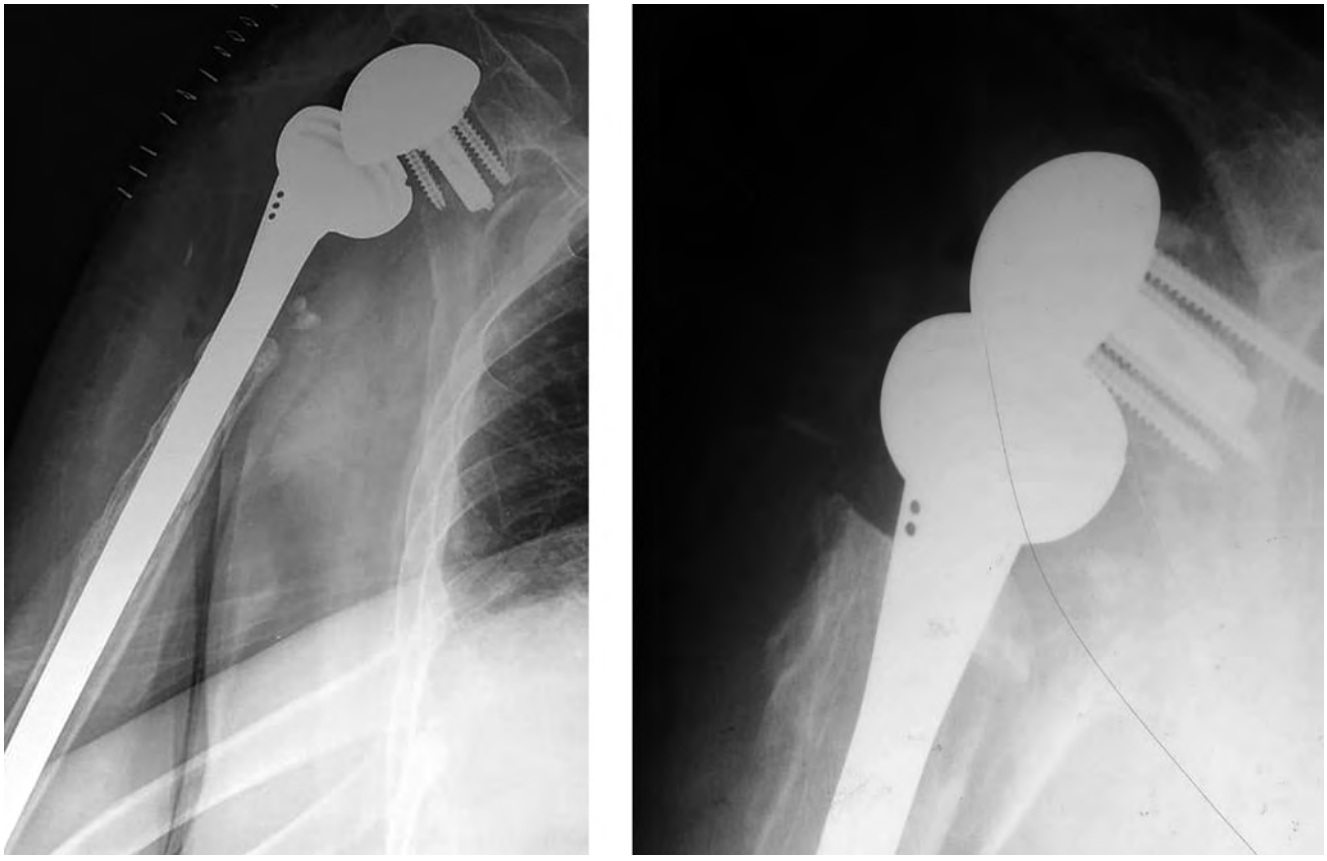


FIG. 2.
Patient K., X-ray after shoulder hemiarthroplasty

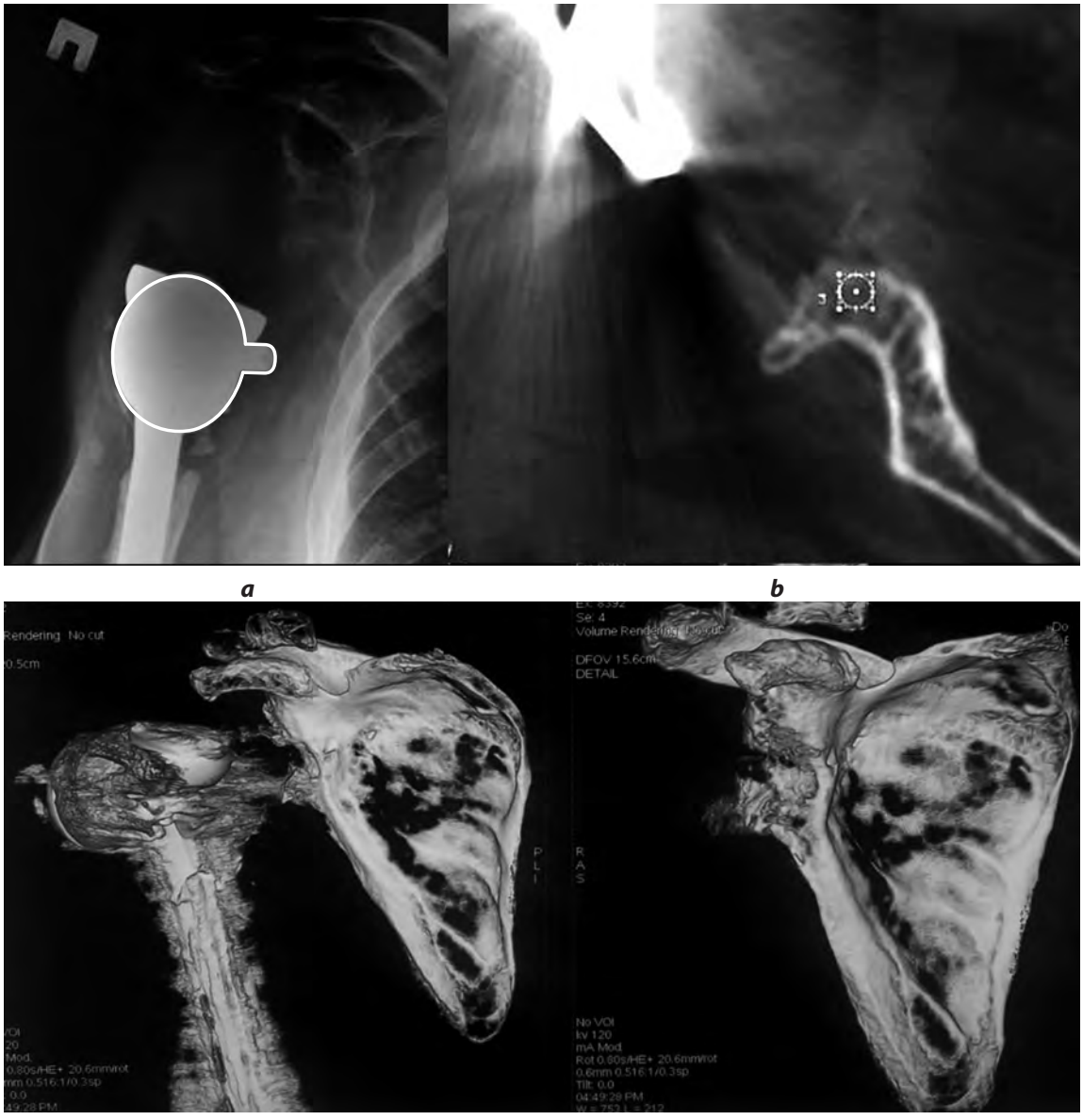


a ***b***

FIG. 3.
*Patient K., X-ray picture straight after (**a**) and 3 months after (**b**) revision reverse shoulder arthroplasty*

FIG. 4.

Patient K., clinical picture at the time of contacting the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov



a ***b*** ***c***

FIG. 5.

Patient K., X-ray picture of instability, migration of the scapular component of the endoprosthesis, destruction of the glenoid: ***a*** *– X-ray of the shoulder joint, the outline of the scapular component is circled in white;* ***b*** *– CT is an axial section of the glenoid, a bone defect is visualized;* ***c*** *– three-dimensional modeling of the scapula with visualization of the glenoid according to CT*

Surgery technique

The first stage of the operation after surgical approach was the removal of the glenoid complex of the endoprosthesis components, and the polyethylene insert with signs of wear was removed (Fig. 6a). Intraoperatively, material was collected for microbiologic examination. Removal of scar-altered tissues and glenoid skeletonization was performed. E3 glenoid deformation according to the Gupta, Thussbas, Koch, Seebauer classification was characterized by a significant loss of bone volume and medialization of the glenoid articular pad (Fig. 6b, Fig. 7).

a ***b***

FIG. 6.

*Patient K., intraoperative photographs: **a** – wear mainly on the upper edge of the endoprosthesis liner; **b** – type E3 predominantly on the medial surface of glenoid according to the classification of Gupta, Thussbas, Koch, Seebauer*

FIG. 7.

Scheme showing E3 glenoid deformity (30–60 % of the articular surface of the scapula) [5]

The next step, taking into account the unsatisfactory bone quality, was the eccentric processing of the glenosphere with a milling cutter until the site for graft and metaglene placement was formed. A surgical approach to the iliac crest was performed, an osteotome was used to take an autograft of the necessary shape and size for adequate lateralization of the glenosphere. The lateralizing graft was placed on the prepared glenoid site and fixed with a wire (Fig. 8).

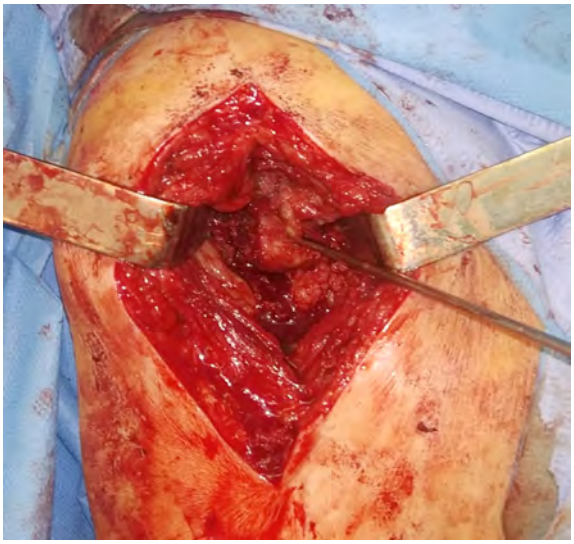


FIG. 8.

Patient K., bone autoplasty of the glenoid: the bone graft was placed along the guide wire

The canal of the extended metaglene stem was reamed through the graft. To improve osseointegration of metaglenes and osteoreparation, syringe injection of hydroxyapatite paste into the formed canal was performed; metaglenes with an extended stem were implanted through the graft.

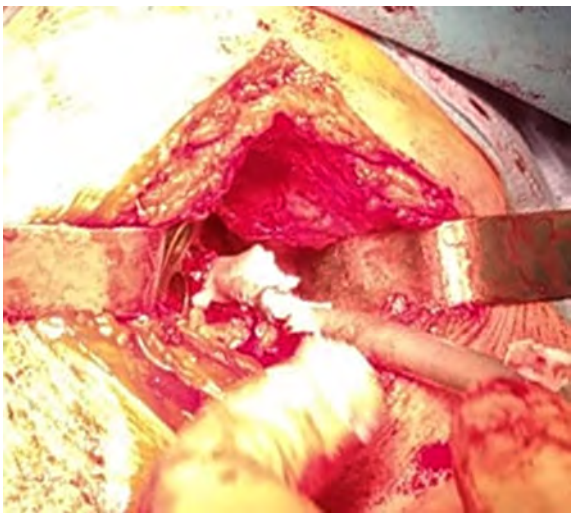


FIG. 9.

Patient K., application of osteoplastic material to the screws to be installed

Based on the preoperative planning, the screw channels were reamed through the areas with the maximum compact content of dense bone tissue, hydroxyapatite paste was injected into the channels with a syringe according to the method described above, and the preparation was additionally applied to the screws themselves (Fig. 9). The screws, glenosphere and liner were inserted, the endoprosthesis was repositioned, and the wounds were sutured.

Postoperative period

Postoperative X-ray control was performed. X-rays performed in two projections visualize a correctly, stably placed reverse shoulder arthroplasty with the offset enlarged at the expense of the bone graft (Fig. 10).

The postoperative period proceeded without complications. The patient received antibacterial prophylaxis for purulent inflammatory complications, anticoagulant prophylaxis, symptomatic and gastroprotective therapy. According to the microbiological study of intraoperative material, no microflora growth was detected. Electrical stimulation of the deltoid muscle and mechanotherapy was started in the early postoperative period in the hospital. After discharge, the patient continued rehabilitation actions, physiotherapy treatment under the supervision of an orthopedist and rehabilitologist. The patient was consulted by osteoporosis treatment specialists at the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia, received osteotropic drug therapy. There were no purulent inflammatory complications.

Computed tomography was performed 3 months after the intervention to evaluate metaglene osseointegration and graft remodeling. Tomographic sections showed rearrangement and autograft union, stable placement of the prosthesis components without signs of peri-implant bone tissue reaction (Fig. 11, 12, 13).

FIG. 10.
Patient K., postoperative X-ray

FIG. 11.
Patient K., X-ray control in the long term after surgery

The medium-term clinical results were evaluated after 5 months; considering the complexity of the case, improvement in movement amplitude was achieved, the patient was free of pain, and limb function was evaluated with a DASH score of 25.8 (Fig. 14).

DISCUSSION

National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia has accumulated extensive experience in the use of bioactive materials based on hydroxyapatite and collagen for the replacement of bone defects, plasty of osteochondral injuries, stimulation of reparative osteo- and chondrogenesis, treatment of osteomyelitis, and use in onco-orthopedics. Positive osteoinductive and osteoconductive properties of these materials were revealed. The paste used clinically is a non-hardening hydroxyapatite mass that completely fills the bone defect. The material attracts biomolecules necessary for the regenerative process and, along with a localized increase in ion levels, contributes to its osteostimulatory effect. Osteoblast colonization and vascularization occur throughout the paste implant. Cell-mediated resorption of the material occurs over several months concurrently with the formation of mature bone.

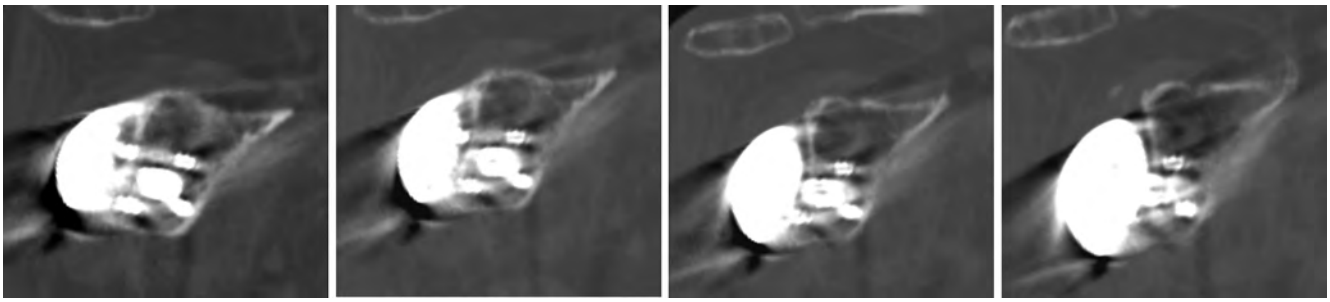


FIG. 12.
Patient K., CT control in the long term after surgery

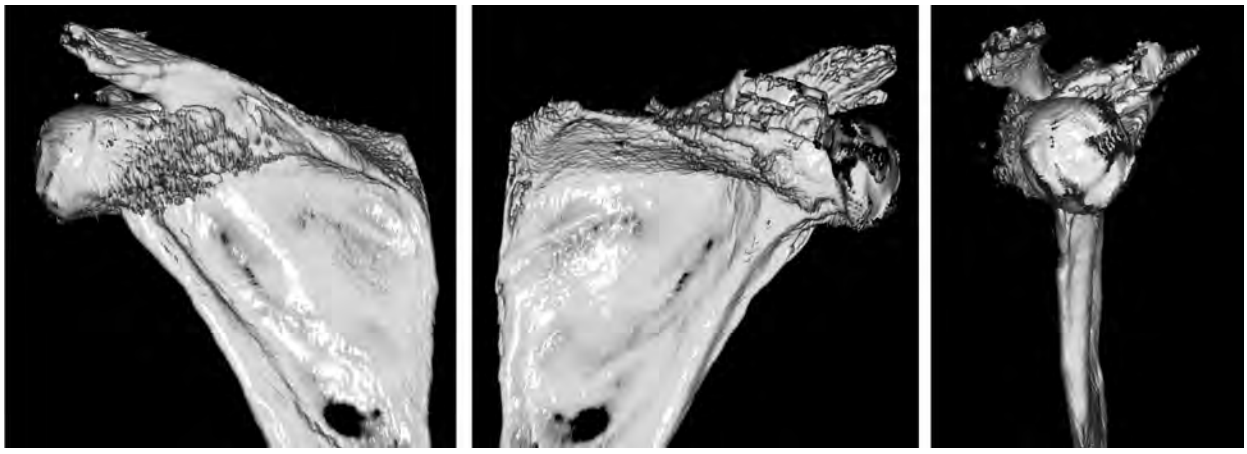


FIG. 13.
Patient K., CT control in the long term after surgery: 3D model of the scapula with the installed glenosphere

FIG. 14.
Patient K., medium-term functional outcome

CONCLUSION

This clinical case illustrates the possibilities of effective application of bioengineering achievements in the form of hydroxyapatite osteoactive material in the form of a paste in complex revision shoulder arthroplasty. This technique makes it possible to level out the undesirable consequences of reduced glenoid bone mineral density, which is aseptic instability of the glenoid component of the endoprosthesis. The use of cement with hydroxyapatite and the combined use of hydroxyapatite in the form of gels, granules, pastes to improve screw fixation has already proven effective in the practice of vertebroplasty and neurosurgery. The positive experience of using this assistive technique in spinal surgery and the present clinical case may justify the need for further development of this problem and introduction of the technology into the practice of shoulder arthroplasty.

Conflict of interest

The authors of this article declare the absence of a conflict of interest.

Standards of ethics

Compliance with the bioethical norms of the study was confirmed by the results of the meeting No. 3 of March 17, 2022 of the local ethics committee of the National Medical Research Center for Traumatology and Orthopedics named after N.N. Priorov of the Ministry of Health of Russia; the study was approved for publication.

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