Morphological Features of Peri-Implant Tissue after Placement of Dental Implants into the Extraction Socket

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In experiments on pigs, bone regeneration was studied after implantation of implants with four cylindrical roots and support cone and laminar crest-shaped implants with shape memory effect. The implants were placed to the extraction socket (mandibular canine) and through the socket immediately after tooth extraction using osteoplastic material or without using collapan-L. The use of collapan-L accelerated regeneration of peri-implant tissue and provided stable fixation of dental construct in the bone over 3 months after surgery, which can be relevant for determining timing of prosthodontic therapy and constructional features of prosthesis.

Key Words: *extraction socket; implantation; peri-implant tissue*

After tooth extraction, the loss of the bone tissue in the defect zone reaches $^1/_6$-$^1/_3$ of the original volume with the formation of saddle-type bone defect of the alveolar ridge as a result of vertical and horizontal atrophy of the alveolar bone [7]. During prosthetics by the method of dental implantation, the choice of types and sizes of dental implants is significantly narrowed due to vertical and horizontal reduction of the alveolar processes. A cosmetic defect appears in the saddle-shaped region at the extracted tooth site during prosthodontic treatment [1,2,5,6].

A method for rapid implantation of screw titanium structures [3] and shape-memory cylindrical implants (CI) into the extraction socket was proposed. It was proven that the formation and restructuring of the bone tissue directly depend on functional loads. Restoration of the chewing ability as soon as possible after tooth (teeth) loss prevents atrophy of the alveolar process in the extraction socket [4,5]. However, regenerate morphology in the area of shape-memory implants placed into the extraction socket and through the fresh extraction socket and the impact of osteoplastic materials on the quality of newly formed tissue are still poorly studied.

The purpose of the study was to investigate experimentally the structure of peri-implant tissue surrounding CI and shape-memory laminar dental implants and the impact of collapan-L (CL) on the quality of the regenerate.

MATERIALS AND METHODS

In the experiment, six pigs at the age of 1.5 months weighing 25-20 kg were used. In group 1 animals (n=3), shape-memory CI was placed into the canine extraction socket on the right side of the mandible. On the right side, a shape-memory laminar implant (LI) was introduced through the canine extraction socket. Slit-like spaces between the bone and implant were filled with osteoporotic material based on hydroxyapatite with antibiotic lincomycin (CL), granule size No. 2. In group 2 animals (n=3), implantation of dental constructs was performed without the use of osteoplastic material.

The surgery and monitoring were performed under vivarium conditions Novokuznetsk State Institute for Advanced Medical Training. Graduate veterina-

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rian carried out anesthesia, monitoring of the animals before and after surgery, and euthanasia with the use of electroshock.

The following experimental implants were manufactured: six four-rooted CI with supporting cone, intrabone body lengths of 8 mm, diameter 3.5 mm; six four-rooted LI, intrabone body length of 8 mm, horizontal size 25 mm. Active elements of shape-memory implant were oppositely separated by 2 mm. The height of intrabone implant end protruding into the oral cavity strictly corresponded to canine crown height of experimental animals.

Thirty minutes after premedication, 1 ml diazepam and 10 ml kalipsol were intravenously injected. In the area of surgical access, local anesthetic was administered (Mepivacaine, 1 ml per 30 mg).

The left and right canine teeth of the mandible were removed with forceps. For implantation of CI, the canine extraction socket of the mandible was deepened by 2 mm with a 3.4-mm cutter.

On the left side, linear cut with relaxing incisions on slopes was performed through the canine extraction socket along the crest of the alveolar process. A mucous-periosteum flap was made, and the location of the implant was determined with LI template. Through the canine extraction socket, the implant bed was formed with 1-mm cutter along the alveolar process.

In group 2 animals, CI with the support cone were cooled with Frisco-Spray, the active leafs of CI were drawn together in a common contour with the body and positioned into the prepared bed 1 mm below the alveolar bone. In group 1 animals, the socket was loosely filled with granules of CL before implantation. After implant placement, its back was covered with CL granules, the mucosa was mobilized, and two interrupted sutures were made.

In group 1 animals, the implant bed and the left canine extraction socket were filled with granules of CL. LI was cooled to 0-1^{o}C, and the active radicals of CI were put together in common contour with its body. The implant was placed into the prepared bed. Slit-like spaces between the bone and implant were filled with CL, and the mucous-periosteum flap was sutured. In group 2 animals, osteoplastic materials were not used.

After anesthesia, operated animals were kept in a 15-m^2 special room equipped with showers and ventilation. Regular wet mopping and bathing of pigs were done. The first feeding with milk porridge was 3 h after surgery. Rectal temperature (38.8-39.0^{o}C) was normal, the animals were active and were daily examined by a veterinarian. After 7 days, the pigs were transferred from the post-operative unit to warm ventilated rooms. Each group of animals was kept in separate cages labeled with tags indicating the experiment code.

Wounds healed within 5 days after surgery, there were no cases of dehiscence and suppuration. Pigs have grown in accordance with the functional norm.

Three months after implantation, the animals were sacrificed by electroshock. The weight of the animals before slaughter was 60-70 kg. After death, the mandible was isolated and cleansed from soft tissue. Fixation of implants in the alveolar process was tested mechanically by rocking and distraction with crampon forceps. The position of all implants was stable. There were no signs of gingivitis around the implant necks.

Bone blocks of the lower jaw with implants in the alveolar process were sawn with a circular saw and cut laterally to expose the intrabone body of the implant. Macropreparations were examined and photographed.

For histological study, the bone tissue was taken in the region of the implant root, in the cervical area, in the region of canine socket from the bone blocks with LI and from the intact bone tissue of the mandible alveolar process.

Bone sections were wrapped with gauze, labeled, and immersed in 7% formalin solution. Histological sections for microscopy were stained with hematoxylin and eosin.

Bone blocks with implants were dried at 50^{o}C and transported to the Institute of Strength Physics and Material Science to determine the degree of mineralization of peri-implant bone tissue as an indirect sign of its maturity.

Analysis of calcium and phosphorus in the experimental animals was performed using a Quant'X 600 spectrometer. Quantitative elemental analysis in biosamples was carried out by the dependence of the characteristic X-ray emission intensity from the element concentration, using calibration curves determined experimentally. The relative error of quantitative analysis did not exceed 0.01%.

RESULTS

Examination of macropreparations showed that the implants were surrounded by the bone tissue, which structurally did not differ from the surrounding bone. CI body in the bone could hardly be separated from the bone. In the region of roots of LI installed in the sockets, the structure of bone tissue was looser (mesh), but it could be separated from the implant only with a scalpel.

In group 2, the position of dental implants in the mandible was stable, the mobility was absent. Cross section of the mandible at the implant–bone interface showed that the bone structure similar to adjacent areas of the lower mandible adjoins the CI. Dense cartilage and lamellar bone tissue were seen around

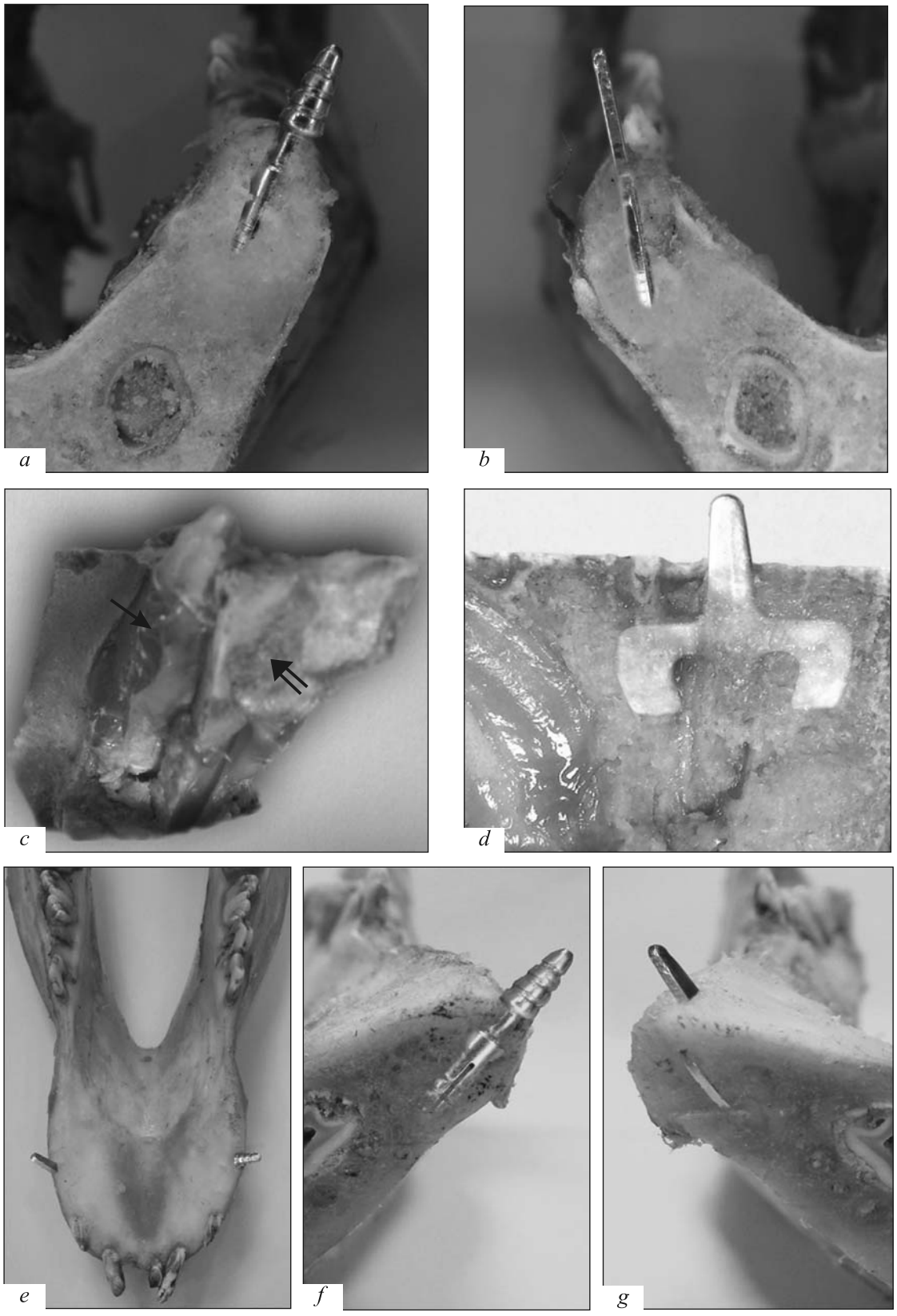

Fig. 1. The lower jaw in experimental animals. *a*, *b*) saw cuts of the jaw in group 1 animals. Implants are surrounded by bone tissue. Bone block after longitudinal splitting and extraction of the implant. Formation of the tooth standing next to the implant was not disturbed; *c*-*g*) a sample of the lower jaw (group 2). The implants along the perimeter are surrounded by the bone tissue with inclusions of dense cartilage tissue. Osteointegration of porous implants 1.5 years after surgery. Single arrow: growing tooth; double arrow: removed implant bed.

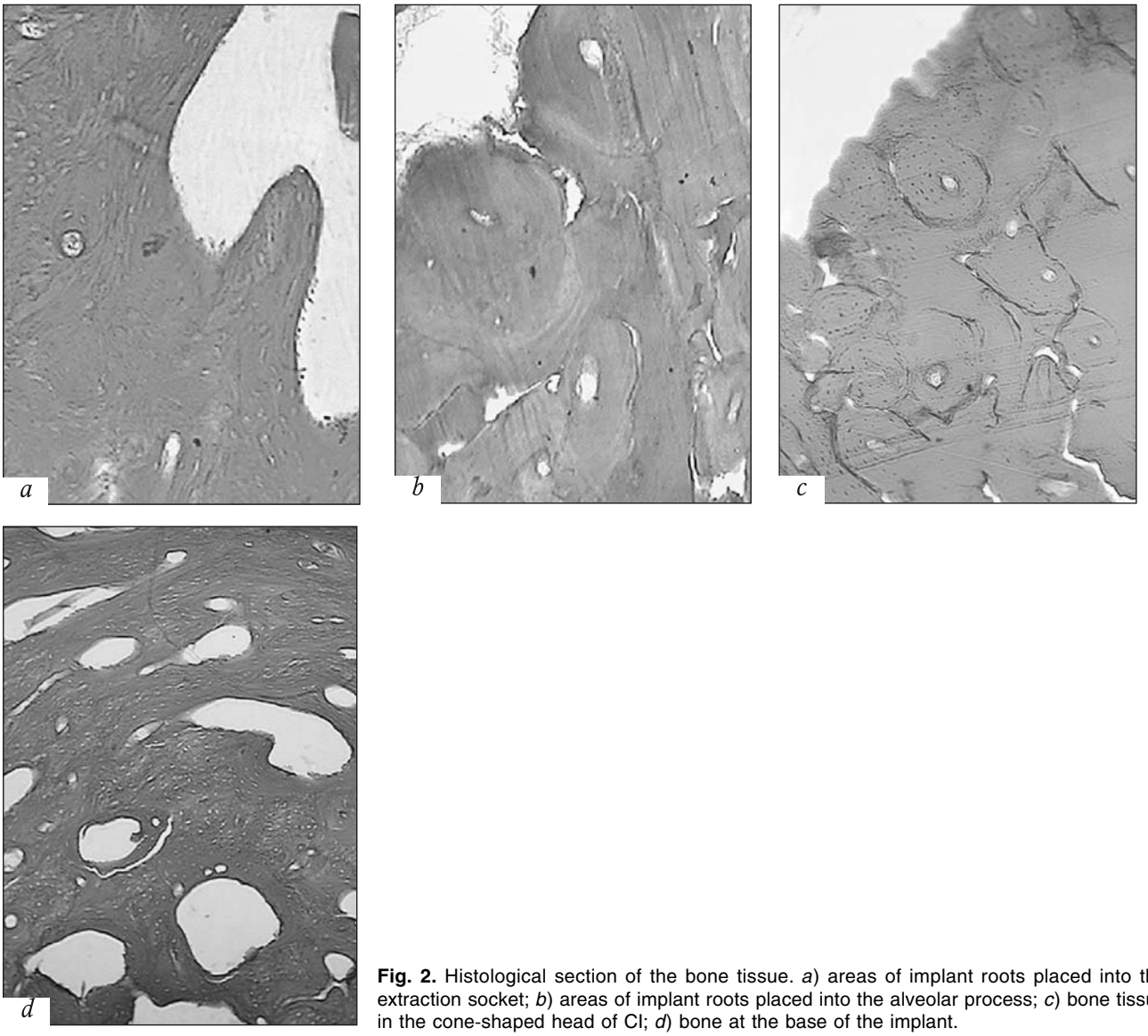

Fig. 2. Histological section of the bone tissue. *a*) areas of implant roots placed into the extraction socket; *b*) areas of implant roots placed into the alveolar process; *c*) bone tissue in the cone-shaped head of CI; *d*) bone at the base of the implant.

LI (Fig. 1). After longitudinal splitting of the jaw we found that the formation of the tooth adjacent to the implant was not disturbed (Fig. 1, *b*).

Histological examination of preparations from the socket region in group 1 animals showed that LI was surrounded by newly formed bone tissue with a pronounced trabecular network, significant number of blood vessels, osteocytes, fibroblasts, and other cells (Fig. 2, *a*). In the slides made at the level of LI roots positioned outside of the socket, the mature bone tissue with formed, primarily not closed osteons, was found. A small amount of blood vessels and osteo-

TABLE 1. Phosphorus and Calcium Content in Peri-Implant Tissue and Intact Areas of the Lower Jaw in Experimental Animals **(*M*±*m*)**

Chemical element	Intact region of the mandible	Group 1		Group 2	
		area of the extraction socket	area outside the extraction socket	area of the extraction socket	area outside the extraction socket
P	56.3±3.4	43.9±2.8	55.9±3.2	30.6±6.7	56.4±2.8
Ca	120.0±5.2	105.0±3.6	115.0±5.8	88.7±4.2	115.0±1.3

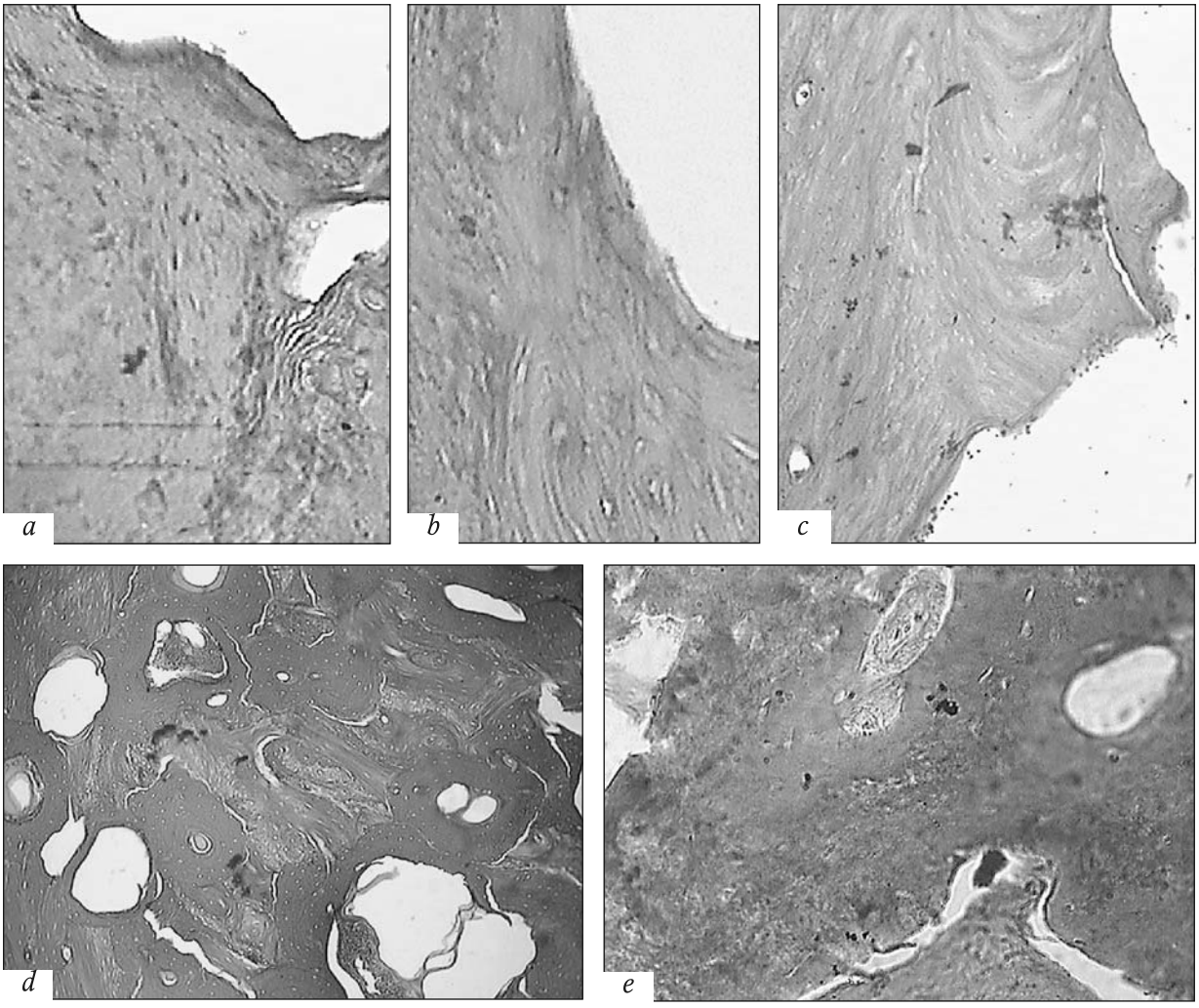

Fig. 3. Histological section of tissues adjacent to the surface of the PI, in animals of group 2. *a*)region of alveolar socket; *b*) tissue adjacent to the alveolar socket; *c*) the tissue outside of the alveolar socket; *d*) tissues in the region of CI; *e*) tissue in the region of CI roots.

cytes, mainly at the periphery of slides, was detected. Mineralization foci were seen between the osteons (Fig. 2, *b*).

On the slides of the bone adjacent to CI body, a thin rim of loose connective tissue capsule was seen. The bone tissue consisted of closed and unclosed osteons with wide fields of the interstitial tissue. No CL inclusions were found. In histological slides made at the base of CI, newly formed spongy bone with a considerable number of mononuclear cells with basophilic nucleus and oxyphilic cytoplasm, pronounced trabecular network, and ossification centers in the interstitium was defined (Fig. 2, *c*, *d*).

In group 2 animals, histological study of periimplant tissues in the region of the canine extraction socket 3 months after the surgery revealed a regenerate at the stage of cartilage transformation into bone adjoining to LI (Fig. 3). Outside the sockets, the implants were surrounded by newly formed bone tissue with a well-defined trabecular network.

The data of histological study confirmed the results of a comparative quantitative evaluation of calcium and phosphorus content in tissues adjacent to the implant in the animals in both groups. Mineralization of tissues in the extraction socket was significantly higher in group 1 animals compared to the corresponding samples in group 2 (Table 1). The differences between groups were statistically significant ($p<0.05$, Student's test).

The results of our pilot study do not contradict the results of clinical use of biocomposite material (CL) as a material for osteoplastic sinus lifting, sannations, and closure of alveolar bone defects [2-5]. CL is a biocompatible matrix with osteoinductive and osteoconductive properties, which is gradually replaced by the bone. Filling the bone defect with osteoplastic material CL promotes remodeling of the bone tissue after placing dental implants in the extraction socket and through the extraction socket.

When osteoplastic material were used, the structure and the mineralization of regenerated bone after

3 months almost corresponded to the intact lower jaw in experimental animals.

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