TO A QUESTION OF THE DIFFERENTIATED APPLICATION
OF OSTEOPLASTIC MATERIALS AT FILLING
OF A DENTAL SOCKET

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SUMMARY

This article discusses osteoplastic materials of various origin for differentiated use, as well as the results of their usage at filling of the dental socket under histological control.

KEY WORDS: osteoplastic materials, undemineralized spongiosa, cancellous bone, hydroxyapatite.

CONFLICT OF INTEREST. The authors declare no conflict of interest.

Methodology of comparative morphological study of bone tissue after osteoplastic surgeries

In the clinical part of the study in 30 patients after extraction of teeth for subsequent installation of implants, the alveolar cavities were filled with the investigated osteoreparative materials:
- synthetic hydroxyapatite (porous hydroxyapatite ceramic), 12 sockets;
- allogeneic hydroxyapatite, 14 sockets;
- non-demineralized spongiosa, 15 sockets.

Biopsy material from tooth 1.1 socket without osteoreparative agents was examined as control material.

Morphological changes in a dental extraction site when using osteoreparative agents in dynamics

Dynamics of the healing of the alveolar socket after extraction of the tooth without osteoreparative agents (control material)

In 1 month after extraction the socket is filled with connective tissue. On its surface there are remains of necrotic masses with a large number of leucocytes.

Under the leucocytic layer there is granulation tissue diffusely infiltrated by leucocytes. Granulation tissue is formed by a large number of capillary-type vessels and plurality of cellular elements. Cellular elements of granulation tissue are presented by fibroblasts, lymphocytes, plasma cells and macrophages. Among capillaries and cellular elements thin delicate collagen fibers are defined.
Granulation tissue is diffusely infiltrated with leukocytes. Lymphocytes with small admixture of macrophages, plasma cells and neutrophils prevail among the infiltrate.

On the surface of granulation tissue areas of regeneration of multi-layered squamous epithelium are found. Epithelium crawls over the granulation surface and forms a layer of 2–3 rows of epithelial cells.

Under the young granulation tissue there is a layer of maturing granulation tissue in which the number of vessels and cellular elements has significantly decreased and the number of fibrous structures has increased. Differentiation of cellular elements with a decrease in the number of hematogenous elements and an increase in the number of fibroblasts takes place. The synthesis of collagen by fibroblasts intensifies, and argyrophilic fibers and then collagenous fibers are formed. Collagen fibers are grouped into bundles. Synthesis of glycosaminoglycans by fibroblasts with formation of the main substance of connective tissue is intensified.

In the maturing granulation tissue, foci of inflammation represented by focal lymphocytic infiltrates are determined, which contributes to the delay of granulation tissue maturation.

Mature connective tissue is found beneath the maturing layer. Thus, the healing of the hole after extraction of the tooth occurs according to the type of secondary tension. The lunette is filled with granulation tissue in which a superficial leukocytic-necrotic layer, a superficial layer of young granulation tissue, a layer of maturing granulation tissue and a layer of mature connective tissue are found. Inflammatory infiltration in the superficial layers remains, which slows down the processes of granulation tissue maturation.

Three months after extraction, mature connective tissue with predominantly fibrous structures is determined in the tooth socket. Vessels are differentiated into arteries and veins. Fibroblasts prevail among cellular elements. The surface of the scar was epithelialized. Signs of osteogenesis were not detected. No inflammatory changes were detected.

After six months the dental socket contains mature connective tissue with formation of a scar. The surface of the scar is covered by multi-layered squamous non-keratinized epithelium. No signs of osteogenesis were detected.

After twelve months there is a connective tissue scar with foci of hyalinosis in the dental socket. Osteogenesis is not detected.

Thus, the healing of the extraction site after a tooth extraction without the use of osteoreparative agents occurs by secondary tension. At first, necrotic masses are rejected, the cavity is cleaned, and then the hole is filled with granulation tissue with its subsequent maturation and scar formation. Epithelium regeneration and epithelialization of the scar surface take place.

After twelve months, hyaline deposits appear in the scar. There are no signs of osteogenesis in the scar. In some cases, the inflammatory reaction delays the maturation of granulation tissue and the formation of the scar is delayed.

Dynamics of the healing of the alveolar socket after tooth extraction with porous hydroxyapatite (PHAK)

After one month in a dental socket blocks of hydroxyapatite are found, which are surrounded by macrophages, phagocytosing particles of hydroxyapatite. Between the blocks of hydroxyapatite there is a proliferation of mesenchymal cells, which are grouped into islands. Among young mesenchymal cells there are mesenchymal cells of the outgrowth form. Between islets of mesenchymal cells there are amorphous eosinophilic masses, i.e. forming intercellular substance.

Thus, in a month after extraction of a tooth with the subsequent application of synthetic hydroxyapatite in a hole around the hydroxyapatite granules growth of fibroreticular tissue with the formation of islands of young mesenchymal cells is noted.

In three months after tooth extraction differentiation of outgrowth mesenchymal cells into osteoblasts was observed. Osteoblasts were located on blocks of hydroxyapatite in the form of a chain. Active proliferation of fibroblasts, increased synthesis of collagen with formation of collagenic fibers was noted. There were clusters of osteoclasts.

Thus, 3 months after the extraction of the tooth in the hole there were determined primitive bone bulks, differentiation of the process mesenchymal cells into osteoblasts and osteocytes took place. Bone balloons were located haphazardly, between them there was a growth of mature connective tissue.

After 6 months, mature cancellous bone tissue was detected in the tooth socket. Calcification of the bone beams took place. Bony crossbars were formed between the bone beams and a wide network of bone beams and crossbars was formed. The bone-beam cavities filled with a mature connective tissue with presence of blood vessels were formed. There was a final differentiation of osteoblasts and osteocytes, single osteoclasts were found.

Thus, after 6 months bone tissue was formed in the dental socket and the final differentiation of osteoblast and osteocyte bone cells took place.

After 12 months a mature bone tissue with an orderly arrangement of bone beams was detected in the tooth socket. The formation of bone tissue in the hole was based on porous hydroxyapatite by direct osteogenesis.

Dynamics of the healing of the alveolar socket after extraction of the tooth with the use of allogenic hydroxyapatite

1 month after extraction of the tooth with filling the hole with allogenic hydroxyapatite there is an expansion of fibroreticular tissue. In the center of the socket clusters of allogenic hydroxyapatite are visible. Fibrous structures and groups of sprouted mesenchymal cells, many fibroblasts are located between the lumps. There was an increased proliferation of fibroblasts, which adhere to the blocks of hydroxyapatite. There are single small lymphocytic infiltrates on the surface. Signs of osteogenesis in these terms are not found, but between islets of outgrowth mesenchymal cells formed amorphous intercellular substance.

As compared to group II, more intensive proliferation of fibroblasts, more intensive formation of amorphous intercellular substance, less pronounced inflammatory reaction were observed.

At 3 months after the tooth extraction, little known primitive bone globules are detected among the osteogenic fibroreticular tissue.
Osteoblasts are located on the surface of the bone beams in 1 row. The differentiation of osteocytes is more intense compared to group II. The number of bone beams is significantly greater than in group II of observations. Bone beams are larger and arranged randomly. The central part of the bone beams is weakly mineralized. Osteocytes are found in small numbers. Mature connective tissue is determined between the bone beams. Inflammatory changes were not detected in the socket.

At 6 months after extraction, mature bone tissue is visible in the extraction socket.

The newly formed bone tissue in the dental socket corresponds to the structure of normal bone in terms of histological picture. Bone beams and bone crossbones are completely calcified, bone cells osteoblasts and osteocytes are finally differentiated, bone marrow cavities are formed. Compared with group II of observations, bone formation and differentiation were more intense.

After 12 months, mature bone tissue with final restructuring of the main structures is determined in the dental socket.

Dynamics of the healing of the alveolar socket after tooth extraction with the use of nondeminylated spongiosis

1 month after extraction of a tooth with spongiosis the socket contains spongiosis granules surrounded by fibroreticular tissue. The fibroreticular tissue contains numerous islands of outgrown mesenchymal cells. In comparison with group II and III of observations with spongiosa the number of cell islets is significantly higher. The proliferation of fibroblasts and outgrowth mesenchymal cells is more intensive. Inflammatory changes were not detected. Osteogenesis is not fully developed, but amorphous basophilic deposits are found among fibroreticular tissue. The described deposits are probably the germs of future bone beams.

At 3 months after tooth extraction, numerous bone beams are identified in the osteogenic fibre-reticular tissue. Bone beams are large, partially calcified, arranged haphazardly. On the surface of bone beams there are osteoblasts in one layer. There are processes of bone cells differentiation. When spongiosis is applied, more intensive bone formation and faster differentiation of bone structures take place.

After 6 months mature bone tissue is detected in the socket.

After 12 months, differentiated bone tissue is detected in the tooth socket.

Summary

Thus, after the tooth extraction and filling with osteoreparative agents, bone formation occurred after 3 months and the final differentiation of the bone tissue by 6 months. The formation of bone tissue occurred as a primary osteogenesis, i.e., by passing the chondrogenesis stage. In the control group, healing with the formation of a connective tissue scar occurred in the socket. We found no signs of osteogenesis. Filling the socket with osteoreparative agents stimulated osteogenesis, proliferation and outgrowth of mesenchymal cells, their differentiation into bone cells: osteoblasts and osteocytes. The mechanism of osteogenesis in all osteoreparative agents is the same – primary osteogenesis. The terms of bone tissue formation are almost the same, but differ in the degree of intensity of formation of bone structures, in the degree of differentiation of bone cells, intercellular substance. Spongiosa had the greatest osteoreparative properties and porous hydroxyapatite had the least. The use of spongiosa and allogenic hydroxyapatite significantly accelerates the formation of bone tissue and its further differentiation. Allogenic hydroxyapatite has a moderate anti-inflammatory effect. When it is used faster stops the inflammatory process, which also accelerates reparative reactions.

Under the influence of allogenic HAP a moderate stimulation of fibroblast proliferation in culture is observed.

Undemineralized spongiosis, which is the basis of Lioplast preparation, has the most pronounced osteoinductive and osteoconductive properties, stimulates growth, development and differentiation of bone tissue progenitor cells. The material enhances mitotic process of fibroblasts and osteoid cells, simultaneously creating conditions for long-term deposition of the main mineralizing calcium and phosphorus ions required for mineralization of the induced bone matrix and compactization of the main bone substance.

The obtained data allow us to arrange the studied materials depending on the degree of osteogenic potential expression in the following sequence. Undemineralized spongiosa (series «Lioplast») has a pronounced osteoplastic potential, allogenic HAP (series «Lioplast») – a weakly pronounced one, predominantly bioinert material – PGAC (f. Fichimed).

Conclusions

1. The use of nondemineralized spongiosis of allogenic origin and allogenic hAP («Lioplast» ®) accelerates the processes of proliferation of connective-tissue cellular elements in the experiment; porous hydroxyapatite ceramics is a bioinert material and does not affect the proliferation of fibroblasts.

2. According to the data of dynamic morphological study for 12 months filling of the hole with osteoreparative agents stimulates osteogenesis, proliferation of sponged mesenchymal cells, and their differentiation into bone cells: osteoblasts and osteocytes. The greatest osteoreparative properties have allogenic spongiosa, the least – porous hydroxyapatite.

3. Allogenic non-mineralized spongiosa is the most effective in bone augmentation in the clinic of dental implantology; allogenic HAP for implantation purposes is less effective. The use of porous hydroxyapatite ceramics often results in complications and implant removal (0.8%, 7.5% and 13.2%, respectively).

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