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CALCIUM-CONTAINING DRUGS IN DENTISTRY: CLINICAL AND BIOLOGICAL BASES OF APPLICATION, ADVANTAGES AND LIMITATIONS.

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Annotation. Calcium-containing drugs are widely used in therapeutic, pediatric and surgical dentistry due to their bioinductive, remineralizing and antimicrobial properties. The most common forms are calcium hydroxide, calcium silicates (including MTA-type materials), calcium phosphate and calcium hydroxyapatite compositions, as well as pastes and cements for temporary and permanent root canal fillings. The mechanism of their action is associated with the release of calcium ions, an increase in the pH of the medium, stimulation of the formation of reparative dentin and mineralized barriers, as well as inhibition of bacterial microflora. However, along with their clinical advantages, calcium-containing drugs have a number of limitations: solubility, insufficient mechanical strength, the risk of microflowing, and possible cytotoxicity if used improperly. The purpose of this work is to systematize current data on the types of calcium—containing materials, analyze their advantages and disadvantages, and identify clinical indications and prospects for further development.

Keywords: calcium-containing drugs; calcium hydroxide; MTA; calcium silicates; remineralization; reparative dentin; endodontics; biocompatibility.

Introduction. Mineralized tooth tissues — enamel, dentin and cement — are characterized by a high content of calcium, which plays a key role in the processes of mineralization and remineralization. Violation of the integrity of tooth tissues due to caries, injury or inflammation of the pulp requires the use of materials capable of stimulating regenerative processes and creating a biologically favorable environment.

Calcium-containing drugs have become the basis of a biological approach in dentistry. Their use covers direct and indirect pulp coating, treatment of pulpitis and periodontitis, apexification, apexogenesis, temporary canal filling and restoration of perforations. The modern concept of minimally invasive treatment has increased interest in materials with the ability to induce natural regeneration mechanisms.

The purpose of the study is to conduct a comprehensive analysis of calcium—containing drugs, to determine their clinical effectiveness, advantages and limitations in various areas of dental practice.

Research objectives:

1. Consider the classification of calcium-containing drugs.
2. Analyze the mechanisms of their biological action.
3. Identify the clinical benefits.
4. Identify shortcomings and possible complications.
5. Evaluate the prospects for the development of these materials.

1. Classification of calcium-containing drugs.

In modern dentistry, several groups of calcium-containing materials are distinguished:

1.1. Calcium Hydroxide ($Ca(OH)_2$)

A classic drug used for more than 80 years. It is used in the form of pastes, cements and liners. It has a pronounced alkaline reaction (pH about 12.5).

1.2. Calcium silicates

These include materials based on mineral trioxide aggregate (MTA) and new generation bioceramic cements. They are characterized by high biocompatibility and the ability to form hydroxyapatite in contact with tissue fluid.

1.3. Calcium phosphate cements

They mimic the mineral structure of bone tissue and dentin. They are used in surgical dentistry and implantology.

1.4. Calcium hydroxyapatite

It is used in the form of powders, pastes and granules for bone grafting and stimulation of osteogenesis.

2. The mechanism of action of calcium-containing drugs.

The main mechanisms include:

1. The release of $Ca2^{+}$ ions stimulates the differentiation of odontoblast—like cells.

2. Alkaline environment — inhibits the growth of most pathogenic microorganisms.

3. Formation of a mineralized barrier — promotes the formation of secondary and reparative dentin.

4. Induction of biomineralization — interaction with phosphates of tissue fluid leads to the formation of hydroxyapatite.

Upon direct coating of the pulp, calcium hydroxide causes superficial coagulation necrosis, under which a mineralization zone is formed. Calcium silicates act more gently, providing long-term calcium release and better tightness.

3. The benefits of calcium-containing drugs

3.1. Biocompatibility

Most modern calcium-containing materials are well tolerated by tissues, stimulate regeneration and do not cause a pronounced inflammatory reaction.

3.2. Stimulation of reparative processes

The materials induce the formation of dentin and cement, which is especially important while maintaining the viability of the pulp.

3.3. Antimicrobial effect

High pH inhibits the growth of anaerobic microflora of root canals.

3.4. Versatility of application

They are used in therapy, endodontics, surgery, and pediatric dentistry.

3.5. Biomineralization potential

Modern bioceramic materials contribute to the formation of a strong apical plug and the closure of perforations.

4. Disadvantages and limitations.

4.1. Solubility

Calcium hydroxide can gradually dissolve, which reduces the durability of the filling.

4.2. Low mechanical strength

Classical drugs do not withstand significant loads.

4.3. Risk of micro-leakage

Insufficient adhesion to the hard tissues of the tooth can lead to secondary infection.

4.4. Possible cytotoxicity

Excessive contact with soft tissues may cause irritation.

4.5. Long setting time

Some calcium silicates take a considerable time to fully harden.

5. Comparative clinical assessment.

Studies show that calcium silicate-based materials are superior to calcium hydroxide in terms of tightness and stability of results. However, calcium hydroxide remains economically available and widely used.

In endodontics, bioceramic cements demonstrate high efficiency in the apexification and closure of perforations. In pediatric dentistry, calcium-containing preparations help to preserve the vitality of the pulp in case of injuries and caries.

6. Development prospects.

Current trends are aimed at:

• creation of nanostructured calcium-containing materials;
• improved adhesive properties;
• reduction of setting time;
• combination with antimicrobial components;
• Development of bioactive composites.

The new generation of bioceramics demonstrates the potential for integration with tooth tissues without a pronounced inflammatory reaction.

Conclusion. Calcium-containing preparations occupy a key place in modern dentistry due to their ability to stimulate regeneration, provide an antimicrobial effect and maintain biological compatibility with tooth tissues. Despite certain disadvantages, such as solubility and limited mechanical strength, the development of bioceramic technologies has significantly expanded the clinical possibilities of their application.The rational choice of the drug should be based on the clinical situation, the condition of the pulp, the degree of infection and the requirements for mechanical stability. The prospects for further research are related to the creation of materials that combine bioactivity, strength and durability.

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