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PHYSIOLOGY OF ORGANS OF MAXILLO-FACIAL REGION

The educational guide

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Ministry of Healthcare of Russian Federation
Federal State Budgetary Educational Institution of Higher Education
«South Ural State Medical University»
of Ministry of Healthcare of Russian Federation
Department of Normal Physiology named after acad. Yu. M. Zakharov

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The educational guide is intended for in-class and external education in Stomatology educational course and includes an educational material in Physiology of organs of the maxillofacial region, including the structure and special features of the secretory function of salivary glands, the mechanism of activity and regulation of the masticatory muscles, special features of blood supply in the maxillofacial region. The educational guide describes detailed methods of studying functions of maxillofacial region organs, namely: mechanisms of salivation, of chewing, and of regional blood circulation. The educational guide is designed in accordance with the working program of a discipline "Normal physiology, physiology of the maxillofacial region"composed in accordance with Federal state educational standard of higher education in Dentistry 31.05.03 (specialist level), and was approved by the order of Ministry of Education and Science of Russian Federation N984, date 12.08.2020.

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GLOSSARY

Gastro-Intestinal (GI) tract, mouth vestibule, oral cavity, alveolar process, hard palate, soft palate, uvula, chewing, biting, drinking, eating, swallowing, digestion, respiration, articulating, speech pattern realization, resonator chamber, tooth organic matrix mineralization, tooth crown, dentin, enamel, cementum, CEJ - cemento-emanel junction, tooth's neck, pulp, tooth's root, teeth notation system, dental formula, maxillary/mandibular premolar/molar/canines/incisor, milk teeth/permanent teeth, main or working side, auxiliary or balancing side, cheek pockets, mucous membrane, salivary glands, composition of salivary secretion, pulp vascular network antistasis mechanism, vascular-platelet and coagulation stages of hemostasis, oral mucous immune system tolerance phenomenon, MALT - mucosa-associated lymphoid tissue, systemic immune response, common inflammatory process, induction and maintaining the immune tolerance, "fast" pain perception with a high degree of localization perception, "late" poorly localized pain sensation with affective manifestations, spinal gate control pain perception regulation, general and specific physiologic patterns of alterations, dental caries, tooth decay, dental plaque, periodontitis, fixed or clasp prosthetics, WHO, health promotional programs

1. PREFACE

The physiology of organs of the maxillofacial region represents a special section of physiology. The regulation of salivation, of muscle activity during chewing, biting, mastication and the neuro-humoral vascular tone regulation in the maxillofacial region that have their special features determine the significance of the general regulatory systems that control digestion, respiration, and speech function realization. A systematic approach to assess the functional condition of salivary glands, masticators and the microcirculatory features of the oral cavity makes it possible to identify both general physiological patterns of functioning organs of the maxillofacial region, some particular signs of dysfunction or the lack of effect despite of activities.

1.1 Oral cavity physiology general questions

Mouth should be considered as the first department of the **gastro-intestinal tract (GI-tract)** that starts the realization of the alimentary function of GI-tract. It is lined with a mucous membrane and contains teeth. The mouth consists of two regions, namely: **the vestibule** and **the oral cavity**. The vestibule is the area between the teeth, lips and cheeks. The oral cavity is in front and at both sides of the alveolar process with teeth, and also at the back of the isthmus. The mouth' roof is the hard palate at front and the soft palate at the back. The mouth' floor is formed by the mylohyoid muscles and contain the tongue. The mouth plays an important role in **chewing**, **biting, and tearing** of the food for alimentary process to prepare. It also plays a role of a **depot** as a temporal container of nearly 55-70 ml volume to hold temporarily a food to process it. The mouth also plays a special role in **drinking, breathing and speaking** (for articulating and as a resonator chamber). In infants it plays a crucial role, since newborn' alimentation occurs only due to an inherent **sucking** reflex presented. In normal conditions the mouth is usually moistened.

1.2 Physiology of teeth special features

There are usually 20 primary (deciduous, “baby”, or “milk”) teeth and 32 permanent (adult) teeth. Most of them have their special features that distinguish them from others, including the upper and the lower teeth. There are several different **notation systems** to refer to for a specific tooth to denote. The three most common systems are the **FDI World dental federation notation**, the **Universal numbering system**, and the **Palmer notation method**.

The permanent teeth are 16 on the maxilla and 16 on the mandible, the total is 32. The dental formula may be read as follows:

2	**1**	**2**	**3**
2	**1**	**2**	**3**

The **maxillary teeth** are the maxillary central incisor, **maxillary** lateral incisor, maxillary canine, maxillary first premolar, maxillary second premolar, maxillary first molar, maxillary second molar, and maxillary third molar. The **mandibular teeth** are the mandibular central incisor, mandibular lateral incisor, mandibular canine, mandibular first premolar, mandibular second premolar, mandibular first molar, mandibular second molar, and mandibular third molar. Third molars are commonly called “wisdom teeth” and they may never appear to the mouth. Teeth usually act to mechanically break down a food by cutting and crushing it and so preparing it to swallow for further digesting. The function of incisors is to **bite and cut the food**, canines **tear the food,** and molars and premolars **crush the food**. The roots of teeth are embedded in the maxilla or the mandible and are covered with gums. Teeth are made of various tissues of different density and hardness. The **crown of a tooth** is covered with enamel above the **cement-enamel junction (CEJ)** or the **neck of the tooth**. Most of crowns are composed of **dentin** with the pulp chamber inside. The tooth’s **root** is located below the CEJ and is covered with a **cementum**.

2 PHYSIOLOGY OF CHEWING

2.1 The structure of the muscular apparatus of the maxillofacial region

A large number of muscles take part in the mechanical processing of food, including facial mimic and tongue muscles, but the main role is played by seven pairs of muscles that provide movement of the lower jaw relatively to the upper one. The force of chewing pressure depends on the degree of contraction of these muscles, and therefore the teeth ability to bite off the food and to crush the food bolus to the consistency required. The main masticatory muscles include the masticatory, temporal, medial and lateral pterygoid muscles, and the auxiliary ones include the chin-hyoid, maxillo-hyoid and anterior part of the digastric muscle.

When lowering the lower jaw, the digastric, maxilla-hyoid, and genio-hyoid muscles are active; when for articular surface displacement the lower part of the lateral pterygoid muscle is active. The activity of the masticatory, medial pterygoid and temporalis muscles, and also of the superior part of the lateral pterygoid muscle results in the mandibular elevation. The movement of the mandible form side to side is achieved mainly be the activity of the posterior part of the temporalis muscle, and also of the medial pterygoid muscle and the lower part of the lateral pterygoid muscle on the contralateral side. For the mandible to move forward, the medial pterygoid, chewing and supra-hyoid muscles become active, as well as the lower part of the lateral pterygoid muscle, and once in a while the anterior group of fibers of the temporal muscle. Until recently it was considered the function of upper and lower heads of the lateral pterygoid muscle do not differ, since they are attached to almost the same points. However, recently performed electromyogram analysis of both muscle heads makes it possible to evaluate some unusual properties of the upper head of the lateral pterygoid muscle, namely:

1. The muscle is attached to the articular disc, movements of which are necessary for the functioning of the temporo-mandibular joint, so the muscle performs important functions related to the disc position,

2. The action of most of body muscles is usually counteracted by either the

gravity, or by muscles-antagonists. The action of these muscles is counteracted by the elastic force of a tissue located behind the disc in the mandibular fossa. The central nervous system does not control this counteracting force therefore it cannot be stopped as antagonist muscles counteract.

3. According to electromyography, the upper and lower heads of the muscle act reciprocally. The upper head is active only when the mouth is closed (lower jaw is up). Possible changes in the upper head of lateral pterygoid muscle functions are considered to be an important stage in the pathogenesis progression of the temporo-mandibular joint dysfunction.

A **contracture** is a partial or complete restriction of the lower jaw movements. As a rule, a contracture occurs due to a pain reflex and subsequent tetanic contraction of the masticatory muscle or due to its cicatricial changes after prolonged wound healing, burns, or specific infections. This alters the opening of the mouth and consequently all the eating process due to altered mechanical processing of food, as well as respiratory and speech-forming functions of the oral cavity. Long-term contracture can even lead to degenerative changes in temporo-mandibular joints.

2.2 Physiological properties of the masticatory apparatus and methods of their studying

Chewing muscles, being striated muscles, have typical physiological properties for them, namely: excitability, conductivity, contractility and lability. Important physical properties of masticatory muscles are extensibility and elasticity.

The absolute strength of the muscle is known as tension developed by the muscle during its maximum contraction. This value is calculated by multiplying the physiological cross-sectional area by the specific force (Weber coefficient). The total area of muscles that act during lifting movement of the lower jaw (masticatory, temporal, and medial pterygoid muscles) is 19.5 cm^2. The absolute strength of these muscles is equal to 195 kg on one side, and for all muscles it is 390 kg, so chewing muscles have a great absolute strength, but it develops very rarely, for instance, during psychologic excitement. It is known that in a towering rage people bite off fingers of their opponent, which requires considerable muscle strength.

In addition to absolute strength, the chewing pressure may be calculated, that means the force developed by the muscles during pressing a certain plane. Chewing pressure will be different for molars and for front teeth in spite of the same effort of chewing muscles. This is due to the lower jaw is a lever with a center of rotation in the temporo-mandibular joint. To measure the masticatory pressure value, the **gnathodynamometry** method could be used. A mechanical gnatodynamometer resembles a mouth expander, which plates are pushed apart by an elastic spring. The device is equipped with a scale with a pointer, so when plates are compressed by teeth, it moves and displays a pressure value. At present, gnathodynamometers equipped with electronic tensosensors, analog-digital transforming interface, and digital indicators are used.

In young men, normal masticatory pressure is 35 kg on average, during anesthesia it increases up to 60 kg. However, the chewing pressure is not the same in different parts of the dental arch. In women, the chewing pressure on incisors is 20- 30 kg, on wisdom teeth to be up to 40- 60 kg, and in men it is - 25-40 kg and 50-80 kg, respectively. The endurance of the periodontium to the pressure load in frontal teeth area is approximately 60 kg, and for chewing teeth is 180 kg. Masticatory pressure values data are used to characterize the functional ability of the periodontium and for assessing its training capability to the load.

The excitability of the teeth is determined using **electroodontometry**. Actually this method uses an electric currency that acts through the enamel and the dentin on the pulp without damaging the tooth's pulp, so it can be measured repeatedly. The study of the electrical excitability of the tooth essentially is the study of the excitability of corresponding sensory nerves and of the pulp of the tooth, so these indicators to depend on the intensity of the blood supply, pH values of both the intercellular fluid and the saliva.

The value of the threshold of excitability is registered by the subjective personal reaction of the patient. An indifferent electrode (+) in the form of a metal plate is fixed on the forearm' skin with a moistened gauze under it. Then the tooth is touched with an active electrode (-) made in a form of a probe at special points recommended for such a measurement. The following points are used for such a

measurement: for incisors - the middle of the cutting edge, for premolars - the top of the buccal tubercle, for molars - the top of the anterior buccal tubercle. Due to anatomical features there is the lowest excitation threshold at these points. To avoid possible wrong results of investigation due to current leakage it is necessary to carry out the study using rubber gloves and plastic spatula instead of a metal one. Gradually increasing the amplitude of the current strength of applied pulses, they stimulate the tooth's pulp until the patient experiences a sense of slight pain.

The reaction of a tooth to electrical stimulation allows you to identify a **specific pattern** of changes in its electrical excitability in various pathological processes. It has been established that in healthy teeth, regardless of group affiliation, they have the same excitability reacting to the same current strength in a range of 2 to 6 μA. If the tooth irritation threshold is less than 2 μA, this indicates to an increase in excitability, which can be observed, for example, in periodontal disease. In a case of pulpitis, on the contrary, there is an increase in the threshold of irritation of more than 6 μA. A decreased excitability up to 100-200 μA is considered to be a sign of a pulp death.

In most of teeth' pathological conditions **electroodontodiagnostics** is the leading method, since it allows to evaluate not only the degree of pulp damage, but also to monitor the dynamics of the pathological process, to control the effectiveness of treatment and to predict the outcome of the disease.

Electromyography is based on recording the action potentials of muscle fibers acting as a part of motor units of a muscle. Electromyography is used in surgical and orthopedic dentistry, in orthodontics and stomatoneurology as a functional and diagnostic method for studying of the peripheral neuro-motor function and assessing the muscle coordination regulation of the maxillofacial region in normal state and during pathological conditions: injuries, inflammation of the maxillofacial region, malocclusion, plastic surgeries, dystrophies and hypertrophies of masticatory muscles, cleft palate abnormal development and other diseases.

For electrical potentials of skeletal muscles to appear a decisive role is played by the ion permeability changes in cell membranes of skeletal muscles, especially for sodium and potassium ions, as well as for chlorine and calcium. Using an electromyography some typical changes in potentials are recorded on the skeletal muscles surface, resulting in the propagation of excitation along the muscle fiber. The recorded dynamic changes of skeletal muscles electric potentials (bioelectrical activity) is called an **electromyogram** (**EMG**).

A **motor unit (MU**) consists of a motor neuron and a group of muscle fibers innervated by this motor neuron. Muscle fibers included in one MU are excited and contracted at the same time. The number of muscle fibers innervated by one motor neuron is varying in different muscles. In the chewing muscle there are about 100 muscle fibers per motor neuron, so is for temporal muscles - 200; while in mimic muscles MUs are smaller and may consist of up to 20 muscle fibers and in small facial muscles this ratio is even smaller. So, different way of facial muscles contractions is achieved and this determines a wide range of facial expressions during emotional exciting.

At rest, the muscle does not generate action potentials, so the EMG of a relaxed muscle looks like an isoelectric line. After a passage of impulses from motor neuron the electrical excitation of muscle fibers occurs, which can be registered with a needle electrode in the form of an action potential, which actually is an integral form of action potentials from many different muscle fibers. The action potential of a single MU usually has 2-3-phases oscillation of 100-3000 μV in amplitude and of 2-10 ms in duration.

An increase in the muscle contraction tension occurs due to an increase in the number of MUs involved and to the frequency of electrical discharges. On EMG, this process is expressed as an increase in the frequency and amplitude of oscillations as a result of temporal and spatial action potentials summation.

There are three main types of electromyography:

1) Interferential (synonyms: superficial, total, global) - is carried out by muscle biopotentials registration by applying electrodes to the skin;

2) Local - registration of the electrical activity of individual MUs using needle electrodes;

3) Stimulatory - registration of the electrical response of the muscle to the nerve stimulation that innervates this muscle.

Since EMG recording is the result of activity of both the muscle as a source of biopotentials and the clinical laboratory equipment to register these biopotentials, the influence of methodological conditions on the EMG recorded should be taken into account. An electromyography is carried out by placing the patient on a dental chair in a convenient position. To perform local electromyography a patient is laid down on a couch. The ground electrode is attached to the patient's wrist with an elastic cuff and connected via a cable to the ground terminal of the equipment. The areas of the skin on which the electrodes are to be applied should be wiped out with a cotton wool moistened with an alcohol. Then superficial or needle electrodes are inserted. After selecting the equipment operating mode switch in a position of registration or record, choose the appropriate gain value for the equipment and start recording the activity at rest and during functional test loads.

To determine the effectiveness of muscles coordination in the maxillofacial region and to identify possible abnormalities in their innervations, various functional tests are proposed. Functional tests may use various natural actions in which muscles usually participate, and also some special external influences to stimulate a reflex reactions of muscles can be used. Usually used functional tests are:

1. The **maximum muscle tension** is used both for global and local electromyography. The patient is asked to make a maximum tension of muscles: for chewing muscles - clenching teeth with maximum force, for the circular muscle of the eye - maximum squinting of eyes, for the frontal muscle - maximum raising of the eyebrows, etc.

2. The **minimum muscle contraction** is used to explore the individual MUs parameters for local electromyography. The contraction should be so weak that the action potentials from each of individual MU can be distinguished on the EMG with no interference (superposition) between them.

3. **Chewing load**. To determine the masticatory muscles functional state, a strictly limited and objectively recorded functional test using **spring gnatodynamometer** that provides an adequate physiological load is used. A patient is asked to compress repeatedly biting areas of the gnatodynamometer with his teeth for 1 min. The maximum force achieved when pressing biting areas is measured in kg on the gnatodynamometer scale with simultaneously registering of EMG. A slow gradual decreasing of the force compressing biting pads up to the minimum muscle contraction level under the control of the gnatodynamometer scale is carried out. Evaluation of the effectiveness of the course of treatment or during the rehabilitation period is carried out by registering an EMG starting from the initial measurements and re-measuring the maximum gain using the gnatodynamometer scale (in kg).

4. **Natural movements**. These movements to reproduced during investigation should involve muscles that usually take part in them, for example, for chewing and some facial muscles, this is chewing of a standard amount of bread, nuts, chewing gum, or swallowing saliva, water or other liquid, also sagittal and lateral movements of the lower jaw; for the near-oral mimic muscles this is the pronunciation of sounds “u”, “o”, “e”, etc.

5. **Concordant movements** of facial muscles are examined by performing type of movements that are not typical for these muscles, for example, for the circular muscle of the eye it is when pulling lips into a form of tube or by pulling the mouth corners downward, for the circular muscle of the mouth it is when closing eyes or raising the eyebrows.

6. Study of masticatory **muscles reflex reactions** by tapping the chin with a hammer. When jaws are closed strongly, the reflex inhibition occurs in the masticatory muscles and its duration has an important diagnostic value. With a freely lowered lower jaw, a myotatic reflex (similar to the tendon reflexes of limbs) in the masticatory muscles occurs, and its amplitude is associated with the sensitivity of muscle spindle receptors.

7. Electrical stimulation of the facial nerve. This functional test is reproduced at **stimulational electromyography**.

When analyzing **EMG** the following parameters are determined:

1) The amplitude, its duration and temporal features of bioelectrical activity during functional tests;

2) The activity concordance in symmetrical muscles;

3) The activity concordance in muscles of one group (for example, raising the lower jaw) and of different groups (for example, raising and lowering the lower jaw).

The analysis of EMG consists of describing the nature of EMG: saturated (rich in number of potentials), unsaturated; the form of the EMG going around line - a smooth or sharp increase with a decrease in activity (typical for EMG during natural movements - chewing, swallowing), also the number of phases of activity. Then describe the duration of phases of activity and of a rest, also time intervals between the activity onset in different muscles during chewing and swallowing acting. The most important quantitative parameter of the global EMG is the total electrical activity of the muscle. It is determined by measuring the amplitudes of EMG oscillations using special equipment with integrator units. As a rule, the EMG amplitude during muscle isometric contraction is proportional to the strength of its contraction and so it goes in a wide range of changes.

2.3 The act of chewing, its regulation

The basic activity of oral cavity that is related to digestion is the chewing process - a complex physiological act consisting of mechanical and chemical food processing to prepare it for next stages of digestion process in gastro-intestinal tract. Chewing is carried out by voluntary and involuntary regulatory mechanisms and it results with formation of a food bolus suitable for further swallowing. The formation of food bolus is characterized by various mechanical parameters, taste, temperature and other bolus parameters. Usually it is formed in a range of 5 to 15 seconds in adults, in children with a milk bite it is 25-30 seconds, and during the period of bite change it becomes 35-40 seconds. However, these figures are relative enough, since formation time depends on several factors: nature of the food (soft or hard), its mucus and moisture conditions, oral cavity condition and its dentition, food temperature (hot or cold), its taste, pres-

ence of spices and seasonings. The volume of the food bolus varies significantly from 1 to 20 g and even more. A significant factor influencing the formation time and bolus volume is linked to food motivation factor – a sense of hunger. A hungry person chews usually hastily and not thoroughly, so a consequently going swallowing could be difficult and may be accompanied by unpleasant sensations or even impossible in some cases. In such cases for swallowing one may use washing down food bolus with some liquid. Control over the parameters of the food bolus during its formation is carried out by vast majority of receptors located in the mucous membrane of the tongue and the mouth: tactile, temperature, taste, pain, and masticatory muscle's proprioceptors (muscle spindle receptors).

During chewing the lower jaw moves in two planes: horizontal and vertical, but it can also move forward, backward, sideways, up, and down. The initial point of these movements is the central occlusion, that is teeth closing position with maximum area of contacting surfaces between them, also the face midline fits the line between central incisors, and the head of the lower jaw is located on the slope of the articular tubercle near its base, and with chewing muscles and the lower jaw raising muscles being contracted. From this initial position the lower jaw goes down and backwards, so some food is captured. The masticatory muscles then contract and the lower jaw rises, while the front teeth (incisors) close with some food biting off. Lateral teeth are slightly open at this time.

Usually chewing is carried out on one side: left or right. The side on which chewing takes place is called the **main or working side**, and the other is **auxiliary or balancing side**, but chewing can also be performed on both sides at once. After biting off here comes a period of chewing as it is with food grinding process. There are three phases of movement of the lower jaw while the oral cavity is closed. At first period it falls down and forward and then moves to the side, so some part of food is placed on the dentition of the working side due to buccal muscles and tongue movements. Next, jaw rises and food goes crushing by cusps of molars and premolars that come into contact with cusps of antagonist teeth of the upper jaw. After this the lower jaw moves horizontally towards the sagittal line rubbing (grinding) the food, and then the dentition closes again in the central

occlusion position. This completes the chewing cycle. Chewing cycles go on and on until the required crushing of food is achieved.

During the molars closing moment the medial ridges of food are pressed to teeth with so-called **cheek pockets** formation. After the food crushes between teeth it falls into these cheek pockets and into the maxillary-lingual groove. With the repetition the chewing cycles both buccal muscles and tongue moves the food towards the dentition, so delivering it for further grinding. As food particles are crushed they are saturated with saliva, become mucinous with mucin and stick together into a food bolus that moves back to the root of the tongue and is prepared for swallowing. The volume and the degree of food grinding are controlled by mucous membrane receptors of cheeks, gums, and the tongue. Due to these receptors food particles are sorted: crushed particles are formed into a food bolus, while large ones are re-entered for further processing, and all of non-consuming bodies (bones, stones) are pushed out by the tongue movement. The degree of pressure between teeth is controlled by periodontal receptors of both upper and lower jaws, and also by the proprioceptors of the masticatory muscles (muscle spindle receptors).

The masticatory pressure regulation reflex:

1. The **periodontal-muscular reflex** is carried out during chewing act with natural teeth when the force of muscular contraction of the chewing muscles is regulated by the degree of periodontal receptors activation.

2. The **gingiva-muscular reflex** is carried out while lost some teeth, so the force of contraction of masticatory muscles is regulated by tactile receptors of the mucous membrane of both gums and alveolar ridges.

3. The **myotatic reflex** is carried out in a case of stretching of masticatory muscles. The start of this reflex begins with impulses from two types of receptors located inside masticatory muscles and their tendons during stretching (intrafusal muscle spindle receptors and Golgi receptors), namely in response to stretching a muscle contraction reflex occurs.

Along with the essential reflexes mentioned above, a complex coordination of muscle activity during chewing of another type - for muscular groups of antag-

onists and synergists - is carried out. This type of muscular activity coordination is known as the **reciprocal inhibition** phenomenon in physiology.

Functions of chewing muscles and of their nervous reception is manifested depending on the position of individual teeth groups in the dental arch. It is of having sense to define chewing process components associated with the areas of frontal and lateral teeth. If the total chewing efficiency of 28 teeth is taken as 100%, then the lower central incisors account for 1% each, the upper central incisors - 2% each, the canines - 3% each, the premolars - 4% each, the first molars - 6% each, and the second molars - 5% each.

The overall value of chewing process is impossible to describe without an effective activity of both **facial mimic muscles** and **tongue**. During chewing process mimic muscles of lips and cheeks regions are also involved in activity to capture food and to close tight the oral cavity for food retention inside. These muscles become essential ones to play a special role in sucking and liquid food uptake. The tongue acts in the distribution of particular parts of food to the dentition, in returning it back to chewing from maxillary-lingual and bucco-maxillary canals, in mixing it, and in effective filling of food with saliva. Due to the tongue muscles activity that pull it down and backward (similar to the pump piston movement in the pump) and the simultaneous lowering of the lower jaw, a significant vacuum is created in the whole oral cavity, which provides an effective suction underlying in sucking process. In this case the oral cavity pressure may be lower than the atmospheric one.

2.4 Methods of studying of the chewing function

Normal movements of the lower jaw, as well as their violations and dynamics of recovery can be studied using a graphical method. Recording of chewing movements of the lower jaw may be carried out with various devices: kymograph, oscilloscope, etc. Starting from I.S. Rubinov a detailed method of chewing movements recording of lower jaw - **masticography** – is proposed and a meaning of each component of this recording is described. The device for chewing movements recording consists of a rubber balloon placed in a special plastic case attached to the chin with a special bandage and having a graduated scale. The

balloon is connected by air transmission with the **Marey's capsule** and with a **kymograph**. The masticogram was suggested to register chewing movements during the process of chewing of a nut of 0.8 g mass.

Analysis of the masticogram shows that it consists of several consequent wave-like curves, initially called **masticatory waves**. The ascending and the descending parts on the chewing wave were distinguished, with the first one to reflect the lowering movement of the lower jaw, and the second one - its rising phase. The lower loop between the waves is called the closure loops. Each of the waves is characterized by her height, by an angle between ascending and descending knees, and by the shape of its top. The **closure loop (occlusional plate**) has characteristic features also. It may look like a flat line or it may have an additional wave, the latter indicates a presence of a lateral shift for the lower jaw.

There are 5 phases to be distinguished during each chewing period:

1. The **resting phase** – it is registered as a straight line on kymograph recordings.

2. The **phase of getting food** into the mouth - on the kymogram this phase corresponds to the first ascending phase that corresponds to the opening of the mouth when food goes into the mouth.

3. The **phase of starting chewing** - on the kymogram it starts with the ascending phase and corresponds to the opening of the mouth when food is introduced. Then depending on the food consistency the record may be different. If the food is sufficiently hard in a consistency a series of additional wave-like rises appear. The moment of jaws to overcome the food resistance a decrease in the curve is noted.

4. The **main phase** - both rhythm of chewing waves and their equal size are characteristic features for it, but if teeth are properly preserved and their closure is correct.

5. The **phase of food bolus formation** and its swallowing – is the end of food chewing.

Along with the recording of chewing movements of the lower jaw, the time marks are made on a kymograph's tape that makes it possible to determine the duration of any of the chewing phase.

There are many factors affecting the masticatory waves parameters, their individual phases and the closure loop phase characteristic features, including factors related to the size and consistency of the food, the type of bite, the occlusal relationships of natural teeth remaining of a person, characteristic features of artificial teeth closure, the type of prostheses fixation, the masticatory muscles functional condition and the temporo-mandibular joint proper functioning, etc.

The masticography disadvantage includes the lack of lateral movements' registration that is necessary for chewing functions complete characteristics. The accuracy of the recording also depends on the pressure using for registration when the rubber balloon is pressed by the chin. Therefore, the recording of chewing movements should be done under the same conditions to obtain appropriate recordings for comparative observation to carry out successfully.

In addition to masticography, the following methods of clinical functional diagnostics are available for the masticatory system clinical and physiological investigation:

1) **myography** (should not be confused with EMG) - registration of movements of particular muscles involved during isotonic or isometric muscular contractions by their transverse size registration.

2) **myotonometry** – a method of the muscular tone of masticatory muscles observation in various conditions.

3) **masticodynamometry** – a method of muscular tension measurement during chewing of various food substances of different hardness.

2.5 Physiological chewing tests

The study of efficiency of chewing function of the oral cavity is usually carried out using functional (chewing) tests that allow a MD specialist in Dentistry to obtain an integral picture of its violations.

The first functional test was developed by **Christiansen**. He proposed to obtain chewing ability by examining the degree of grinding of food of a certain consistency and mass. A person was given an amount of 5 g of hazelnuts or coconut to chew and then after 50 chewing movements he spat out the resulting food mass. Then the mass was dried and sifted through a sieve to determine the

degree of grinding obtained. Chewing ability was assessed by the residue mass on a sieve.

In **Manly** test the duration of chewing is 20 movements and the portion of peanuts is 3 g. The ratio of mass remaining on a sieve of rounded holes 2.4 mm after sieving under a stream of water and drying comparing to the total mass of the product extracted from the oral cavity is determined.

Dahlberg proposed the following test: a portion of 3 g of peanuts was processed for 40 chewing movements and a portion of the crushed test material was sifted through a set of sieves with round holes from 10 to 1 mm. Then these masses of residues obtained were multiplying by the specific coefficients with calculating the ratio of the surface area of the crushed particles to their volume.

S. E. Gelman developed by simplifying the Christiansen chewing test technique. Instead of a hazelnut he took 5 g of almonds and instead of 50 movements he offered to chew it for 50 seconds. Further development of functional chewing test was carried out by **I. S. Rubinov**. He believed that chewing of 5 g of almond kernels to be a task beyond the ordinary limits for chewing apparatus. Therefore I.S.Rubinov offers a portion of 0.8 g of nuts which is approximately equals to the mass of one almond kernel. The test was carried out as follows: a person was given 0.8 g of a hazelnut and was asked to chew it until the swallowing reflex to appear. As soon as the subject has a desire to swallow a chewed nut he is asked to spit it out into a kidney-shaped tray. Then the chewing time is estimated by a stopwatch. There are two indicators are obtained as a result of the functional test: the percentage of food chewed (the chewing ability) and the chewing time. These studies have shown that with an orthognathic bite and an intact dentition a portion of 0.8 g of a nuts is completely chewed in 14 seconds. As teeth are lost the chewing time lengthens and the residue on the sieve increases at the same time. When analyzing the test results both chewing time and the percentage of chewed food should always be taken into account.

A. N. Ryakhovsky in 1992 proposed to perform chewing test as following: duration of chewing was set to 20 chewing movements, and the analysis of useful work of crushing was determined. During the test the chewing time and the

integral bioelectric activity of the chewing muscles involved were recorded and then calculations of chewing effect, chewing ability and chewing efficiency were done. As a test portion 2 cylinders of 20% gelatin of 16 mm in diameter and of 10.5 mm in height were used. Overall chewing energy consumption was estimated by assessing of total bioelectrical activity of masticatory and of temporal muscles.

2.6 Questions for self-control assessment

Choose one or more correct answers

1 WHEN MOVING DOWN THE LOWER JAW THE FOLLOWING MUSCLES BECOME ACTIVE

1. digastric muscle
2. maxillofacial muscle
3. geniohyoid muscles
4. superior head of the lateral pterygoid muscle
5. pectoralis major

2 WHEN LIFTING UP THE LOWER JAW THE FOLLOWING MUSCLES BECOME ACTIVE

1. chewing muscle
2. medial pterygoid muscle
3. temporalis muscle
4. superior head of the lateral pterygoid muscle.
5. pectoralis major

3 THE MOVEMENT OF THE LOWER JAW FROM SIDE TO SIDE IS ACHIEVED WITH THE FOLLOWING MUSCLES BECOME ACTIVE

1. pectoralis major
2. geniohyoid muscles
3. back group of fibers of the temporal muscle
4. medial pterygoid muscle
5. lower head of the lateral pterygoid muscle on the contralateral side

4 WHEN THE LOWER JAW MOVES FORWARD, THE FOLLOWING MUSCLES BECOME ACTIVE

1. medial pterygoid muscle
2. chewing muscle
3. suprahyoid muscles
4. lower head of the lateral pterygoid muscle
5. anterior group of fibers of the temporal muscle

5 THE EXCITABILITY OF HEALTHY TEETH DURING ELECTROODONTOMETRY IS

1. 2 - 6 mkA
2. less than 2 mkA
3. 100-200 mkA
4. 10-20 mkA
5. 6-10 mkA

6 THE EXCITABILITY OF A TOOTH WITH PULPITIS DURING ELECTROODONTOMETRY

1. 2-6 mkA
2. less than 2 mkA
3. 100-200 mkA
4. 10-20 mkA
5. 6-10 mkA

7 EXCITABILITY OF A TOOTH WITH DEAD PULP DURING ELECTROODONTOMETRY

1. 2 - 6 mkA
2. less than 2 mkA
3. 100-200 mkA
4. 10-20 mkA
5. 6-10 mkA

8 THE ASCENDING PART OF THE MASTICOGRAM CORRESPONDS TO

1. lowering down of the lower jaw
2. mandibular lifting up movement
3. lowering down of the upper jaw
4. lifting of the upper jaw
5. closing up the mouth

9 THE DESCENDING PART OF THE MASTICOGRAM CORRESPONDS TO

1. lowering down of the lower jaw
2. mandibular lifting up movement
3. lowering down of the upper jaw
4. lifting up of the upper jaw
5. closing up the mouth

10 FUNCTIONAL CHEWING TESTS ARE CARRIED OUT USING

1. nuts
2. gelatin
3. caramel
4. chewing gum
5. milk

3 PHYSIOLOGY OF SALIVARY GLANDS

3.1 Salivary secretion composition.

Saliva is a mixture of secrets of three big paired and a large number of small salivary glands. Epithelial cells, food particles, neutrophilic granulocytes, lymphocytes, mucus produced by the mucous glands, as well as microorganisms are mixed with the secret released from excretory ducts of salivary glands. This kind of saliva mixed with various inclusions is called an **oral fluid**. It is opaque and has a viscous consistency. The composition of the oral fluid may vary significantly depending on the food composition, on the total body health condition, and on personal oral hygienic habits.

The process of saliva secretion is an active process. The evidence for such an active process of secretion in the salivary glands is based on the following facts:

1) during the secretory process in the acini cells the membrane potential is registered to change;

2) after ligation the excretory duct of functioning salivary glands in animal models the pressure of saliva in the duct may exceed the pressure of blood in a nearby blood vessels;

3) after ligation of the arteries supplying the salivary gland the secretion of saliva is still presented.

There are 5 phases of the secretory cycle of the salivary gland cells:

1) first, the entry of initial substances into the glandular cell;

2) intracellular synthesis of the primary secretory product;

3) formation of the distinct secret;

4) accumulation of the secret in cells and then

5) secretion from the cell.

The intensity of blood flow circulation in salivary glands goes in line with the level of secretory activity. In experiments on animals, it was found that the blood flow, which at rest is 20-40 ml per 100 g of gland substance, can be increased 5 times higher during active secretion. For such an enhancing of blood flow the activation of the **parasympathetic** autonomous nervous system, as well

as the synthesis of **kallikrein** play an important role with consequent dilatation of blood vessels of glands and with an increase of permeability of capillaries.

The secret of salivary glands contains about 98-99% of water and the rest is the dry residue, which contains chlorides, phosphates, bicarbonates, iodides, bromides, fluorides, sulfates, sodium, potassium, calcium, magnesium, iron, copper, nickel, lithium, etc. The concentration of inorganic substances, such as iodine, calcium, potassium and strontium is usually many times higher than in the blood. Organic substances presented are predominantly proteins: albumins, globulins, and enzymes. In addition, nitrogen-containing components are found in saliva: urea, ammonia, creatinine, free amino acids; gamma-amino-glutaminate, taurine, phosphor-ethanol-amine, hydroxyl-proline, several types of vitamins. Some of these substances (amino acids, albumins, urea) pass from the blood plasma into the saliva unchanged, but as for others (amylase, glycoproteins) they are synthesized in the salivary gland.

Large and small salivary glands normally produce a secret that differs both in quantity and composition. Particularly for the **parotid** gland it secretes liquid saliva containing large amounts of potassium chloride and sodium chloride. Among the organic compounds in the secret of the parotid salivary glands several enzymes are of great importance: catalase and amylase. The secret of the parotid gland does not contain alkaline phosphatase, but the activity of acid phosphatase is quite high. The secret produced by the **submandibular** salivary gland contains a large amount of organic substances (mucin, amylase) but has little of potassium thiocyanate. Amylase is presented in a smaller amount than in the saliva of the parotid gland. In the secret of the submandibular gland, different salts predominate: sodium chlorides, calcium chlorides, calcium phosphate, magnesium phosphate. The **sublingual** salivary gland secretes saliva rich in mucin and have a definite alkaline reaction. In the saliva of various glands, the composition of proteins are not the same. In the saliva of the submandibular salivary glands, proteins are identical to erythrocyte' agglutininogens that correspond to the blood group. Some proteins, in particular gamma globulins are of serum origin. In the oral cavity saliva performs mainly digestive and protective functions as well as trophic functions referring to its action on tooth' hard tissues - enamel.

3.2 Functions of saliva

The digestive function of saliva consists of the preparation of the food in a form of a bolus for swallowing and digestion. When chewing food is mixed with saliva, which is about 10-20% of the amount of food. Mucin is the most important organic element of saliva. Mucin molecules are made up of long strands of glycoproteins that give a saliva its viscous consistency. During intense mechanical mixing the bonds between glycoprotein molecules become broken up and the viscosity of saliva decreases drastically almost to the level of viscosity of the water. In the neutral pH environment saliva evenly envelops the teeth and is easily washed off by any liquid but in an acidic pH environment mucin covers the surface of teeth with a hard-to-remove plaque.

In the oral cavity saliva acts also as a digestive juice. It contains more than 50 enzymes, namely: hydrolases, oxidoreductases, lipases, isomerases. Saliva contains small amounts of proteases, peptidases, alkaline- and acidic phosphatases. Saliva contains some proteolytic enzymes that act in a way similar to pancreatic trypsin (salivalin, glandulin, kallikrein-like peptidase). Especially a lot of these enzymes are secreted by the submandibular salivary gland. Salivalin shows maximum activity at pH 9.2-9.9 and glandulin - in an acidic environment. Been absorbed to the blood circulation these enzymes can cause a drop in blood pressure level.

The protective function of saliva is that it protects the mucous membrane and teeth surface from drying out, also it equalizes the temperature of food and the oral cavity, and also binds acids and bases as an amphoteric electrolyte solution. Saliva washes plaque, promotes self-cleaning of the mouth and teeth. Saliva contains lysozyme having a bactericidal activity that is involved in the protective reactions realization and in the regeneration processes of the epithelium in case of damage to oral mucosa. An important group of enzymes that have a protective function are nucleases: acid and alkaline ribonucleases, transaminases, peroxidases. They are involved in the degradation of nucleic acids of viruses and therefore they play an important role in protection against viral infection. These enzymes also act on a microcirculation by dilating blood vessels and increasing

capillary permeability, increasing the migration of leukocytes by mean of vasoactive polypeptides action - kinins. The protective function of saliva is also in the presence of blood coagulation factors. The process of regeneration of the mucous membrane depends on the activity and concentration of these factors. Several substances that promote blood clotting were found in the oral fluid, namely: thromboplastin, antiheparin factor, fibrinase, and factors identical to IV, V, VIII, and X plasma factor.

All types of saliva have thromboplastic activity that is most active in the oral fluid and less active in the saliva of the submandibular, sublingual and parotid salivary glands. This high activity of these substances in the oral fluid is considered due to the presence of epithelial cells, platelets and leukocytes in it. After centrifugation of the oral fluid, its thromboplastic activity dropt to those of pure saliva secreted from the ducts. The antiheparin properties of saliva are also can be detected in the oral fluid, apparently for the same reasons. Some substances like plasma coagulation factors are filtered into the oral fluid from the blood plasma mainly, but they may also have a tissue origin. Saliva also contains several substances that act to prevent blood clotting (natural anticoagulants): antithromboplastins and antithrombins. In healthy people the saliva of the parotid gland has the highest anticoagulant activity, and oral fluid has the lowest. Substances with a fibrinolytic activity were also found in the salivary secretion: plasminogen, plasminogen proactivator and activator, antiplasmin. A fibrin-stabilizing substance resembling XIII plasma factor was also found in saliva. The fibrinolytic property of saliva is different. The oral fluid has the highest fibrinolytic activity and the saliva of the submandibular gland has the lower, while of parotid glands has the lowest. The fibrinolytic components of saliva are well studied and their content in saliva and in blood plasma changes in a similar way during daytime. The plasminogen activator factor that was found in saliva is presented not only in the oral fluid, but also in the saliva of parotid salivary glands. The presence of the plasminogen activator in saliva may be due to its involvement in providing the passage throw the salivary duct.

The significance of blood coagulation factors and fibrinolytic substances of

the oral fluid under physiological conditions, as well as in state of diseases of the oral cavity is definitely high. The presence of procoagulant factors in the saliva is essential for providing reliable local hemostasis. It is well known that oral mucosa' injuries occur daily during eating thus the possibility of blood vessels damage of this section of the digestive tract is significantly high. However, bleeding in the oral cavity stops quickly due to the presence of procoagulants - first of all thromboplastin - in the oral fluid. The high regenerative capacity of oral mucosa is providing mainly due to action of fibrinolytic agents of saliva. By helping to cleanse oral mucosa from fibrin debris and desquamating epithelial cells they play a beneficial role in regeneration processes. Fibrinolytic components of saliva are also essential for the cell growth. Thus, saliva provides a rapid healing of wounds without complications, so small abrasions in the oral cavity heal much faster than of the skin.

Saliva also carries out a trophic function. From the moment of teeth appearance and throughout a person's life saliva is in contact with teeth enamel, being the main source of calcium, phosphorus, zinc and other trace elements. At pH 7.0-8.0, saliva is oversaturated with calcium, so providing optimal conditions for inclusion of calcium ions into the enamel. When the environment of the oral cavity becomes acidic (at pH 6.5 or below) the oral fluid becomes deficient in the content of calcium ions, that leads to it release from the enamel. It was evaluated that transport of phosphorus-calcium compounds to the enamel occurs with the help of oral fluid enzymes.

Thus, the oral fluid plays the role of internal environment for tooth tissues. On the other hand, both the composition and properties of the oral fluid depends on the state of the whole organism, so under normal conditions it causes the inclusion of mineral components into the tooth enamel. Being a complex buffer solution, it helps to neutralize pH deviations on the tooth enamel surface. Being a reflection of the whole organism health condition, the composition of saliva may be changed in several numbers of diseases. For example, in a case of nephritis complicated with uremia the amount of residual nitrogen in saliva increases. There is an increase in saliva nitrogen content linked to gastric and duodenal

ulcerations. In case of the stroke, salivary glands on the side of the hemorrhage secrete saliva with higher protein content. Changes in saliva lead composition were linked to the tartar deposition, and this is known to be a predisposing factor for gingivitis occurrence.

The secretion of salivary glands is also age-depending. The salivary glands start secretion from the moment of birth but for several months it is insignificant. This causes some relative dryness of the oral mucosa in children during first months but starting from 5th to 6th month of life the salivation increases significantly. The next difference is that the duct projection of the parotid salivary gland in newborns and young children is different from that in adults. The location of the duct is relatively low, indirect, and opens at 0.8-1 cm from the anterior edge of the masticatory muscle. The other difference is that the parotid salivary gland is more rounded in shape, located slightly forward and reaches the angle of the lower jaw. The facial nerve is located relatively superficially. During puberty period of growth all secretory processes in salivary glands occur relatively intensively that is considered to be due to hormonal changes in the body. Age-related involution of small glands of oral mucosa begins after 60-70 years old. In elderly person some part of protein producing glands of the mucosa ceases secretion of protein secret and secretes rich in acidic and neutral glycosaminoglycans secret. Some of these cells in glands undergo subsequent atrophy changes with an increase in connective tissue and fat cells relative content. Atrophic changes were also noted in cells of the epithelium lining the ducts of these glands that leads to disturbances in secretory function of the glands and subsequently leads to dryness of the oral mucosa.

3.3 Regulation of salivation

The afferent pathways of both motor and secretory components of the chewing act are common and start from the main receptive field of the salivary reflex from oral mucosa. But salivation process has not only an unconditioned reflex but also a conditioned reflex mechanism: at a sight, at a smell of food, about talking of food, etc. The salivation center is located in the reticular formation of the medulla oblongata and is represented by the upper and lower salivatoreus

nuclei. The salivary center functionally interacts with the centers of respiration, vasomotor reactions, sweating, etc.

The efferent pathway of salivation is represented by fibers of both parasympathetic and sympathetic autonomous nerves. Parasympathetic innervations is carried out from both upper and lower salivary nuclei. From the upper salivary nucleus excitation is directed to the sublingual, submandibular and small palatine salivary glands. Preganglionic fibers for sublingual and submandibular salivary glands go as a part of drum strings and they conduct impulses to both submandibular and sublingual autonomic nodes. From autonomous ganglions regulatory excitation impulses switches to postganglionic secretory nerve fibers, the latter being the part of the lingual nerve pathway, and then approach submandibular and sublingual salivary glands. Preganglionic fibers to minor salivary glands go as part of the intermediate nerve to the pterygo-palatine ganglion. Postganglionic fibers leave it with large and small palatine nerves and approach small salivary glands located on the hard palate of the oral cavity.

From the lower salivary nucleus excitation impulses goes along with preganglionic fibers as part of the inferior stony nerve (glossopharyngeal nerve) to the ear node, in which there is a switch from preganglionic to postganglionic fibers, being a part of the ear-temporal nerve (from trigeminal branch), innervate the parotid salivary gland. The nuclei of the sympathetic division of the autonomic nervous system are located in lateral horns of 2 to 6 thoracic segments of the spinal cord. Excitation impulses from them through the preganglionic fibers enters the upper cervical sympathetic ganglion and then through postganglionic fibers along with the external carotid artery (external carotid nerves) reach salivary glands.

Stimulation of parasympathetic fibers that innervate salivary glands provokes an abundant secretion of saliva containing many salts and relatively few organic substances. Stimulation of sympathetic fibers leads to release of a small amount of saliva, rich in organic components and containing relatively few of salts. The denervation of the salivary gland results in a continuous (paralytic) secretion. In first days after denervation such a degenerative secretion goes on due

to the ability of regenerating nodes to synthesize the acetylcholine in the absence of ability to retain it. With further degeneration progress to continue the release of acetylcholine decreases, while the sensitivity of damaged cells to humoral factors, particularly to pyrocatechins, which are formed during pain irritation, hypoxia and other conditions, increases constantly.

In the regulation of salivation a significant role plays hormones of pituitary, adrenal, pancreas, thyroid glands, and also some of metabolites. Humoral factors can regulate the activity of salivary glands in several ways: either by acting on the peripheral department (secretory cells or synapses) or directly on nerve centers in the brain. The central regulatory department of salivary glands provides the necessary adaptability of salivation intensity to actual needs of the body that are most essential at that moment.

As an example of such a regulatory influence, when taste buds are irritated then saliva is released rich in organic substances and enzymes. On the other hand, when thermoreceptors are irritated then the saliva is liquid poor in organic substances. Saliva production also decreases in state of depression, during fever, after significant fluid loss, in case of systematic use of sleeping pills, in diabetes mellitus, anemia, uremia, and also in systemic diseases of the salivary glands (Sjögren's syndrome). A reflex that increases the salivation occurs after painful processes to appear in the oral cavity (gingivitis, stomatitis), as well as in a case of duodenal ulcer or pancreatitis. An increase in salivation also accompanies several drugs uptake (pilocarpine, physostigmine, etc.).

3.4 Methods of studying salivary glands function.

The study of secretory function in the oral cavity is an integral part of the clinical examination of the dentistry patient. For example, the method of separate collecting of a secret from large salivary glands with the help of **Leshli-Krasnogorsky** capsules is used. However, this method is rather difficult to apply in a case of collecting saliva from two glands simultaneously, or from ducts of submandibular glands, or in a case where the stone is located close to the opening of the duct. There is also a technique for collecting of the salivary glands secretion using cotton balls of a certain size and mass, which are placed on the opening of

the gland studied and then to proceed their weigh measurement.

Another method to study the secretory function of the salivary gland using special cannulas may be used. The cannulas are usually 85 to 97 mm long and 0.8 to 1 mm in diameter. The parotid gland cannula has a thickening part of an olive form located 3 mm from the blunt end and with the diameter of 1.6 to 2 mm. It is important for cannulas to be individually selected in advance. The process of selecting the definite cannula is a stage of preparation of a patient for the procedure of saliva collecting, thus reducing the influence of emotional factors on the salivation process. The study is usually carried out in the morning on an empty stomach. After receiving of 8 drops of 1% solution of pilocarpine hydrochloride by the patient, the cannula is inserted into the duct of the salivary gland to a depth of 3 to 5 mm. The end of the cannula is located into a graduated test tube held by the examined patient. It is necessary to ensure the end of the cannula not to be obturated by the wall of the secretory duct. If during the study the secret does not flow out from the cannula within 2 or 3 minutes, then it is recommended to pull slightly the cannula to remove it from the duct by 1- 2 мм. This may provide more favourable conditions for the secret leakage. Within 20 minutes from the first moment the secretion to appear (time should be controlled), saliva is collected in a test tube and its amount is determined. In cases of any of salivary glands diseases this method allows to determine the degree of secretory function violation, but only if the secret remains liquid and there are no mucous or fibrinous inclusions in it, so that the physical properties of the secret are not violated. In a healthy person the amount of saliva released during 20 minutes is 0.9-5.1 ml in average (usually 1.1-2.5 ml) for the parotid gland, and is 0.9-6.8 ml (usually 1-3 ml) for the submandibular gland.

The secretion of minor salivary glands may be assessed by using an ordinary filter paper strips by weighing them before and after the secretion study. Another method to count the number of functioning minor salivary glands of mucous membrane a lower lip stained with methylene blue is used by counting them within a frame of 2x2 cm after stimulation of their secretion by pilocarpine hydrochloride solution.

To examine excretory ducts of the salivary glands a **probing/catheterisation** procedure is used to establish the duct direction, or some narrowing, or complete obliteration, and also the presence and the location of some possible calculus in the duct. For probing procedure realization either a special probe/catheter for the salivary ducts is used, or an eye catheter may also be used.

Sialography is a method of radiography of salivary glands with special contrasting that allows to evaluate and to assume the state of both ducts and parenchyma of the gland. To perform an appropriate contrasting an oily agents are used (iodolipol, iodipine, iodethiol, etc.). On the sialogram, the image of the gland depends on the patient's position during radiography. The more detailed image of the structure of the **parotid gland** can be obtained on a side projection. On a direct anterior projection, the image of the parenchyma of the gland has a shape approaching to an oval and is located on the outer side of the jaw' branch. On an axial view, the parotid gland is located on the posterior jaw region. Its pharyngeal process is located medially from the posterior edge of the mandibular branch. The rear edge of the gland reaches the level of the mastoid process. At front side, the gland is closely adjacent to the posterior edge of the mandibular branch and passes to its outer surface up to the middle of the notch of the mandible. On the sialogram of the **submandibular gland** in a lateral projection, the duct is usually seen on the level of the lower jaw's body, so the upper pole of the gland is superimposed to the lower jaw's angle, and most of it is projected below its base. On the axial projection, the image of the submandibular gland is projected on the inner surface of the mandibular branch, and the shape of the projected gland approaches a shape of an oval.

Pantomosialography is a technique for x-ray examination of salivary glands after simultaneous contrasting of the parotid, submandibular or all four (parotid and submandibular) glands, followed by **panoramic tomography** with obtaining images of all contrasted glands on one x-ray film. This technique is used in the same cases as sialography. Simultaneous examination of paired glands allows a medical specialist to identify some possible hidden pathologic processes in paired glands. Pantomosialography is performed on a panoramic tomography mentioned above.

The description of both sialogram and pantomosialogram are made according to the following scheme.

When examining the **parenchyma** of the gland, it is established:

1) how the image is projected: good, or blurry, but homogenous, or blurry and heterogeneous, or not detected;

2) occurrence of a filling defect;

3) occurrence of point-shape cavities (from 0.1 to 0.5 cm in diameter) and cavities of more than 0.5 cm in diameter;

4) clarity of cavities' contours (clear, blur, fuzzy).

When examining the **ducts** of the gland, the following are determined:

1) narrowing of ducts of I to V degree/sequence (even or uneven);

2) expansion of ducts of I to V degree/sequence (uniform, uneven);

3) expansion of the main excretory duct (uniform, uneven);

4) displacement of ducts;

5) discontinuity of ducts;

6) clarity of duct's contours (clear, blur, fuzzy).

Sialotomography is a method of a layer-by-layer X-ray examination of salivary glands after filling their ducts with a contrasting agent. The method is used to determine the location of foreign bodies or in a case of neoplasia of the gland and is performed when there are encountered difficulties to decipher the picture on sialograms in anterior direct and in lateral projections. When analyzing tomosialograms, it is possible to clarify the location, shape, structure and degree of damage to the salivary gland.

CT-scan. The image is built up on the basis of axial projections perpendicular to the axis of the subject's body, followed by an angular displacement of the detector system and the X-ray tube by 60-120°. Digital information is then processed and presented as serial slices. The high sensitivity of detectors makes it possible to simultaneously obtain clear images of tissues of different density (bone, muscle, liquid, etc.). The transverse sections obtained are near to topographic anatomical sections, similar to the Pirogov' type of sections.

Radiosialography. With the applying of radionuclide compounds into the

clinical laboratory investigation in dentistry, it became possible to study the excretory function of salivary glands with such kind of methods in clinical practice. The method of radiosialography of the parotid glands consists of the process of recording curves of the intensity of radioactive radiation intensity simultaneously over the parotid glands and the heart or a thigh.

Scintigraphy (**radiosialoscintigraphy**) allows for a specialist in dentistry to simultaneously obtain all images of salivary glands. It is performed using a gamma camera 20 minutes after intravenous administration of sodium pertechnetate in a direct naso-chin/naso-mandibular projection in the supine position. Registration of the radioactivity of the head and neck region in the formerly mentioned time interval makes it possible to evaluate the absorption of the radiopharmaceutical compound by salivary gland parenchyma. The functional assessment of the salivary function of the gland is carried out by determining the degree of radioactivity fall in the salivary gland after giving a salivary stimulator.

Echosialography, or ultrasound investigation of salivary glands is the method based on the recording of different degrees of absorption and reflection of ultrasound signal by salivary gland tissues with different acoustic impedance. Echosialography allows you to get a layer-by-layer echo-image of the salivary gland and to evaluate its macrostructure. According to the echosialogram, one can assume the size, the shape and the ratio of layers of the gland tissue of different echo-densities, thus to identify sclerotic changes in the investigated gland. **One-dimensional echosialography** makes it possible to evaluate the relative density of adjacent tissue structures and the depth of their locations. With the reciprocal up-and down movement of the ultrasound emitting head of the ultrasonic scan, an image of the so called “sections” of the observed gland (ultrasound tomogram) is obtained on the screen.

Thermovisiography (**thermal imaging)** of salivary glands allows you to observe dynamic changes in temperature of various areas of the human body, including salivary glands area. This method is based on various infrared radiation registrations from different morphological structure tissues. It is also possibly to observe the objects temperature at a distance and to observe its distribution

over the body surface in dynamic way of investigation. For thermovisiography, special devices are used - thermal vision image sensors. On the monitor a thermal image - cartogram - is created of the face and neck region temperatures distribution, where the “warm” areas are white, the “less warm” ones are gray, and the “cold” ones are black in a black-and-white version. The study is carried out in a darkened room of 18-20°C. All heating or light-reflecting objects should be shielded to eliminate interference of infrared radiation. There should be no air movement also. The patient should be examined at the all the same time, usually in the morning (from 8 to 10 am), on an empty stomach (since eating increases the parotid glands temperature). One or two days before thermovisography procedure it is recommended to exclude any alcohol or medications, also women need to remove their earrings and to cleanse the skin from cosmetics. It is also necessary for women to remove hairs behind ears before the examination procedure. For men it is necessary to told them to shave their sideburns, mustache and beard if necessary. Before thermovisiography all patients should undergo an adaptation period for 30-60 minutes at a room temperature. During the procedure, first step is to visualize the temperature picture of the maxillofacial region, then the definite temperature of various zones is measured. Ordinarily, in the area of a face, depending on special features of the thermal image and the measured definite values of temperature, there are three zones that can be distinguished: hyperthermic (the temperature is above 35°C), mesothermic-normothermic (the temperature within 31-35°C) and hypothermic (the temperature within 23-31°C). Since the area of salivary glands is usually located in the mesothermal zone, salivary glands are not contoured on the thermal image monitor, so the temperature of the skin above salivary glands is measured of the anatomical location areas of glands, namely:

1) 2 cm to the front of the tragus and earlobe and parallel to the line descending down behind the lower jaw’s angle,

2) along the line along the front edge of the tragus and earlobe and parallel to the line descending down behind the lower jaw’s angle,

3) in the area of the projection of the submandibular gland and the lower jaw’s body.

In normal conditions, there are 3 variants of thermo-images observed of the maxillofacial region: cold, intermediate (mosaic-cold), and hot (mosaic-hot). For the same person observed in identical conditions of examination the thermal image of his face remains the same.

In general, the temperature of the oral mucosa is determined by a number of factors: first, the temperature and humidity of the external environment, then, the intensity of cellular metabolism, also the anatomical and physiological tissues special features, and then the condition of their vascular bed. In a normal state the microvasculature conditions depend on the number of capillaries and their functioning, as well as on arterioles circulation intensity. These circumstances explain the different topography of the temperature values of the oral cavity.

3.5. Questions for self-control assessment

Choose one or more correct answers

1 THE SEROUS GLANDS OF THE ORAL CAVITY INCLUDE

1. parotid
2. submandibular
3. sublingual
4. thymus
5. thyroid

2 MIXED-TYPE GLANDS INCLUDE

1. parotid
2. submandibular
3. sublingual
4. thymus
5. thyroid

3 THE RATE AND VOLUME OF SALIVA SECRETION DEPEND ON THE FOLLOWING FACTORS

1. gender
2. age
3. teething moment
4. type and quality of food
5. act of chewing

4 THE MOST IMPORTANT PROTEIN COMPONENT OF SALIVA CONTENT IS

1. glycoproteins
2. mucin
3. lipoproteins
4. immunoglobulins
5. pepsin

5 SALIVA pH VALUES AT REST ARE

1. 5.15-5.45
2. 5.45-6.06
3. 6.06-6.56
4. 6.56-7.0
5. 7.0-7.4

6 MAIN FUNCTIONS OF SALIVA

1. digestive
2. protective
3. mineralizing
4. buffer
5. trophic

7 THE PROTECTIVE FUNCTION OF SALIVA IS PROVIDED BY THE COMPONENT

1. lysozyme
2.interferon
3. neutrophils
4. interleukins
5. calcium

8 THE MINERALIZING FUNCTION OF SALIVA IS PROVIDED BY

1. calcium
2. potassium
3. magnesium
4. phosphorus
5. fluorine

9 MIXED TYPE SALIVARY GLANDS PRODUCE SALIVA RICH IN

1. mucopolysaccharides
2. protein, water and mineral salts
3. pepsin
4. hydrochloric acid
5. electrolytes

10 SALIVARY GLANDS OF THE SEROUS TYPE PRODUCE SALIVA RICH IN

1. mucopolysaccharides
2. protein, water and mineral salts
3. pepsin
4. hydrochloric acid
5. electrolytes

4 BLOOD SUPPLY OF ORGANS OF THE MAXILLOFACIAL REGION

4.1 Special features of blood flow in the maxillofacial region and its regulation

The periodontal blood supply is characterized by extensive collateral tracts and a rich network of vascular anatomizes with microcirculatory network of alveolar processes of the jaws, with dental pulp and with surrounding soft tissues. There is a vascular network between the alveolar wall and the tooth root that form loops and capillary glomeruli, that serves as a kind of periodontal buffer providing a mechanism of equalizing of hydrostatic circulatory pressure during chewing process. The gum capillary network comes very close to the surface of the mucous membrane. There are horseshoe-shaped capillary glomeruli located in gingival papillae that provide a close contact of gingival margin to the tooth's neck along with the gingival margin vascular system.

The pulp blood supply is carried out by arteries entering the pulp through an apical opening of the root canal, as well as through its deltoid branches. These arteries form a well developed pulp vasculature. There are peculiar reservoir vessels, so called "giant capillaries", along which a flask-shaped enlargements and sinuses in the tooth pulp. These vessels are referred to as the venular system of the dental pulp. The capillary network is extensively developed in the layer where odontoblasts are located, and it is considered to be an important feature for ensuring their high metabolic and plastic functional activities. This association of blood vessels changes with functional activity alteration in odontoblasts was clearly observed in cases of deep caries or pulpits.

Since the pulp blood circulation goes inside the tooth cavity with rigid walls, all pulsating fluctuations in the blood volume in a closed cavity would cause an increase in tissue pressure value and would lead to physiological processes violation in the dental pulp. However, this does not happen due to distribution of pulse oscillations from arteries to veins. Another special feature of the pulp vascular network is it has an effective antistasis mechanism, when the total lumen of veins in the coronal pulp is much greater than in the apical foramen, so the linear blood

flow velocity in the apical foramen region is higher than in the coronal pulp.

The regulation of blood circulation in the vascular system of the maxillofacial region and oral cavity is carried out by neurogenic and myogenic mechanisms. Like in other zones of circulation the autonomous nervous system regulation of vessels of jaws and teeth's pulp is provided by tonic impulses from the vasomotor center of the medulla oblongata through sympathetic fibers. The sympathetic innervation is carried out mainly by fibers from the upper cervical sympathetic ganglion. The average frequency of tonic impulses in the constrictor fibers of this area is 1-2 impulses per second and vasoconstrictor fibers tonic impulsation is essential for maintaining the vascular tone of resistive vessels, since the neurogenic tone is predominant in vessels of maxillofacial region.

Vasoconstrictor reactions of resistant vessels of the maxillofacial region and dental pulp to sympathetic fiber impulses are mediated by norepinephrine release in their synaptic endings and excitation of alpha-adrenergic receptors. However, beta-adrenergic receptors were also found in jaw's vessels, so the excitation of them leads to vasodilatation in response.

For a long time, the mandibular nerve was considered to be completely sensitive, but recent investigations show the presence of efferent vasomotor fiber in it, since its irritation causes a slow increase with a consequent even more slow decrease in blood vessel dilatation in the lower jaw vessels. These dilatory reactions are similar to the dilatation of skin vessels caused by irritation of the peripheral segment of dorsal spinal root. Since the vast majority of fibers of the mandibular nerve are afferent, providing a sensitive innervation of the periodontal region and of the dental pulp, it is quite possible that these dilator reactions are the response reaction to impulses coming along the afferent fibers of the trigeminal nerve. According to modern concepts, the "posterior radicular vasodilation" of skin vessels develops according as the axon-reflex mechanism to provide reparation process regulation after tissue damage. In this respect it can be assumed that the axon-reflex mechanism is significant for both the periodontium and the dental pulp.

The maxillofacial region vessels also have their own proprior myogenic mechanism of local vascular tone regulation. An increase in the myogenic tone of

arterioles and precapillary sphincters may leads to a rapid vasoconstriction with even partial reduction of the microcirculation in the region, so it may significantly affect the regional transcapillary exchange. This may prevent the increased fluid filtration in tissues and an increase in intravascular blood pressure, so it serves as a physiological protection mechanism from edema development. This myogenic mechanism of blood flow regulation and of transcapillary exchange regulation plays a significant role in providing a pulp vital activity since it is located in a closed space limited by the tooth cavity walls. The weakening of the former myogenic vascular tone regulatory mechanism may be one of the crucial factors in the development of the pulp tissues edema, of periodontis or other oral cavity tissues infiltration during inflammation. The myogenic tone of resistive vessels is significantly reduced during tissue functional load that may leads to an increase in its blood supply with "working hyperemia" development. In periodontotis when the blood supply of periodontal tissues is disturbed significantly, the functional load (for example, chewing) may be used as a therapeutic effect for prophylactic purposes to improve blood supply and nutrition of the periodontium. This is important due to the fact that according to the latest data in the pathogenesis of periodontal disease, functional changes in the vessels play a leading role.

There are several humoral regulators that may take part in the vascular tone regulation of the maxillofacial region, such as: vasopressin, angiotensin II, serotonin, histamine, prostaglandins, and bradykinin in addition to adrenaline.

The oral cavity mucous membrane should be considered as a significant reflexogenic zone with impulses from which can change even the heart activity and the vascular tone. Irritation of the taste buds of the tongue with sweet compounds usually causes vasodilatation in extremities, and with bitter ones, on the contrary, to narrow them.

4.2 Methods of microvasculature examination of maxillofacial region

The study of the vital microvasculature has a number of advantages. First, the microscopy makes it possible to study intimate functions of blood vessels microcirculation under physiological conditions without tissue damage, which

is very important for an adequate assessment and correct interpretation of the observed picture of investigation. Secondly, it allows studying the morpho-functional features of capillaries under the influence of physical and chemical stimuli. However, some visual study of vital micro vessels encounters a number of difficulties; the main of them is the lack of technically advanced special optical devices and lighting systems, as a result only superficially located vessels can be studied.

The life-time study of vital blood vessels of the oral mucosa is carried out using two main methods: **capillaroscopy** and **contact microscopy**. Capillaroscopy of the oral mucosa is carried out in parallel way with capillaroscopy of the nail bed, which gives a general impression of the peripheral circulation condition in the body. The capillaroscopic method is widely used in clinical dentistry. However, it is not appropriate for intimate studies of the microcirculatory bed, requiring the identification and the analysis of microscopic level details of venules and arterioles.

The method of contact microscopy with a special contact microscope (in Russia it is of the MLK-1 type) has been successfully applied in clinical studies in recent years. The device provides two modes of investigation: the luminescence mode of the object and the polarized reflected light mode, which allows you to increase the depth of investigation up to 0.1 mm, and the contour observed of microvessels become more contrast and clear, that makes it possible to study not only superficially located, but also arterioles and venule lying deeper from superficial layer observed.

The clinical life-time study of vital micro vessels of the oral mucosa should be carried out in compliance with a number of methodological items:

1) reliable and comfortable for the patient fixation of his head;

2) reliable fastening of the optical system of investigation, providing the ability to move it in any direction to make it possible to study different regions of the oral mucosa;

3) a powerful light source with no thermal radiation effect on a region under investigation;

4) a precise adjustment of the image recording equipment, allowing it to be used at any moment during the course of study.

To investigate the functional state of blood vessels microcirculation, several functional tests are used, including vasoactive agents of general or local mode of action to be used. During the vital microscopy there can be used vasoconstrictive agents (for example, adrenaline 1:1000) in a form of local applications. It is also possible to study the vascular response to temperature, for this purpose an isotonic sodium chloride solution is used with a temperature of 10°C to 40°C.

Pathological changes observed in the microvasculature of the oral mucosa during investigations are classified as follows:

1) intravascular disorders;

2) morphologic or functional changes in the vascular wall;

3) extravascular disorders.

One of the most frequently observed **intravascular** disorder is a disturbance in blood flow. Normally the blood flow in arterioles and venules is clearly visible, and in such a case the type of blood vessel can be determined by blood flow direction, in arterioles and venules it has different flow directions. Individual erythrocytes in the vessels are impossible to distinguish due to high blood flow velocity. However, in some pathological conditions (for examples, various infections, allergic reaction, state of shock, signs of stagnation) due to alterations in rheological properties of the circulating blood, or due to a decrease in blood flow velocity, or when blood flow which is continuous in normal conditions becomes intermittent. Due to blood flow disturbances the aggregation of erythrocytes occurs and the formation of microthrombi occurs.

During assessing the nature of blood flow in capillaries, the following observations can be registered:

1) Continuous blood flow

2) “Beady” blood flow

3) Intermittent blood flow

4) Pendulum blood flow

5) Thrombosis

6) Desolation of capillaries

Observation of vessels condition is of great importance for microcirculation to assess. There could be several forms of capillary condition:

1) Thick or thin

2) Straight or curved

3) Long or short

4) Deformed

5) Microaneurismal protrusions

The microscopic observation of the mucous membrane of gums in healthy people with a normal state of the gingival margin reveals a picture of gingival capillaries that is the same for gingival capillaries in general. There are three zones in the mucous membrane observed by the microscopy of gums that are quite distinguishable and can be distinguished by the capillaroscopic pattern:

the **first zone** is the gingival margin, where terminal loops of capillaries are observed;

the **third zone** is an area bordering with a transitional fold or frenulum;

and the **second zone** is an area located between them.

Such a zonal division not only facilitates the study and description of the state of the microvasculature, but also makes it possible to clearly systematize capillarograms, which are of considerable complexity in a case of a periodontal disease to occur.

At present time to study the resistance of capillaries the **dosed vacuum** method has been applied to a practice of dental clinics. For these purposes a commercially available vacuum devices for treatment of periodontal disease can be used. As the tips of their probes there could be used glass tubes with internal diameter of 6-7 mm, that are bent at a proper angle to be convenient to use them for the gum. The capillary resistance investigation is based on time recordings during which a hematoma is formed in the gum. After creating a vacuum space in the system (about 720-740 mm Hg at a residual pressure of 20-40 mm Hg) the sterile tip is attached to the gum. Through the transparent wall of the vacuum tube it could be observed how the gum is drawn into the tube, its color changes,

and some separate hemorrhages appear which relatively quickly merge together, forming a vacuum hematoma. In the frontal region of the jaws hematomas are formed normally in 50-60 s, and in other regions the time of formation may be longer. A repeated study of the resistance of gum capillaries makes it possible to monitor the dynamics of the process under treatment prescribed.

The intensity of tissue blood supply is examined by the **rheography** based on a graphic registration of the resistance to an electric high-frequency alternating current passing through. Changes in electrical resistance normally occur due to pulsate fluctuations linked with rhythmic activity of the heart which ejects a portion of blood to arteries during systole under high pressure. The blood volume pulsating changes increases the electrical conductivity of tissues, since the circulating blood has a greater electrical conductivity than ordinary tissues of the body.

The intensity of tissue blood filling depends on the pulse volume and the blood flow velocity, therefore the electrical resistance of tissues experience the same dependence. Actually, the rheography consists of graphic registration of pulse fluctuations of electrical resistance of tissues investigated, which depend both on the activity of the heart and on the circulation in peripheral blood vessels, and also on their elasticity and extensibility. These abilities of blood vessels are associated with the functional state of blood vessels, their structure and tone. Therefore, the analysis of rheogram requires a complex clinical interpretation, taking into account all indicators of central hemodynamics and functional properties of peripheral blood vessels.

All currently used rheographs actually are of 3 types according to the schemes of connecting them to a biological object: bipolar, tetrapolar and focusing rheographs. A multichannel electrocardiograph may be used as a recording device, and the rheogram should be recorded synchronously with the ECG registration in the second standard lead as the reference method for estimation of a definite cardiocycle period during investigation. Electrodes used could vary in shape and area, but in any case a moistened pad under the electrode is used to reduce the electrical resistance between it and a tissue under an electrode.

To evaluate the functional condition of vascular bed of maxillofacial region tissues several **local functional tests** are used of a natural origin: temperature stimuli (heat or cold) and chewing load.

Thermal stimuli are an adequate functional load under normal conditions that has a direct effect on blood vessels. As a temperature stimuli a paraffin application that heated up to 45°C is used (under control of a thermometer to avoid possible burns) or ice stones. A gauze strip equal in size to the surface of the examined area is moistened with heated paraffin and applied for 5 minutes. For a cold reaction to study a chopped ice prepared in advance is placed in a plastic bag or rubber glove's finger part and applied to the tissue to investigate also for 5 minutes.

Another task is to evaluate the functional condition during chewing pressure that is the main functional load on tooth and periodontium. It acts as a factor that reduce its own myogenic (basic at a local level) vascular tone of tooth's pulp and periodontium, in another words it act as a vasodilator. For chewing one can chose either static or dynamic load that is determined by the objectives of the study. For perfect individual dosing of the chewing load and to ensure high reproducibility of a study a gnatodynamometer usually is used. In such a case using a gnatodynamometer it is also possible to determine the maximum chewing muscles force when chewing pressure is achieving. Actually a rheographic curve resembles a sphygmogram. To describe a rheogram there are several indexes and values to estimate, for example: the main amplitude of rheogram, the rheographic index, the vascular tone index, the elasticity index, the index of peripheral resistance, etc. A qualitative analysis of rheographic curve makes it possible to assess the functional state of vessels, as well as also some morphological changes in a wall, for example, atherosclerotic ones. When the vascular tone regulation condition is normal the ascending part of the rheogram is steep, its apex is sharp, and the descending part is sloping with a dicrotic wave is located in the middle of the descending part and clearly pronounced. In case of an increase of vascular tone the ascending and descending parts of the rheograms are sloping with the flat top and the dicrotic wave is smoothed and located in the upper third part of the descend-

ing part of the rheogram. In a case of severe spasm the dicrotic wave is smoothed out or completely disappears. If a vascular tone is decreased the ascending part is significantly steep, the apex is peaked, and the descending part is also steep with a pronounced dicrotic wave located on its lower third or close to the base level of the curve.

According to the configuration of the rheogram some age-related changes in the functional state and morphological structure of the vascular bed can be evaluated. It is always an item to remember when analyzing rheograms. One should take them into account when pathological changes in the vascular network are registered, since the elasticity of the vascular walls decreases, and their rigidity increases with age. This makes it difficult for pulse wave to pass along the blood vessel wall. On a rheogram it is reflected in a decrease in the steepness of the ascending part, in a smoothing of both apex and dicrotic wave, and also in its displacement towards the apex of a rheogram.

In dentistry the rheography is used in the following cases:

1. **in therapeutic dentistry** - for rheography of the tooth pulp, rheoparodontography, rheography of the oral mucosa.

2. **in surgical dentistry** - for determining parameters of central hemodynamics, to assess the effectiveness of local anesthesia, to evaluate the effectiveness of prescribed treatment of trigeminal neuralgia and of the facial nerve neuritis, and also to monitor the result of sclerosis of vascular tumors in the maxillofacial region.

3. **in orthopedic dentistry** - for determining the functional state of tooth pulp and periodontium in cases of fixed or clasp prosthetics, for rheoparadontography to evaluate a traumatic overload of the periodontium, for rheography of the oral mucosa with removable prosthetics.

Evaluation of the effectiveness of local anesthetics could be registered by their vasoconstrictor action by recording a fatal decrease of the rheogram amplitude. The time from decreasing and to complete restoration of the amplitude of rheogram corresponds to anesthetic effect period, and the degree of this decrease is related to the depth of anesthetic effect.

4.3 Physiological background of preventive measures in case of prolonged bleeding after tooth extraction

From the course of physiology it is known a hemostasis to realize by three main components that are functionally and structurally interrelated: 1. blood vessel walls, 2. blood cells, 3. plasma coagulation factors. In addition, the state of both the **fibrinolytic and kallikrein-kinin systems** is quite important for blood coagulation process to control. The interaction of platelets with the microvessel (less than 100 mkm in diameter) walls plays a leading role in stopping bleeding from microcirculation blood vessels (**vascular-platelet stage of hemostasis**). When large vessels are damaged, the vascular-platelet hemostasis plays only the initial role, and formation of a fibrin clot occurs when plasma coagulation factors interact with the components of the vascular wall and platelets (**coagulation stage of hemostasis**).

Violation in the vascular-platelet hemostasis can be indirectly evaluated by the **Duke's test** results. Normally a platelet thromb formation to stop bleeding from microvessels in 2-4 minutes. Prolongation of bleeding time is observed in case of severe **thrombocytopenia** (less than $50x10^9$/l), with platelets abnormalities by themselves (**thrombocytopathy**), as well as in case of platelet adhesion factors deficiency (for example, in **von Willebrand disease**, the bleeding time increases up to 60 minutes).

Violations in coagulation hemostasis can be congenital or acquired. Among diseases with the hereditary deficiency of plasma coagulation factors, forms associated with a deficiency of two X-linked factors, YIII and IX, are considered to be predominant in male population. Acquired coagulopathy is characterized, on the contrary, by complicated and multidirectional abnormalities in various parts of coagulation cascade. The most frequently observed acquired coagulopathies are:

1. Syndrome of disseminated intravascular coagulation
2. Hemorrhagic diathesis linked with liver diseases
3. Vitamin K deficiency and complications after anticoagulant treatment

Among the hereditary coagulopathies the **hemophilia A** consists of 68-78% It is linked with factor YIII plasma deficiency. In such a case a hemophilic patient

should be prepared beforehand to undergo a set of preventive treatment before dental procedure. In case of tooth decay treating it is enough to administer a cryoprecipitate or factor YIII concentrate once intravenously and to prescribe gama-aminocapronic acid in a dose of 4-6 g 4 times a day during 3 days for oral administration after the procedure. Along with a strong antifibrinolytic effect of gama-aminocapronic acid, it inhibits the plasminogen activators in saliva and normalizes the clot formation in tissues of the oral cavity. In case of big surgical manipulations in oral cavity or the extraction of permanent teeth a hemophilic patient should be hospitalized.

In case of an acquired coagulopathy a dentist should be aware of the syndrome of disseminated intravascular coagulation to develop in a patient after perspective of an extensive surgical intervention. Syndrome of disseminated intravascular coagulation is a complex pathological process associated with the entry of activators of plasma factor coagulation and platelet aggregation into the bloodstream, followed by depletion of these factors later. Actually there are two stages in Syndrome of disseminated intravascular coagulation development: 1. widespread intravascular coagulation stage with a subsequent impairment of microcirculation in tissues; 2. depletion of plasma factors of hemostasis with an uncontrolled bleeding stage. The development of **Syndrome of disseminated intravascular coagulation** is extremely life-threatening with the death of a patient to occur both on the first and on the second stage.

In order to prevent Syndrome of disseminated intravascular coagulation the dentist must follow the following rules:

1. To perform any surgical manipulations with the least dramatization of oral cavity tissues

2. Do not use forceps on a gum

3. Let the patient out only after making sure that the bleeding has stopped

4. Do not leave any dental deposits or unfilled cavities on teeth adjacent to the operational wound

5. If there are definite indications for several adjacent teeth removal it is necessary to remove them all at the same time, since bacterial pathogenic factors

can cause to undergo lysis of thrombi, thus to cause a secondary bleeding onset. The majority of multiple tooth extractions cases require stitches to be applied, especially if the bleeding lasts longer than usual.

4.4. Questions for self-control assessment

Choose one or more correct answers

1 IN THE MAXILLOFACIAL REGION AND DENTAL PULP VASOCONSTRICTION REACTION OF RESISTANT VESSELS BY IMPULSES FROM SYMPATHETIC FIBERS ARE CARRIED OUT BY

1. excitation of alpha-adrenergic receptors
2. excitation of beta-adrenergic receptors
3. inhibition of alpha-adrenergic receptors
4. release of acetylcholine
5. excitation of M-cholinergic receptors

2 TONGUE TASTE RECEPTORS STIMULATION WITH SWEET SUBSTANCES CAUSES

1. vasodilatation of extremities
2. vasoconstriction of extremities
3. vasodilatation of the head
4. vasoconstriction of the heart
5. vasoconstriction of the head

3 PECULIARITIES OF THE PERIODONTAL BLOOD SUPPLY ARE

1. blood stasis
2. high blood pressure
3. high blood flow rate
4. collateral pathways
5. vascular network rich in anastomoses

4 THE MOST DEVELOPED CAPILLARY NETWORK IS LOCATED IN TOOTH AREA OF

1. enamel of the tooth
2. layer of odontoblasts
3. crown of the tooth
4. neck of the tooth
5. nerve fibers

5 THE PULP VASCULAR NETWORK HAS AN EFFECTIVE ANTI-STASIS MECHANISM OF

1. decreased reabsorption of the sodium and water
2. total lumen of the coronal pulp veins is more than in the apical foramen region
3. linear velocity of blood flow in the apical foramen region is higher than in coronal pulp
4. high blood pressure
5. low venous return ratio

6 NORMALLY A VACUUM HEMATOMA IN FRONT JAWS IS FORMED FOR

1. 50-60 s
2. 5-6 s
3. 20-30 s
4. 110-160 s
5. 1-2 s

7 VESSEL VITAL MICROSCOPY ALLOWS

1. to examine the shape and size of blood cells
2. to study the morpho-functional features of capillaries when exposed to physical or chemical stimuli
3. to study chewing pressure
4. to study the speed of blood flow
5. to study blood coagulation

8 MECHANISMS OF PHYSIOLOGICAL PROTECTION OF DENTAL TISSUES AGAINST THE EDEMA PROGRESSION ARE

1. enhanced filtration
2. increased myogenic tone of arterioles and precapillary sphincters
3. narrowing of the microvasculature
4. restriction of transcapillary exchange
5. increased intravascular pressure

9 RHEOGRAM FEATURES WITH A NORMAL TONIC TENSION OF VASCULAR WALLS

1. the ascending part of the rheogram is steep, and the apex is sharp
2. the descending part is flat
3. the dicrotic wave is smoothed out or completely disappears
4. a pronounced dicrotic wave is located in the lower third of the descending part or close to the base line
5. a well-defined dicrotic wave is located in the middle of the descending part

10 RHEOGRAM FEATURES WITH AN INCREASED VASCULAR TONE

1. both ascending and descending parts of the rheograms are sloping
2. top is flat
3. dicrotic wave is smoothed and located in the upper third of the ascending part
4. dicrotic wave completely disappears
5. a pronounced dicrotic wave is located in its lower third or close to the base line

5 PAIN PERCEPTION SYSTEM PHYSIOLOGY, NOCICEPTION

5.1 Physiology and structural organization of pain sensation nervous system

Pain may be defined as an unpleasant sensation that occurs under super strong stimuli to act that cause structural and functional disorders in the whole body. Pain differs from other sensations in that it does not inform the brain about the quality of the stimulus, but indicates that the stimulus is damaging. Another feature of the pain sensory system is the most complex and powerful efferent control of it.

The pain analyzing system in the central nervous system launches several programs of the body's response to pain. Therefore, there are several components in pain acceptance:

- The sensory component of pain is characterized by an unpleasant, painful type of sensation.
- The affective component characterizes it as a strong negative emotion to come along with a pain sensation.
- The motivational component as a negative feedback loop regulation triggers the body's behavior pattern aimed at recovery of an organism.
- The motor component of pain is represented by various motor reactions: starting from elementary unconditioned reflexes of extremities flexion to complex motor programs of anti-pain behavior of an organism.
- The vegetative component of pain characterizes the occurring dysfunction of internal organs and metabolism level in chronic pain conditions.
- The cognitive component is associated with a self-assessment of pain as a psychological pattern of suffering.

During other systems activity these components of affection are not much expressed.

The biological role of pain may be described by several factors affected. Pain plays a role of a signaling factor related to threats or damages of body tissues to make a general warning for an organism. Pain has also a cognitive function

throw which a person learns “through pain” to avoid possible danger objects or events of the surrounding environment. The emotional component of a pain plays a role of reinforcement of further formation of conditioned reflexes in the central nervous system. Pain may also be considered to be one of the strongest factors in mobilization of adaptive and protective reactions of the body in case of its tissues and organs damage.

In physiology there are two types of pain conventionally defined: somatic and visceral. The somatic type of pain can be subdivided into superficial and deep types, while the superficial type also can be subdivided into early (fast appearing, so-called “epicritic” pain) and late (slow one, the so-called “protopathic” pain).

There are three actual theories of pain.

1. The **theory of intensity** was proposed by E. Darwin and A. Goldsteiner. According to this theory, pain is not a specific feeling and does not have its own special receptors. It arises under the extra strong stimuli action on the known sense receptors of five traditional sense organs. Due to the convergence and summation processes of different impulses both in the spinal cord and the brain there goes a pain sensation formation.

2. The **theory of specificity** was proposed by the German physiologist M. Frey. According to this theory, a pain is a specific sense of feeling that has its own receptors, its afferent fibers and particular brain structures involved in a definite processing of pain information. Nowadays this theory has received its complete experimental and clinical confirmations.

3. The modern theory of pain is based primarily on the **theory of specificity**. Since the specific pain receptors have been proven to exist, a modern theory of pain is based on both central **summation and convergence** mechanisms of pain occurrence. The most significant achievements of modern theory of pain are the development of mechanisms of **central perception** of pain and the mechanism of a **launch of anti-pain system** in the brain.

5.2 Specific pain receptors physiology

Pain receptors are represented by freely endings of sensitive myelin-covered Aδ-type fibers and of non-myelin C-type fibers. They are found in the skin, in mucous membranes, in the periosteum, inside teeth, in muscles and joints, in numerous internal organs and their capsules, and also in blood vessel walls. They are not found in the nervous system tissue of the brain and spinal cord. The highest density of pain receptors is **at the border of dentin and the tooth enamel**.

There are several types of pain receptors:

1. Mechano-nociceptors and mechano-thermo-nociceptors of Aδ-fibers that respond to strong mechanical or thermal stimuli, and are involved in rapid both mechanical and thermal pain occurrence, but adapt quickly. They are located mainly in the skin, in muscles, in joints, and in periosteum. Their afferent neurons have small receptive fields in the central nervous system.
2. Polysensor-nociceptors of C-fibers respond to all mechanical, thermal, and chemical stimuli, they are involved in a late poorly localized pain sensation, they adapt slowly, and their afferent neurons have large receptive fields in the central nervous system.

Pain receptors can be excited by three types of stimuli:

1. Mechanical stimuli that create a pressure more than 40 g/mm^2 during squeezing, stretching, bending, twisting of tissues of a body.
2. Thermal stimuli either hot (more than 45^0 C) or cold (less than 15^0 C).
3. Chemical stimuli that may be released from damaged tissue cells, from mast cells, or from platelets (K^+, H^+, serotonin, acetylcholine, histamine), and also may be presented in blood plasma (bradykinin, kallidin) and in nociceptive neuron endings (substance P). Some of them act as an excitation substances for nociceptors (K^+, serotonin, histamine, bradykinin, ADP), while the others act to sensitize them.

Properties of pain receptors are defined by their physiologic features: pain receptors have a high threshold of excitation that ensures their response only to extreme stimuli. Nociceptors C-afferents do not adapt well to long-acting stimuli.

It is possible to increase the sensitivity of pain receptors due to a phenomenon of a decrease in the threshold sensitivity after repeated or prolonged stimulation occur, called **hyperalgesia**. At the same time, nociceptors are able to respond to subthreshold stimuli as well as to be excited by stimuli of other modalities.

5.3 Pathways of pain sensitivity

Neurons that perceive the pain impulsation starting from pain receptors of the trunk, neck and limbs are Aδ- and C-fibers of first sensitive neurons. Their bodies are located in the spinal ganglia and they go as a part of definite spinal nerves. They enter the spinal cord through the posterior roots where they branch out in the posterior columns to form synaptic connections directly or through interneuron-type connections with secondary sensory neurons, the long axons of which are part of the spinothalamic pathways. They may connections with two types of neurons: some neurons are activated only by painful stimuli, while others – called convergent neurons – may also be excited by non-painful stimuli. The second neurons of pain sensitivity are predominantly a part of the lateral spinothalamic pathways, which conduct most of the pain impulses. At the level of the spinal cord axons of these neurons pass to the opposite side of the spinal cord, opposite to a stimulation side, and at a level of the brainstem they reach the thalamus to form synapses with its nuclei' neurons. Part of a pain impulses of the first afferent neurons are switched through interneurons to motor neurons of the flexor muscles to participate in the realization of protective pain reflexes. There are two pathways in the lateral spinothalamic pathway: the evolutionarily younger neospinothalamic pathway and the ancient paleospinothalamic pathway – may be defined:

1. The neospinothalamic pathway conducts pain signals along Aδ-fibers mainly to specific sensory nuclei of the thalamus (ventral posterior nuclei), which have distinct topographic projection of the body's parts. An additional small part of impulses enters the reticular formation at the brainstem level and further on they go into nonspecific nuclei of the thalamus. The excitation transmission in the synapses of this pathway is carried out with the help of a fast-acting neurotransmitter glutamate.

From the specific nuclei of the thalamus, pain signals are transmitted mainly to the sensory cortex of the cerebral hemispheres, thus participating in realization of the so-called **"fast" pain perception with a high degree of localization perception** - the main function of the neospinothalamic pathway.

2. The paleospinothalamic pathway conducts pain signals along C-fibers mainly to the nonspecific nuclei of the thalamus directly or after switching to in the neurons of the reticular formation at the brainstem level. The excitation transmission in synapses of this pathway occurs more slowly with a help of the substance P mediator. Further on from nonspecific nuclei impulses go to the sensory and other parts of the cerebral cortex. A small part of these impulses goes to specific nuclei of the thalamus also and terminate on neurons of: 1) nonspecific nuclei of the thalamus; 2) reticular formation; 3) central gray matter; 4) blue spot; 5) hypothalamus. Through the paleospinothalamic pathway the so-called **"late" poorly localized** pain sensation is realized with an **affective-motivational** manifestation of pain sensitivity accompanied.

In addition, pain sensitivity is partially conducted along some ascending tracts: the anterior spinothalamic, the subtle, and the sphenoid tracts. The mentioned pathways also conduct other types of sensitivity: temperature and tactile senses.

5.4 The role of the cerebral cortex in pain perception

A full range sensory perception of body pain is impossible without the cerebral cortex participation. The primary projection fields of the so-called "pain analyzer" is located in the somatosensory cortex of the posterior central gyrus. It provides the perception of "fast pain" and identifies its place of the body. For a more precise identification of pain localization the motor cortex neurons of the anterior central gyrus are involved obligatory.

The secondary projection field is located in the somatosensory cortex at the border of intersection of the central sulcus with the upper edge of the temporal lobe. The neurons of this projection field have bilateral connections with several nuclei of the thalamus that allows this projection field to selectively filter some pain excitations passing through the thalamus. This, it allows for this projection field to be involved in the processes associated with retrieving the engrams of necessary behavioral act to undergo from the long-term memory with its implementation in the effectors activity and in assessing the achieved results of a behavior.

The motor component of pain behavior is formed by the concordant activity of both motor and premotor cortex, of basal ganglia, and of the cerebellum.

The frontal cortex plays a crucial role in the overwhelmingly accepted pain sensation by a person. It provides a self-assessment of pain (its cognitive component) and formation of a person complex behavior.

The limbic system (hippocampus, cingulate gyrus, dentate gyrus, and amygdala complex of the temporal lobe) receives information about pain from the anterior nuclei of the thalamus to coordinate the emotional component of the pain, and to trigger the onset of vegetative, somatic and behavioral reactions that provide a complex adaptive reaction of an organism to a painful stimulus.

5.5 Types of pain special characteristics

There are pain types that are called **projection or phantom pain**. Their occurrence is based on the pain projection principle: no matter what part of the afferent pathway is stimulated, the pain is felt in the whole receptor region of this sensory pathway. According to modern data, all parts of the pain sensory

system are involved in the formation of this type of pain sensation. There is also a so-called **reflected pain**, when pain is felt not only in the affected organ, but in the corresponding "**dermatome**"- an innervation region of the body. The area of the body surface, corresponding to "dermatome", is called the **Zakharyin-Ged zones,** where a sensation of pain occurs. Such a phenomenon of reflected pain is due to neurons, conducting pain impulses from the affected organ and from skin receptors of the corresponding dermatome usually converge on the same neuron in the spinothalamic pathway. Stimulation of the inner receptors of the affected organ of such a neuron leads to a situation when the pain is also felt in the area of located superficially skin receptors, according to the principle of pain projection mentioned above.

5.6 Antinociceptive system physiology

The "anti-pain" system consists of four levels: spinal, brainstem, hypothalamic and cortical level.

1. **Spinal level of the antinociceptive system**. An important component of the spinal antinociceptive system is so-called "**gate control**" of the spinal cord, the concept of which has the following meaning: pain impulses nerve transmission from the first neurons to the spinothalamic pathways second neurons in the posterior columns of the spinal cord is modulated by the **spinal gate** mechanism – by inhibitory neurons located in spinal cord substance gelatinous. Numerous branches of various sensory pathways axons end there on these neurons. In its turn, the neurons of the gelatinous substance exert presynaptic inhibition on a level of switching points of both the first and second neurons of pain- and other sensory pathways. Some of neurons are so-called "convergent" neurons that mean synapses formation from not only pain receptors, but also from other receptors on those neurons. Spinal gate control is regulated by the ratio of impulses quantity coming from large diameter afferent fibers (of non-pain sensitivity) and from small diameter (of pain sensitivity). A very intense impulses flow along the large diameter fibers evokes limitation in the transmission of pain signals to the neurons of spinothalamic pathways -"**close the gate**". On the contrary, an intense flow of pain impulses along the first afferent neuron **by inhibition of in-**

hibitory interneurons facilitates transmission of pain signals to neurons of the spinothalamic pathways -"**opens the gate**". The spinal gate control mechanism is under a permanent influence of the brainstem structures that is transmitted along the descending pathway to both the gelatinous substance and to spinothalamic pathway neurons.

2. **The brainstem level of the antinociceptive system**. Brainstem structures involved in analgesic system include, firstly, the central gray matter and the raphe nuclei, that form a functionally common unit, and secondly, giant cell nuclei and paragiant cell nuclei of the reticular formation and the blue spot. The first complex blocks the pain impulses passage at the level of relay neurons in the posterior horn nuclei of the spinal cord, as well as relay neurons in the sensory nuclei of the trigeminal nerve, which form an ascending pathway for pain sensitivity. The second complex excites almost the entire antinociceptive system.

3. **The hypothalamic level of the antinociceptive system**, on the one hand, functions independently, but on the other hand, it acts as a setting point to control antinociceptive mechanisms of the brainstem level, due to hypothalamic neurons have numerous connections with different nuclei and are of different neurochemical specificity. There are also specific neurons presented with axon endings to excrete enkephalins, β-endorphin, norepinephrine, and dopamine.

4. **Cortical level of the antinociceptive system**. The somatosensory area of the cerebral cortex implements its influence in a way of integration and controlling of antinociceptive structures activity of various levels. At the same time, the secondary sensory areas play the most important role in activation of both spinal and brainstem structures. The secondary sensory neurons form an enormous number of descending fibers for pain sensitivity control, heading to both posterior horns of the spinal cord and to nuclei of the brainstem. The secondary sensory cortex acts to modify the activity of the brainstem complex of the antinociceptive system. Besides this, several somatosensory fields of the cerebral cortex can control the conduction of afferent pain impulses through the thalamus. In addition to the thalamus, the cerebral cortex can regulate the pain impulses passage in hypothalamus, limbic system, reticular formation, and in spinal cord.

The leading role in providing these cortico-hypothalamic influences is assigned to neurons of the frontal cortex.

5.7 Mediators of the antinociceptive system

Mediators of the analgesic system include several different classes of substances, among them peptides that are formed from inactive precursors in the brain, adenohypophysis, adrenal medulla, gastrointestinal tract, and even in placenta. Nowadays the opiate mediators of the antinociceptive system include: ά-, β-, γ-endorphins; enkephalins; dynorphins. These mediators act on all three known types of opiate receptors: μ-, δ-, κ-receptors. The most selective stimulator of μ-receptors are endorphins, for δ-receptors are enkephalins, and for κ-receptors are dynorphins. The density of μ- and κ-receptors is high in the cerebral cortex and in the spinal cord, but medium - in the brain stem. On the other hand, the density of δ-receptors is medium in the cerebral cortex and in spinal cord, but low - in the brainstem. Opioid peptides inhibit the action of pain-inducing substances at the nociceptor level, also reduce the excitability and conduction of pain impulses, and inhibit the reaction of neurons in chains that transmit pain impulses. These peptides are delivered to the neurons of the pain sensory system with blood and cerebrospinal fluid. Opioid mediators are released in synaptic endings of neurons of the analgesic system. The analgesic effect of endorphins is considerably high in the brain and spinal cord, while the effect of enkephalins in these structures is medium, and the effect of dynorphins is low in the brain, and is high in the spinal cord.

The perception of pain sensation is determined not only by the strength of exogenous or endogenous pain effects alone. In many cases it depends on the ratio of activity levels of the nociceptive and antinociceptive departments of the pain perception system, and thus has an important adaptive value for nervous system to react adaptively even to a damage causing impact on the body.

5.8 Questions for self-control assessment:

Choose one or more correct answers

1 WHERE IS THE ORAL CAVITY HIGHEST PAIN RECEPTORS DENSITY?

1. in the pulp of teeth
2. in the periosteum
3. in mucous membranes of the oral cavity
4. at the border of dentin and the tooth enamel
5. in the apex of the enamel

2 WHAT ARE THE SENSITIVE MYELIN-COVERED AΔ-TYPE NEURAL FIBER FEATURES IN PAIN PERCEPTION?

1. they carry out sensitive information from mechano-nociceptors and mechano-thermal-nociceptors that respond to strong mechanical or thermal stimuli, they provide a rapid pain perception, but adapt quickly.
2. they carry out sensitive information from special nociceptors that provide a rapid pain perception and a rapid pain relief
3. they carry out sensitive information from special nociceptors that provide a slowly ascending pain perception and cause a long-term thalamic pain type
4. they carry out sensitive information from mechanoreceptors that provide a rapid pain perception, and a rapid pain relief
5. they have no pain sensation fibers

3 WHAT ARE THE SENSITIVE NON-MYELIN C-TYPE NEURAL FIBER FEATURES IN PAIN PERCEPTION?

1. they carry out sensitive information from polysensor-nociceptors that respond to all mechanical, thermal, and chemical stimuli, they provide a late poorly localized pain sensation, and they are slowly adapted
2. they carry out sensitive information from all type of sensory receptors with a slowly ascending pain perception and a slow pain relief, but well localized sensation

3. they carry out sensitive information from special slow nociceptors that provide a slowly ascending pain perception with a rapid pain relief
4. they carry out sensitive information from special rapid nociceptors that provide a rapid pain perception and cause a thalamic long-term type of pain
5. they have no pain sensation fibers

4 WHAT IS THE ANTI-PAIN SYSTEM CONSIST OF?

1. spinal, thalamic, and cortical levels
2. spinal, brainstem, hypothalamic, and cortical levels
3. tissue peripheral level, spinal cord level, thalamic, and cortical levels
4. paleo- and neocortex levels
5. specific and non-specific nuclei of the thalamus

5 WHAT IS MODE OF ACTION OF OPIOID PEPTIDES?

1. they inhibit the pain-inducing substances action at the nociceptor level
2. they reduce the excitability
3. they reduce the conduction of pain impulses,
4. they inhibit a complex chain reaction of pain-transmited neurons
5. they inhibit a damage effect on peripheral tissues of the body

6 WHAT IS THE MODERN PAIN PERCEPTION THEORY BASED ON?

1. it is based primarily on the former theory of specificity
2. it is based on central summation mechanism
3. it is based on a convergence mechanism
4. it is based on central perception of pain sensation
5. it is based on mechanisms of a launch of anti-pain system

7 WHAT IS THE LOCAL LEVEL OF ACTIVITY OF A “GATE-CONTROL” ANTI-PAIN SYSTEM?

1. the spinal cord level
2. the brainstem level
3. the thalamic level
4. the hypothalamic level
5. the cortical level

8 WHAT ARE THE OPIATE MEDIATORS OF THE ANTINOCICEPTIVE SYSTEM AND WHAT TYPES OF RECEPTORS THEY CAN ACT ON?

1. ά-, β-, γ-endorphins
2. enkephalins;
3. dynorphins
4. these mediators act on all three known types of opiate receptors: ά-, β-, γ- receptors
5. these mediators act on all three known types of opiate receptors: μ-, δ-, κ-receptors

9 WHAT PLAY ROLE IN THE "GATE-CONTROL" PHENOMENON OCCURENCE?

1. an intense impulses flow along the large diameter fibers evokes transmission of pain signals to neurons of spinothalamic pathways -"open the gate"
2. an intense impulses flow along the large diameter fibers evokes limitation in the transmission of pain signals to neurons of spinothalamic pathways -"close the gate"
3. an intense flow of pain impulses along the first afferent neuron facilitates transmission of pain signals to neurons by inhibition of inhibitory interneurons of the spinothalamic pathways -"opens the gate"
4. an intense flow of pain impulses along the first afferent neuron by inhibition of inhibitory interneurons inhibits transmission of pain signals to neurons of the spinothalamic pathways -"close the gate"
5. "gate control" system switches on in every case of pain impulses to occur

10 WHAT IS THE SIGNIFICANCE OF DYNAMIC BALANCING OF ACTIVITIES OF NOCI- AND ANTINOCICEPTIVE SYSTEMS DURING PAIN SENSATION?

1. it gives an adaptive value for nervous system to react adaptively
2. it gives a way to reduce pain sensation
3. it coordinates the activity of thalamic specific nuclei to provide a localization feature of a pain sensation
4. it coordinates the activity of thalamic non-specific nuclei to reduce a localization feature and all other features of a pain sensation
5. it coordinates the activity of non-thalamic nuclei to provide the low pain sensitivity feature regarding its high discrepancy pain sensation

6 PHYSIOLOGY OF THE ORAL MUCOSA IMMUNOLOGIC FEATURES

The oral mucosa is the mucous membrane epithelium lining the inside surface of the mouth: both sides and the under surface of the tongue to the gums, lining the inner process of the mandible. It receives the secreted saliva from the submandibular and sublingual salivary glands. Despite high bacterial colonization and frequently occurred allergen contact and high probability of dramatization by food components and debris the acute inflammation or allergic reactions are rarely seen in the oral mucosa.

6.1 The physiology of the immunologic tolerance phenomenon of the oral mucosa

The key players in the oral mucosa immunologic tolerance features are the antigen presenting dendritic cells and T cells that define the initial phases of immunological reactions with the manifestations of immunologic defense system potentials or allergic reactions occurrence. In healthy state, the mucosal immunologic defense system provides a proper protection against pathogens with a simultaneous maintaining of an appropriate tolerance level towards non-harmful commensal normally persistent microbes and benign environmental biologically active substances in an oral cavity. For example, the local secretion of IgA in the oral mucosa provides an adequate immune response to potential food antigens presented without a full-range **systemic immune response**.

Since mucosal membranes are the primary place of a contact between the host and its environment, there is a large amount of "secondary lymphoid tissues" presented in the oral mucosa. The **mucosa-associated lymphoid tissue** or **MALT** provides the whole organism with a first line defense potential, that are highly important for the whole organism to keep general tolerance. Along with the spleen and lymph nodes, the tonsils and MALT are also considered to represent a so called "**secondary lymphoid tissue"** concerning the whole organism. The "**mucosal immune system**" provides three main functions for immunologic defense system actual state:

- serving as a body's **first line of defense** from antigens and infectious agents,
- second, preventing **systemic immune generalized responses** to commensal bacteria and food antigens in the "**gut-associated lymphoid tissue"-** a so-called oral tolerance,
- and the third one, regulating appropriate immune responses to pathogens encountered on a daily basis while experiencing an ordinary living.

The oral microbiome provides natural signals for early activation and regulation of oral natural defense system activity. Disturbances in the oral microbiome composition (dysbiosis of any kind) trigger an onset of a **general inflammatory process** to occur in the gingival, called periodontitis. There is a **specialized immune cell network** that controls the dynamic defense barrier in the gingiva. The oral mucosal barrier with its local natural signals may modulate (or train) a local immune responsiveness. The immune cell network that mediates an immunologic control at a level of a specific oral barrier - the gingival - is constantly under a stimulation influence. Only when this balance is disturbed it results in an inflammatory generalization as in a case of periodontitis.

There is much attention being paid to immunoglobulin's protective functions of saline content regarding their confirm activity on microorganisms of the oral cavity. Today there is a theoretical background elaborated about a discovered phenomenon that tends our knowledge to develop in a way that in addition to immune system response there is an innate immune system of the oral cavity to produce secretory factors to saliva. There are additional data about protective functions of peptides, proteins, and glycoproteins being involved in the innate immune system backing up, thus presenting the first line of the oral defense level. Mucosal environment presents a **network of immunoregulatory mediators** to maintain its integrity at a steady state but also be ready to face the infection attack or inflammation onset. Because of the extraordinary antigenic pressure at the oral cavity level, many mucosal cell types can exert regulatory activities.

6.2 Physiology of the oral mucosa local secretory immune system referring to the systemic immune regulation.

Taking into consideration the general problem of local oral tolerance in spite of myriad of antigens derived from food and from local oral microbiota it should be accepted to be an active suppression of inflammatory response. A complex regulatory network of special populations of antigen presenting cells, lymphocytes, and innate natural cytokines constantly supervises the oral mucosa immunologic homeostasis and could conditionally switch it to an antigen presentation breakthrough. Various populations of T-regulatory cells have been ascribed to play a **central role in the induction of oral tolerance**. In particular, CD4+ T-regulatory cells play an essential role in **maintaining peripheral immune tolerance,** as well as preventing **autoimmunity and chronic inflammation** occurrence. These T-regulatory cells are also considered to coordinate their function by cell-to-cell interactions to maintain the actual **balance between immunity and tolerance**. Thus, this T-cell collaboration with a cross-processing activity among T-regulatory cell populations should be considered as essential for the integrated supervision of immune system reactivity.

6.3 Questions for self-control assessment:

Choose one or more correct answers

1 MOUTH CONSISTS OF TWO REGIONS, ONE OF THEM IS CALLED THE ORAL CAVITY AND WHAT'S THE NAME OF THE OTHER?

1. teeth
2. the palate cavity
3. the nose cavity
4. the vestibule
5. the tongue

2 WHAT IS CAPACITY OF ЕРУ ORAL CAVITY AS A TEMPORAL CONTAINER?

1. 35-50 ml
2. 55-70 ml
3. 80-100 ml
4. 120-150 ml
5. 0.33 l

3 IN WHAT PROCESSES EXCEPT CHEWING THE MOUTH PLAYS ROLE?

1. drinking
2. biting
3. respiration
4. articulating
5. resonator chamber

4 ADULTS USUALLY HAVE 32 PERMANENT TEETH. WHAT ABOUT IT'S NUMBER FOR BABIES?

1. 8 "baby" teeth
2. 16 deciduous teeth
3. 20 primary teeth
4. 24 "milk" teeth
5. the same 32 teeth

5 THE NUMBER OF THE PERMANENT TEETH ON THE MAXILLA IS:

1. 8
2. 10
3. 12
4. 16
5. from 16 to 22 and more

6 WHAT IS THE DENTAL FORMULA?

2-1-2-3
2-1-2-3
2. 2-1-1-3
3. 2-1-2-3
4. 2-1-3-3
5. 1-2-3-4

7 DESPITE HIGH BACTERIAL COLONIZATION AND FREQUENT ALLERGEN CONTACT WHY THE INFLAMMATION OR ALLERGIC REACTIONS ARE RARE IN THE ORAL MUCOSA?

1. local secretion of IgA in the oral mucosa
2. antigen presenting dendritic cells
3. protective functions of peptides, proteins, and glycoproteins
4. mucosal environmental network of immunoregulatory mediators
5. mucosa-associated lymphoid tissue or MALT

8 WHAT IS THE ROLE OF MALT - MUCOSA-ASSOCIATED LYMPHOID TISSUE IN IMMUNE RESPONSE?

1. lymphoid cells presented in “secondary lymphoid tissue” undergo proliferation, maturation, and conditioning in the oral mucosa environment
2. MALT provides the whole organism with a first line defense potential
3. mucosal cells exert inhibitory activities to systemic immune cells preventing a full-range immune response of an organism
4. local secretion of IgA by the oral mucosa to provide an adequate immune response to food antigens presented

5. complex regulatory network of special populations of antigen presenting cells, T-lymphocytes, and innate natural cytokines

9 WHAT THE ORAL TOLERANCE PHENOMENON MEANS?

1. maintenance of a low level activity of immunological integrity at a steady state but also be ready to face the infection attack or inflammation onset
2. initially low activity of mucosal immune cells of the oral mucosa to commensal bacteria and food antigens
3. an active inhibition of constantly activating immune cells of the oral mucosa
4. low activity of the oral mucosa immune cells due to a high activity of the systemic immune reactions of the organism
5. low inflammatory occurrence due to a low number of immune cells presented in the oral mucosa initially, that start to migrate to oral mucosa after possible traumatization

10 WHAT TRIGGERS THE ORAL TOLERANCE TO A FULL-RANGE SYSTEMIC IMMUNE RESPONSE?

1. salive immunoglobulin's protective activity triggers an onset of a general inflammatory process
2. CD4+ T-regulatory cells local depletion triggers an onset of a general inflammatory process
3. CD4+ T-regulatory cells local migration from the circulation triggers an onset of a general inflammatory process
4. microbiome dysbiosis of any kind triggers an onset of a general inflammatory process in the oral mucosa
5. microbiome dysbiosis of any kind triggers an onset of a full-range systemic inflammatory process in the organism

7 m-DENTISTRY, TELEDENTISTRY

The m-Dentistry, or mobile Dentistry, is a term used for practical medical professionals communication both in medicine and public health, referring to the use of mobile communication devices, such as: mobile phones, tablet computers, personal digital assistants (PDA), and smart watches, and also for health care services, and medical information processing. It is a part of e-Medicine and e-Health technologies exteriorized to Dentistry using telecommunication information technologies (Telecom IT). At present days, various mobile devices are invented in clinical health data monitoring and collecting, in delivery/sharing of healthcare information for medical practitioners, and also for researcher. The possibility of a patient's real-time monitoring with vital parameters deviations pattern to register makes it possible for the direct provision of critical care medicine patterns to be registered automatically with a subsequent consultations (via telemedicine) and emergency ambulance appointment to realize, as well as for training purpose and health care professionals collaboration to proceed. Telemedicine broadly encompasses telecommunication and multimedia technologies due to their universally broad distribution, and also due to they are already integrated in wireless medical devices for professional and patient personal remote monitoring.

Telemedicine as well as m-Medicine provide an easy access to healthcare and health-related information for still hard-to-reach groups of people, thus improving their effectiveness to diagnose and monitor the rehabilitation period, and even to prevent the onset or broad spreading of diseases. Telemedicine has already proved it effectiveness in public health information distribution, and also in expanded access to ongoing medical educational courses and professional training courses, and in medical collaborations to proceed. As Telemedicine can be considered as a technology providing the basic functions and delivery of healthcare digital technologies, the m-Medicine is basically oriented on providing a necessary access for a patient or a person undergoing rehabilitation course, and also for medical specialists, and their collaborations, and practitioner educational groups - teledentistry and distance learning technologies used to facilitate access to oral health education and preventive medicine materials.

Among actual trends successfully developing in m-Medicine and m-Dentistry the one represents the most actual and easy-to-perform service – a hotline help-providing service. Hotline help service may consist only of a special multi-channel phone number a patient can call to and to receive a necessary access to a wide range of medical services on-line via such a dialing. These include phone consultations, counseling, information on facilities, on drugs, on equipment, and available clinics and MD specialists of particular specialization in dentistry.

Another technology that has already widely used in m-Medicine and m-Dentistry and still has high growth potentials for development is a remote monitoring of patient's vital parameters and its general condition. The stream technology remote access to a patient's mobile device provide an ultimate real-time access in case of emergency in any location of a person for instant healthcare and professional advice to deliver. The same technology is used in remote consulting of a dentist's patient by using his case history recordings, local area images, specific dental tests results, Roentgen-bases data, and clinical laboratory analysis prescribed by a dentist. In case of such an m-Dentistry remote consultation session the presence of a patient is not necessary.

The next direction for m-Dentistry to have widespread perspectives to develop is an oral health promotion activity and **online educational opened courses (MOOC**) for population healthcare professionals to develop. After first good impressions of health promotional and health-related materials were successfully diffused, a delight turned to disappointment, since there was no actual feedback control of state of understanding of delivered materials by people of different initial educational level and retained abilities to study. The possible issues may include misinterpretation of informational messages and fragments of a course, and also privacy issues.

8 WORLD HEALTH ORGANIZATION ORAL HEALTH PROMOTIONAL PROGRAMS

The World Health Organization (WHO) **Global oral health program** has been worked out to increase the awareness of oral health problems as an important component of general health and quality of life worldwide several years ago and was successfully promoted (**WHO health promotion programs**). Unfortunately, oral diseases are still remains a major population health problem in countries with high welfare. In the Global oral health report published in 2003, the WHO Global oral health program define a strategy for oral disease prevention and of oral health promotion that should be obligatory integrated with a set of **WHO chronic disease prevention programs** and **WHO general health promotion program**, since a vast majority of ways to develop are common. The WHO Assembly, the Executive board (EB), are several Supreme governance bodies of the WHO have declared the oral health to be the subject of discussion at a higher national and WHO level. At the EB120 and the WHO Assembly60, all of WHO Member States agreed with a plan of action proclaimed for oral health diseases and **WHO integrated disease prevention**. The WHO declaration approvement forms the basis for a future fruitful development of oral health programs at a national level worldwide.

9 ANSWERS TO SELF-CONTROL QUESTIONS

Section 2.6	Section 3.5	Section 4.4	Section 5.8	Section 6.3
1.-1,2,3	1.-1	1.-1	1.- 4	1.- 4
2.-1,2,3,4	2.-2,3	2.-1	2.- 1	2.- 2
3.-3,4,5	3.-1,2,3,4,5	3.-4,5	3.- 1	3.- all
4.-1,2,3,4,5	4.-2	4.-2	4.- 2	4.- 3
5.-1	5.-2	5.-2,3	5.- 1-4	5.- 4
6.-5	6.-1,2,3,4,5	6.-1	6.- all	6.- 1
7.-3	7.-1,3	7.-2	7.- 1	7.- all
8.-1	8.-1,4,5	8.-2,3,4	8.- 1,2,3,5	8.- 2, 5
9.-2	9.-1	9.-1,2,5	9.- 2,3	9.- 1
10.-1,2	10.-2	10.-1,2,3	10.- 1	10.- 4

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- **Electronic catalog** of the Scientific Library of the South Ural State Medical University of the Ministry of Healthcare of Russia: http://www.lib-susmu.chelsma.en/jirbis 2/

- **EBS “Student Consultant”:** http://www.studmedlib.en

- Open access free educational materials:

https://www.freebookcentre.net/medical_text_books_journals/Physiology_Books_Download.html

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- **Open resource software packages of mHealth** for preliminary free acquaintance: https://en.wikipedia.org/wiki/List_of_open-source_health_software#Mobile_devices
- **Clinical trials protocol review** for educational purposes:
https://clinicaltrials.gov/search/open/condition=”Xerostomia”
- **Open educational video materials** in oral health and dentistry:
https://www.youtube.com/watch?v=x1B39e6fItQ - Leap into Action for Oral Health - 57min
https://www.youtube.com/watch?v=tSiaZtRcFHM - Oral Cell Catalog: A Resource - 2min

https://www.youtube.com/watch?v=wjk4RP25WOk - Epidemiology of tooth decay - 3min

https://www.youtube.com/watch?v=Jcd2sCgFhh4 - Periodontal (Gum) Disease - 2min

https://www.youtube.com/watch?v=0N88Zd-Rykg - TMJ Temporal-Mandibular Joint - 1min

https://www.youtube.com/watch?v=OE-9E8Dj6wU - the Tooth Decay Process: How to Reverse … Tips for Parents - 2min

https://www.merckmanuals.com/professional/resource - Collection of educational video, 3D-models

QR-codes for multimedia educational materials free access:

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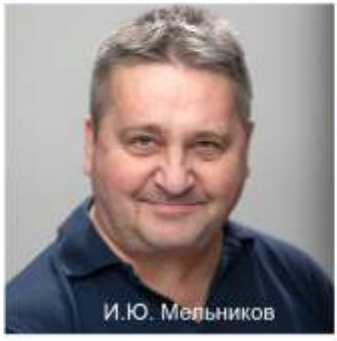
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