Research Article

Microcirculation dynamic of changes in the oral mucosa in patients with paresthesia during orthopedic dental treatment

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ABSTRACT

Aim: Based on laser Doppler flowmetry and optical tissue oximetry, a change in the state of microcirculation of the oral mucosa (OM) in 39 patients with paresthesia of the OM was evaluated. All patients had a secondary deformation of the dentition, accompanied by a decrease in the interalveolar distance and needed orthopedic treatment. **Materials and Methods:** A two-stage method for treating patients with paresthesia of the OM using individual caps is proposed, aimed at restoring the central ratio of the jaws and correcting the orientation of the mandible in the facial skeleton space. **Result and Discussion:** Based on the results of the work performed, during initial treatment, there was a violation of microcirculation in the area of lesion by paresthesia of the mucous membrane of the cavity. Correction of occlusive relations led to optimization of microcirculation. **Conclusions:** Thus, all the examined patients (100%) with OM paresthesia showed a significant improvement in microcirculation indices with a decrease in tissue hypoxia in paresthesia sensations after the use of the treatment and diagnostic apparatus.

KEY WORDS: Increasing occlusal vertical dimension, Laser Doppler flowmetry, Mouth burning syndrome, Optical tissue oximetry, Secondary deformity of dentitions

INTRODUCTION

According to modern concepts, paresthesia of the oral mucosa (OM) is a disease mainly manifested in orofacial pain, in the absence of any macroscopic structural damage to the OM and a tongue.[1,2] The prevalence of OM paresthesia in individuals aged 35–60 years is 1.5–5%, and the share of those suffering from paresthesia among patients consulted for OM for the first time ranges from 14% to 35%.[3] In recent years, the prevalence of the disease has been steadily increasing. According to the literature, most patients with OM paresthesia have occlusive disorders. At the same time, several authors emphasize that paresthesia of the OM is accompanied by microcirculation disorders, which plays a major role in the trophic supply of tissues.[4,5]

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A high prevalence of paresthesia, the lack of clear diagnostic criteria and data on the mechanisms of the development of the disease, and the persistent and long course of pathology - all these facts are the subject of constant attention of clinicians and researchers dealing with this pathology.[7,8]

MATERIALS AND METHODS

We followed up 106 patients with dentition defects, accompanied by a decrease in the interalveolar distance against the background of loss of individual teeth or groups of teeth. Depending on the presence or absence of paresthesia, 106 patients were divided into two groups:

1. Main group - 39 patients with dentition defects, accompanied by a decrease in interalveolar distances and OM paresthesia (10 [25.6%] men and 29 [74.4%] women);
2. Control group - 67 patients with dentition defects accompanied by a decrease in interalveolar distance,

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without pain syndrome (18 [26.9%] men and 49 [73.1%] women).

The exclusion criteria were as follows:

- Digestive diseases at exacerbation (chronic liver and biliary tract diseases, chronic gastritis, etc.);
- Endocrine disorders (diabetes mellitus, thyrotoxicosis, etc.), as well as hormone replacement therapy in postmenopausal women;
- Blood diseases (iron deficiency and B_{12}- and folate-deficiency anemia);
- Ischemic paresthesia (diagnosis was carried out with the help of adrenaline test);
- Inflammatory diseases of periodontal tissues;
- Generalized compensated increased erasure of dentin.

All patients underwent clinical, radiological, and instrumental examination. A specially designed patient questionnaire was used.

To determine the severity of the disease, patients completed a visual analog scale for assessing pain intensity, based on a subjective assessment of the patient's pain sensations.

Before treatment, all patients underwent a functional study of their OM microcirculation using laser Doppler flowmetry (LDF) and optical tissue oximetry (OTO). The measurement of capillary blood flow in all patients was carried out vestibularly in the alveolar gum area between the first and second lower premolars.

The optimal ratio of the jaws was determined by the functional-physiological method with the help of the "AOTsO" device (functional physiologic method of normal occlusion registration by system of central occlusion registration) on the basis of recording the maximal compression forces of the jaws and the trajectory of the displacement of the mandible from the starting position.[9,10]

To record the movements of the lower jaw, Freecorder®BlueFox (DDI-Group, Germany) was used - a computerized registration system for instrumental functional diagnostics, recording in three mutually perpendicular planes and analysis of the position of the mandible heads in a static and dynamic state.

To assess the intergroup differences in the values of characteristics that have a continuous distribution, Student's t-test was used.

RESULTS AND DISCUSSION

The indicators of microcirculation before treatment are presented in Table 1.

The data analysis showed that patients with OM paresthesia on the affected side have a decrease in M by 35.9% ($P < 0.01$) in comparison with the control group. The average value of the index σ was increased by 20.7% ($P > 0.05$). The coefficient of variation was significantly increased by 70.5% ($P < 0.05$).

Significant differences in the functioning of regulatory influences on microcirculation in patients with OM paresthesia were revealed, which is manifested in a sharp decrease in active control factors [Table 2].

The contribution of endothelial rhythms was 30% lower ($P < 0.001$), which indicates a decrease in endothelial modulations of the gingival microcirculation and a decrease in vasodilator production by the microvascular gingival endothelium.

A significant decrease in the neurogenic contribution (by 42%, $P < 0.001$) indicates oppression of the vasomotor mechanism of tissue blood flow regulation, which is accompanied by an increase in venous congestion in the microcirculatory bed with an increase in vasoconstriction and intravascular resistance, i.e., difficulty in the outflow of blood.

There is a slight decrease in the amplitude of myogenic fluctuations (by 6%, $P < 0.001$), which causes an increase in muscular resistance, and consequently, a decrease in nutritional blood flow.

At the same time, patients with OM paresthesia have an increase in the amplitude of passive rhythms. The volume of arterial blood flows into the microcirculatory bed modeled by the pulse wave (AmaxC), increased by 17% at damage, which is associated with a decrease in vascular tone. An increase in the amplitude of the respiratory wave by 19% indicates a decrease in microcirculatory pressure. Patients with OM paresthesia have a significant (3-fold) increase in the neurogenic tone on the affected side and a decrease in the neurogenic nature of the disorder compared to the control group ($P < 0.001$). The IB value exceeded unity and was 2 times greater than in the control group.

Thus, according to the amplitude-frequency analysis of LDF image in patients with OM paresthesia, as compared with the control group, microcirculatory disturbances are detected, which are manifested in a decrease in the vasomotor component and predominance of stagnant phenomena in the venular part.

Patients with OM paresthesia have a significant decrease in the relative fraction of erythrocytes passing through microvessels (by 26%, $P < 0.05$). The changes are accompanied by a decrease in the effectiveness of gas exchange in patients of this group: A decrease in the perfusion saturation index in patients with OM paresthesia (by 30.5%, $P < 0.05$) and the specific

Table 1: The indicators of microcirculation in patients with paresthesia of the oral mucosa on the affected side and in patients of the control group

Indicator	Main group (*n*=39)	Control group (*n*=67)	t	*P*
M (perfused unit)	13.37±0.38	20.85±0.72	6.47	<0.001
σ (perfused unit)	3.97±0.20	3.29±0.14	0.29	>0.10
Kv (%)	29.57±0.95	17.43±1.04	3.21	<0.001

Table 2: The indicators of microcirculatory bed regulation in patients with paresthesia of oral mucosa and patients of the control group

Indicator	Main group (*n*=39)	Control group (*n*=67)	t	*P*
AmaxE (perfused unit)	0.34±0.03	0.49±0.01	16.23	<0.001
AmaxN (perfused unit)	0.35±0.04	0.60±0.01	12.66	<0.001
AmaxM (perfused unit)	0.61±0.01	0.65±0.01	7.26	<0.001
AmaxR (perfused unit)	0.38±0.02	0.32±0.01	5.74	<0.001
AmaxC (perfused unit)	0.55±0.02	0.47±0.01	8.53	<0.001
NT (rel.un.)	7.72±1.88	1.97±0.01	12.18	<0.001
MT (rel.un.)	4.03±0.61	1.96±0.01	12.53	<0.001
IB (rel.un.)	2.17±0.56	0.99±0.01	5.69	<0.001

AmaxE: Endothelial rhythm amplitude, AmaxN: Neurogenic rhythm amplitude, AmaxM: Myogenic rhythm amplitude, AmaxR: Rhythm amplitude of respiratory undulation, AmaxC: Rhythm amplitude of cardiac rhythm, NT, MT, IB (index bypass)

Table 3: Relative volume of the erythrocyte fraction, indicators of mixed blood, arterial blood, and the specific oxygen consumption index in tissues in patients with paresthesia of the oral mucosa on the affected side and in patients of control group

Indicator	Main group (*n*=39)	Control group (*n*=67)	t	*P*
Vr (%)	11.33±0.63	15.35±0.36	1.98	0.050
MSO_2 (%)	86.67±0.52	95.34±0.57	10.24	0.001
Sm (rel.un.)	5.01±0.12	7.21±0.21	7.03	0.001
U (rel.un.)	0.93±0.01	0.97±0.01	2.64	0.010

oxygen consumption by tissues (by 4.1%, $P < 0.05$) compared to similar values obtained from the patients of control group. In this case, an increase in MSO_2 by 9.01% ($P < 0.001$) was noted by OTO method. Expressed oxygenation disorders are the result of tissue hypoxia. The data are presented in Table 3.[6]

Treatment of patients with OM paresthesia and dentition defects with a decrease in interalveolar distance was performed by the method developed by us. At the same time, all patients were prepared for prosthetics with the help of a gum guard with the restoration of interocclusion distance and optimal orientation of the lower jaw in the space of the facial skull.

After the use of individual medical-diagnostic devices in patients with OM paresthesia, a significant increase in M was observed by 31.6% ($P < 0.05$). The amplitude of erythrocyte flow fluctuations (σ) was reduced by 65.5% ($P > 0.001$). The coefficient of variation is significantly reduced in comparison with the initial data up to 7.79, which is 73.7% ($P < 0.001$) (data are presented in Table 4).

After the performed orthopedic treatment, a significant increase in the amplitude of the endothelial contribution to the regulation of capillary blood flow by 26.5% ($P < 0.001$) is observed. The maximum amplitude of the neurogenic contribution was reduced by 5.7% ($P < 0.001$). Against this background, the myogenic contribution was increased by 14.7% ($P < 0.001$). There is a significant decrease in the maximum amplitude of the respiratory wave by 18.4%, without changes on the part of the respiratory wave, which indicates the absence of stagnant phenomena in the venular part of the microcirculatory bed.

An increase in the myogenic tone of pre-capillaries by 21.6% is a consequence of a decrease in the diameter of microvessels, leading to an increase in shear stress on the vascular wall, the release of nitric oxide by the endothelium of the vascular wall, which prevents the vasoconstrictor effect and a decrease in tissue hypoxia.

Taking into account the obtained results of wavelet analysis, it can be noted that patients with OM paresthesia after orthopedic treatment showed improvement in microcirculation on the affected side, which is manifested in blood flow to the capillary channel bypassing arterio-venular anastomoses, in activation of sympathetic vasomotor reflex and absence of stagnant phenomena in the venular part of the capillary blood flow (data are presented in Table 5).

Improvement of blood supply, and accordingly, a decrease in hypoxia, in patients with paresthesia on the affected side before and after the use of a gum

Table 4: The indicators of microcirculation in patients with paresthesia of the oral mucosa on the affected side before and after using a gum guard (*n*=39)

Indicator	Before treatment	After using a gum guard	td	*P*
M (perfused unit)	13.37±0.38	17.59±0.24	3.19	0.001
σ (perfused unit)	3.97±0.20	1.37±0.06	2.57	0.001
Kv (%)	2.57±0.95	7.79±0.03	2.18	>0.10

Table 5: The indicators of microcirculatory bed regulation in patients with paresthesia of the oral mucosa on the affected side before and after using a gum guard (*n*=39)

Indicator	Before treatment	After using a gum guard	td	*P*
AmaxE (perfused unit)	0.34±0.03	0.43±0.05	7.89	0.001
AmaxN (perfused unit)	0.35±0.04	0.33±0.04	5.86	0.001
AmaxM (perfused unit)	0.61±0.01	0.70±0.02	12.03	0.001
AmaxR (perfused unit)	0.38±0.02	0.31±0.01	2.08	0.001
AmaxC (perfused unit)	0.55±0.02	0.55±0.02	5.97	0.001
NT (rel.un.)	7.72±1.88	5.68±1.31	8.96	0.001
MT (rel.un.)	4.03±0.61	4.90±0.87	11.06	0.001
IB (rel.un.)	2.17±0.56	1.21±0.10	5.87	0.001

Table 6: Relative volume of the erythrocyte fraction, indicators of mixed blood, arterial blood, and the specific oxygen consumption index in tissues by the tissue oximetry method in patients with paresthesia of the oral mucosa before and after the use of a gum guard (*n*=39)

Indicator	Before treatment	After using a gum guard	td	*P*
Vr (%)	11.33±0.63	14.05±0.27	2.03	0.05
MSO_2 (%)	86.67±0.52	95.20±0.63	1.98	0.05
Sm (rel.un.)	5.01±0.72	6.87±0.07	5.96	0.001
U (rel.un.)	0.93±0.021	1.08±0.02	2.99	0.01

guard influences other indicators too.

Patients with OM paresthesia on the affected side after treatment with a gum guard show a significant increase in the relative fraction of erythrocytes passing through microvessels (by 24.0%, $P < 0.05$). These changes were accompanied by an increase in the effectiveness of gas exchange in this group of patients on the side affected with OM paresthesia: An increase in the index of perfusion saturation in the OM paresthesia lesion (by 37.1%, $P < 0.001$) and an increase in the specific consumption of oxygen in tissues (by 16.1%, $P < 0.01$) relative to similar indicators obtained before the beginning of orthopedic treatment. The data are presented in Table 6.

Thus, all the examined patients (100%) with OM paresthesia showed a significant improvement in microcirculation indices with a decrease in tissue hypoxia in paresthesia sensations after the use of the treatment and diagnostic apparatus.

To evaluate the treatment provided, patients were offered a visual analog scale for assessing pain intensity.

All 39 patients with OM paresthesia had an improvement in microcirculation observed on the affected side and a decrease in paresthesia sensations after treatment, 33 (84.6%) of them noted a complete absence of paresthetic sensations or rated them as mild. These patients underwent rational prosthetics with various orthopedic structures. However, in 6 (15.4%) patients, the intensity of the sensation decreased slightly, and this group of patients after prosthetics was referred to a neurologist who prescribed the medication.

All patients had the final prosthetics completed after receiving a persistent positive therapeutic effect.

SUMMARY

1. All patients with paresthesia of the OM on the affected side had microcirculatory disturbances detected, including a decrease in the blood perfusion of tissues, a decrease in the vasomotor component, a predominance of stagnant phenomena in the venular part, a decrease in the relative fraction of erythrocytes, a perfusion saturation index, and an index of specific oxygen consumption by tissues relative to similar indicators obtained in the examination of patients of control group. With adequate recovery of the interalveolar distance, the microcirculation parameters approach the normal values.
2. A two-stage orthopedic treatment ensures positive therapeutic effect in 85% of cases in patients with dentition defects, accompanied by paresthesia on the background of a decrease in the interalveolar distance. In the absence of any positive therapeutic effect from dental orthopedic measures provided that microcirculation parameters are improved in the

field of paresthesia, consultation of a neurologist and the appointment of drug therapy aimed at correcting the patient's psychological status and improving cerebral circulation and metabolism in the tissues of the OM are necessary.

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