Artificial food lump from porous neoprene and the method of its use for the evaluation of adaptation patients to the dental constructions

A Reshetnikov¹, A Urakov², A Kasatkin², M G Soiher¹, M Kopylov¹

¹Institute of Biotechnology and Interdisciplinary Dentistry, Moscow, Russia
²Izhevsk State Medical Academy, Izhevsk, Russia

E-mail: areshetnikov@list.ru

Abstract. New dental product called artificial food lump is offered for dental practices. In its size and shape it is similar to the natural food bolus, which is formed in adult’s mouth when chewing white bread. This innovative product resembles an inedible and non-swallowable chewing gum. Artificial lump is made of porous neoprene; it is elastic and has food flavor. It is not destroyed by chewing and has stable elasticity during chewing. Besides, artificial lump is manufactured in a way that it can be attached to the patient's clothes with a braid line. New medical device is intended to create the masticatory loading in patients’ mouth in order to evaluate the quality of mounted dental restorations as well as patient’s adaptation to it during the chewing process.

1. Introduction

While providing dental care to a patient with pathology of oral hard and soft tissues, we mount various types of dental restorations with different strength and irritation characteristics [1]. Using temporary or permanent restorations made of advanced materials and ensuring high biological compatibility with human tissues, allows us to minimize their irritating effect for the patients. However, on the one hand there are some cases of partial and/or complete dental restorations damage, and oral cavity tissues damage on the other hand. All this leads to decreased efficiency and safety, and increases dental treatment duration and costs [2-5].

Intense mechanical interaction between tissues and dental restorations while chewing could be one of the reasons for these complications development. Moreover, the food damaging effect is related to its hardness and temperature. However, current standards for assessing the quality of dental restorations materials do not include the assessment of their suitability for chewing with the use of reference loading [6-11]. However, nowadays the only way to solve this problem is to use the reference chewable product. It is clear that in order to create a reference masticatory loading we should use a medical device in the form of natural bolus, but having "reference" characteristics. Here we mean constant elasticity during chewing and the product hydrophobicity.

In our opinion, infrared thermography could be used as a possible method for assessing patient’s adaptation to the dental restorations [12]. This method allows us to detect artificial constructions defects as well as soft tissues local inflammation in its normal and irritated states and with different pathologies [13-15]. In particular, infrared monitoring of skin local temperature dynamics at the injection site allows us to define the local inflammation that occurs in the chemical, physical and biological irritation [16-18].
Thus, the infrared monitoring of the patient's oral cavity which is performed after dental restorations mounting and followed by chewing the artificial lump, can provide the information on the mounted dental restorations strength when masticating food as well as the patient’s oral tissues durability when he has his dental restorations mounted and is masticating food with it. All this provides a new way for evaluating the quality of dental treatment.

The aim of our research is to study the possibility of preventing the complications in the chewing process after mounting the dental restorations by means of well-timed chewing of artificial lump with constant and safe elastic properties, and defining the local temperature dynamics in oral cavity tissues.

2. Materials and Methods
At first we defined the size of natural food bolus which was formed in adult’s mouth when chewing natural food. For this purpose we asked healthy adult volunteers (n = 80) to chew pieces of wetted solid food for 30 seconds, after which the pieces were taken out for examining their mechanical and physical and chemical properties. In particular, the lumps shape, size and volume were defined with the use of proper measuring instruments at ambient temperature of +25°C.

Infrared thermography of oral tissues for 80 healthy adult volunteers and 100 adult patients was performed at «ReSto» dental clinic (Izhevsk, Russia) using a thermal ThermoTracer TH9100XX (NEC, USA) in the temperature range of +25 - +36° C and at temperature of air +25° C. We studied temperature and infrared spectrum before and after chewing the sample. The data were processed using Thermography Explorer and Image Processor computer software programs. Dental restorations in accordance with International Organization for Standardization (ISO) were mounted as indicated in agreement with international recommendations and standards.

The study was approved by the Ethics committee at Izhevsk State Medical Academy and complied with the Declaration of Helsinki. All patients gave informed consent.

3. Results
Our results showed that the natural bolus had a cylindrical shape with a diameter of 1 cm and a length of 4 cm and a hemisphere shape at its ends. Such shape and dimensions allow easy lump placement inside the mouth of an adult person. The results analysis showed that the estimated bolus size and shape were optimal for solving the problem, because the smaller size doesn’t not provide a proper simulation for the physiological process of chewing semi-coarse and coarse food, especially bread products, and does not insure the mechanical impact on the entire premolars and molars chewing area. The bigger sizes, in its turn, exceed safe and comfortable bolus size.

While studying the elastic properties of synthetic materials we found that porous neoprene with a porosity of not more than 30% could be chosen as an elastic base for the artificial lump. Neoprene is the most inert synthetic polymer, and it does not react with water, alcohol and other organic solvents. The porosity of neoprene is not more than 30%, and pore air filling provides safe physical and chemical conditions and elasticity level.

We conducted a clinical trial of artificial food lump made of neoprene and with size and shape similar to natural bolus. The results confirmed our assumptions. In particular, all the healthy volunteers and patients with mounted dental restorations admitted that they could easily move the artificial food lump in the mouth and chew it without feeling of discomfort. Clinical studies showed that during chewing, artificial lump should be provided with a thread attached to it with one end, and with another end fixed with a clip to the patient's clothing. This prevents accidental ingestion of artificial food lump during evaluating patient’s adaptation to the dental restorations.

The study of the local temperature dynamics of patients’ oral tissues immediately after mounting new dental restorations proved infrared thermography method to be highly informative for assessing the patient's adaptation to dental restorations elements. As a result, we developed a special method for instant assessing of dental restorations resistance to the patient chewing. The method is based on the detection of heat radiation of oral cavity tissues, carried out by means of infrared thermography of oral cavity tissues after chewing the "sample for chewing" [19].
Instant diagnosis of patient adaptation to the dental restorations is based on using two artificial food lumps preheated to +37°C. The first lump is used before mounting dental restorations, and the second one is used after it. In both cases the patient is asked to put a lump into his mouth and chew it for 30 seconds, consistently moving the lump along the tooth alignment. When chewing is finished each lump is taken out and examined with the help of thermal camera in order to analyze heat radiation dynamics of oral tissues. In this case, if local hyperthermia or short uniform and symmetrical temperature rise in the oral tissues are not detected after chewing the first lump, the patient’s adaptation to chewing is evaluated as excellent, predicting high patient's durability regarding dental restorations, and in this case the decision about its safe mounting could be positive. Dental restorations are mounted together with controlling the dynamics of tissues thermal radiation after chewing the second identical artificial lump for 30 seconds. After that, we compare these data on thermal radiation dynamics with the original, and if hyperthermia values and its duration are higher, then we evaluate patient’s adaptation to dental restorations as poor and predict tissue damage.

4. Conclusions
In summary, the artificial food lump and its application method for instant assessment of patient's adaptation to the dental restorations expand the evaluation scope and increase its urgency, informative value and reliability, as well as prevent complications in the chewing process after mounting dental restorations due to chewing artificial food lump with constant safe and elastic properties at proper time and by defining the temperature dynamics in oral tissues during dental care.

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