Researches Regarding New Biomaterials Involved in Sports Mouthguard

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The aim of this study is to individualize from the structural point of view the silicon materials which lay at the basis of the manufacturing the oral mouth guards in full accordance to the features of the subject who is going to benefit from these devices, a highly important role belonging to the maxillary architecture and the occlusion type. Choosing the election biomaterial for the oral protection gear was done based on mathematical modelling using the Abaqus Standard system, with the aim of evaluating the tensions transmitted at the jaw level by different types of biomaterials which are embedded in the structure of these devices. The biomaterial represents an alternative favorable for the oral protection gear given the degree of elasticity and the possibility of including an antiseptic material, such as Eugenol, important features which individualize it.

Keywords: sports mouthguard, siliconic biomaterials, mathematical analysis, antimicrobian effect

The oral protectors represent those devices which protect the teeth from possible injuries while performing different sports; they materialize in highly important elements of the sportive equipment adjacent to football, basketball, American football, hockey, skateboarding, gymnastics, mountain-biking [1-3].These mouth guard protection gear have a certain degree of elasticity, are made of silicon material which cover especially the upper teeth, having as aim the prevention of dental fractures as well as other injuries at the upper lip level [4, 5].

The mouth guard protection gear is divided in three categories:

- *Individual mouthguard protection (splint):* these are individually made based on the imprint done by the dentist staff, done using the individual model in a dental technique laboratory, with the use of a vacuum-based special equipment (fig.1).

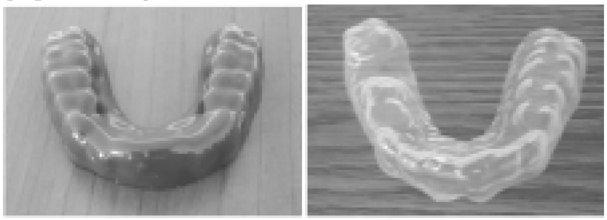

Fig. 1. Individual mouthguard protection

- *Pre-shaped mouthguard protection splint from self—polymerizing acrylate:* these present themselves in a plastic shape which can be plastified through boiling in water, later on taking the shape of the arch. Such types of devices are marketed in sportive equipment shops and are superior to the universal ones given their adaptability, but they are inferior to the individual protection ones.

- *Universal mouthguard protection (splint):* are manufactured in series. The disadvantage is that most of the times they are cannot be superposed on the dental arch. They can be voluminous and uncomfortable while chewing and talking (fig. 2).

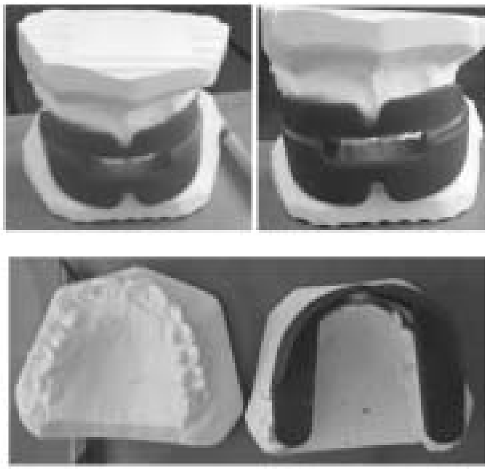

Fig. 2. Universal sports mouthguard

Ideally, the mouth guard protection gear must be replaced after every sportive season because they wear off fast and are not as efficient. For teenagers, they need to be replaced at time intervals because of the growing phenomenon of the dental-maxillary apparatus [6].

The best known biomaterials out of which the oral protection gear can be made are the silicon materials [7, 8].

The polysiloxanes with generic name of silicones are the most important polymers with inorganic skeleton which decisively placed their mark over the evolution of techniques and technologies that governed the last century. Another variety of practical applications is attributed to this type of biomaterials, given their inherent features [9, 10]. The silicones find themselves in the speciality literature under the generic name of “miracle substances” and this expression, unsuitable from the scientific point of view, could have create the danger that this group of materials could have been overestimated [11,12]. However, this term applied to silicones represents a special position which they occupy given their practical possibilities of adapting

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to individual issues, generated by particular aspects which are encountered in the medical practice. The special interest encountered in the dental medical practice towards this class of polymers is due, mainly, to their unique combinations of features [13-15].

The extraordinary qualities of the silicones, which recommend them as selection biomaterials for the oral protectors or different types of mouth guards are due, mainly, to the energy of the good connection of the connection between Si-O and the non-polarity of the organic groups attached to the silicium atom [16, 17]. The silicones are remarked through their impressive thermal stability until approximately 250°C, pouring point of –60°C, and a very low transition to glass temperature of –120°C [18, 19]. The silicon biomaterials present very good electric isolating features and, thus, are excellent isolators. The silicones present insignificant varieties of temperature for come important physical features, such as viscosity. Given the organic groups, especially the methyl group, the silicones are hydrophobic, the methyl group acting as a filter towards the water [20, 21].

Experimental part

The starting point of this study is materialized by the fact that the silicon biomaterials are recognised as biocompatible materials, which, generally, do not allow for the development of bacteria. With the aim of improving the performances in this direction, there is the possibility of projecting systems with controlled release of antibacterial substances, such as Eugenol or Timol.

Choosing the election biomaterial for the oral protection gear was done based on mathematical modelling using the Abaqus Standard system, with the aim of evaluating the tensions transmitted at the jaw level by different types of biomaterials which are embedded in the structure of these devices.

The first biomaterial used was a silicon material, elaborated with the help of the "Petru Poni" Molecular Chemistry Institute in Iasi, into whose matrix structure eugenol was incorporated, an action motivated by its antiseptic role (fig. 3a).

A dimethylmethylvinylsiloxanic copolymer of high molecular mass (approximately 400,000) was used as the polymeric matrix in order to obtain a silocanix-silic nano-composition. As reinforcement material, the silic Aerosil 380 (Degussa) was used, with 100 % purity, specific surface of 380 m^2/g and the diameter of the particles of 0.003- 0.015 microns. This was previously made hydrophobic in order to prevent the structuring in time of the composite material obtained based on it. To the resulted material a mixture of pigments was added in order to confer as much as possible a natural colour, close to the tissue with which it comes into contact. The reticulation of the material, in order to confer the desired stabile shape, was done through a radical mechanism at high temperatures.

Following the addition of Eugenol, in a 0.2 % proportion, the experiment was pressed between two glass plates and was kept in drying equipment 150 degress Celsius for 1 h, after which one of the plates was removed and the material was kept again in the drying equipment at 170 degrees Celsius for another 2 h in order to finalize the reticulation and remove the volatile products. The experiment was removed from the glass support in order to evaluate the parameters necessary to the mathematic modelling.

The next biomaterial used in the mathematical analysis as a polyvinyl xiloxan which is marketed in the shape of sheet (Tehnodent Poka), without antiseptic substances,

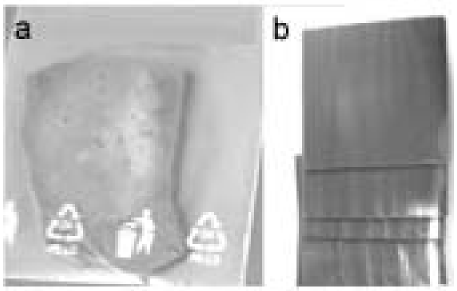

Fig. 3. The biomaterials used in research: a - Silicon material with an addition of antibacterial substance and b - Polyvinyl xiloxan biomaterial

and which transforms itself in oral protection through thermo-formation, with the help of the Ultravac equipment (fig. 3b).

The third material is an auto-polymerisable acrylate used in pre-shaped mouth protection splint.

Results and discussions

In the mathematical analysis undertaken it is observed that the Von Mises tensions are represented in a colour code, from violet (0 value) to red. It is observed that the minimum tensions are at the level of the soft structures, while the maximum ones (given the small area of contact and the end effect) are at the level of the dental contact. The trajectories of the tension's tensor are remarked because, in this analysis, there does not appear a single type of tension, but a resulting tension, the expression of combining normal (traction – compression, crushing or results following bending) and tangential (shearing, distorting) tensions.

It has to be specified the fact that in all the cases analysed using the finite element method, the same charging system was applied, taking into consideration the opposite dental maxillary, in order to make a comparison between the analyses results.

For the usage of oral protection splint made of auto-polymerisable acrylate (longitudinal elasticity module E = 2,495,500,000 Pa, Poisson coefficient n = 0.3588) we notice the presence of some concentrations of relatively high tension, that is why these oral protection splint are not highly recommended (fig. 4).

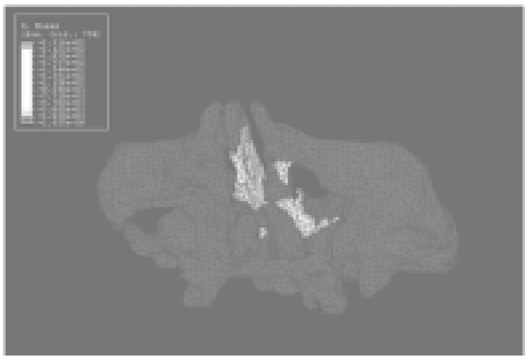

Fig. 4. Mathematical analysis-mouthguard made of auto-polymerisable acrylate

With regard to the usage of polivinylxiloxan frequently used under the shape of sheets (longitudinal elasticity module E = 1,300,000,000 Pa, Poisson coefficient n = 0.4) it is noted concentrations of tensions much less reduced than the previous case with a uniform tendency (fig. 5).

In the case of the mathematical analysis of the siliconic biomaterial elaborated in partnership with the Macromolecular Chemistry Institute (longitudinal elasticity module E = 113,760,000,000 Pa, Poisson coefficient n = 0.35) in which Eugenol was added, we notice the lowest number of tension concentration, given the higher elasticity and uniformity. The positive results confer the antiseptic effect without modifying the biomechanical features (fig. 6).

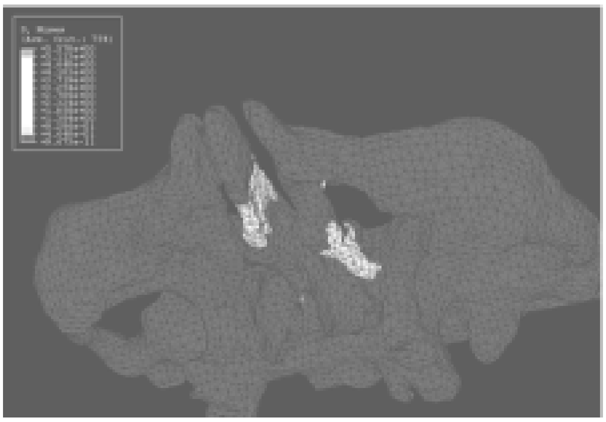

Fig. 5. Mathematical analysis-mouthguard made of polivinylxiloxan

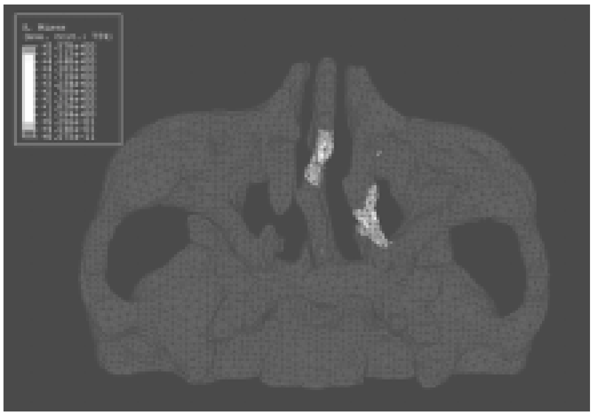

Fig. 6. Mathematical analysis-mouthguard made of siliconic biomaterial with antimicrobian substance

Fig. 7. Individual sports mouthguard–technological stages

For exemplification we choose a clinical situation in which for the subject, for which the oral protection gear was manufactured, practiced martial arts (fig. 7).

The first stage was represented by the recording of the print, followed by the creation of the model out of plaster. The model is applied on the small table of the thermosformation equipment, and the silicon sheet is subjected to the pre-heating process until it reaches 250 degrees Celsius, then it is applied on the model, adapting to it. After cooling, the cutting up follows.

Conclusions

From the present study we can draw the following conclusions:

Oral protectors are devices absolutely necessary in protecting the natural dentition or different types of prosthetics restorations for the subjects who practice various sports which can threaten their integrity.

The silicon biomaterial are elective biomaterials for obtaining these oral protection gears given their degree of elasticity, which they have in their structure, their biocompatibility and comfort offered.

The mathematical analysis represents an easy instrument in the detection of the tension concentrations of biomaterials, taking into account the elasticity module and the Poisson coefficient.

The biomaterial elaborated in partnership with the “Petru Poni” Institute represents an alternative favorable for the oral protection gear given the degree of elasticity and the possibility of including an antiseptic material, such as Eugenol, important features which individualize it.

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