

# Advantages of a Polyethylene Terephthalate Glycol-modified Coated with a Thermoplastic Polyurethane as an Occlusal Appliance Material

CORINA MARCAUTEANU<sup>1</sup>, ENIKŐ TÜNDE STOICA<sup>1</sup>, CRISTINA BORTUN<sup>2</sup>, MEDA-LAVINIA NEGRUTIU<sup>3</sup>, COSMIN SINESCU<sup>3\*</sup>, ANCA TUDOR<sup>4</sup>

<sup>1</sup> University of Medicine and Pharmacy "Victor Babeş" Timișoara, Faculty of Dentistry, Department of Occlusion, 9 Revolutiei Blv., 300070, Timișoara, Romania

<sup>2</sup> University of Medicine and Pharmacy "Victor Babeş", Faculty of Dentistry, Department of Dental Technology, Timișoara, 9 Revolutiei Blv., 300070, Timișoara, Romania

<sup>3</sup> University of Medicine and Pharmacy "Victor Babeş" Timișoara, Faculty of Dentistry, Department of Prostheses Technology and Dental Materials, 9 Revolutiei Blv., 300070, Timișoara, Romania

<sup>4</sup> University of Medicine and Pharmacy "Victor Babeş" Timișoara, Department of Informatics and Medical Biostatistics, 14 Tudor Vladimirescu St., 300173, Timișoara, Romania

*The unwanted effects of bruxism can be prevented by using an occlusal appliance during sleep. The therapeutic efficacy of appliances is conditioned largely by the appropriate choice of the appliance material. This study investigates the advantages of a polyethylene terephthalate glycol-modified (PETG) coated with a thermoplastic polyurethane (TPU) compared to mere PETG and to urethane oligomers. Most subjects preferred a PETG coated with TPU appliance, because it combines the advantages of a hard material with those of a resilient one, namely flexural strength and an excellent abrasive, chemical and high – impact resistance. The PETG coated with TPU must be replaced sooner than the PETG and the urethane oligomers due to the very poor microbial resistance of TPU.*

*Keywords: polyethylene terephthalate glycol-modified, thermoplastic polyurethane, occlusal appliance material*

The efficacy of occlusal appliances (splints) in the treatment of bruxism has been widely proved in the dental literature [1-3]. Bruxism consists of forceful, involuntary, parafunctional grinding and/or clenching of teeth, during the waking state and/or sleep [4] and can damage the various components of the masticatory system.

Heat – cured and chemical – cured polymethyl methacrylates (PMMA) persisted for many years as the materials of choice for occlusal appliances. Unfortunately, the residual monomer (methyl methacrylate MMA) can cause irritant or allergic reactions [5]. To compensate for this shortcoming, manufacturers have released advanced materials, such as those based on glycol-modified polyethylene terephthalate (PETG).

Glycol - modified polyethylene terephthalate is a thermoplastic polymer, with an excellent high – impact and chemical resistance, simultaneously with flexural strength. Glycol - modified polyethylene terephthalate is obtained from polyethylene terephthalate (PET) by copolymerization. Cyclohexane dimethanol (CHDM) is added to the PET backbone in place of ethylene glycol. The resulting copolymer has a lower melting temperature and is a useful material for thermoforming applications which require complex shapes. Glycol - modified polyethylene terephthalate is used in many fields, including medicals, electronics, automobiles etc. In dentistry, orthodontic devices [6] and muscle relaxation occlusal appliances [7] are often made from PETG.

This study presents our experience in the proper selection of occlusal appliance materials and investigates the advantages of PETG coated with a thermoplastic

polyurethane (TPU) compared to mere PETG and to urethane oligomers.

## Experimental part

### Materials and methods

30 subjects, 23 – 60 years of age (average 35.6; standard deviation 11.69), were screened for sleep bruxism by means of a standard questionnaire and through BiteStrip devices; the electromyographic (EMG) recordings were made during 3 nights/1 month.

The BiteStrip (S.L.P. Tel Aviv, Israel) is a single-use disposable EMG-device used to detect sleep bruxism [8]. The device, which monitors masseter muscles EMG signals throughout the night, performs an automatic analysis and produces an indication of bruxism presence and severity in the morning (the „B score”): L - no bruxism: comparable to a sleep lab brux count of up to 30 over 5 h; 1 - mild: comparable to a sleep lab brux count between 30 and 60 over 5 h; 2 - moderate: comparable to a sleep lab brux count between 61 and 100 over 5 h; 3 - severe: comparable to a sleep lab brux count of more than 100 over 5 h.

The 16 subjects diagnosed with sleep bruxism received muscle relaxation occlusal appliances, covering the entire maxillary dental arch. For each subject, three types of hard appliances were made of the following materials:

- PETG (Erkodur from Erkodent), available as hard thermoformable sheets, 2 mm thick (fig. 1), that bond to acrylate [9,10];

- PETG coated with TPU (Erkoloc– pro from Erkodent), presented as a double layer plate (hard and soft); the thickness of the soft layer is always 1 mm; the external hard layer bonds to acrylate [10,11];

\* email: minosinescu@yahoo.com

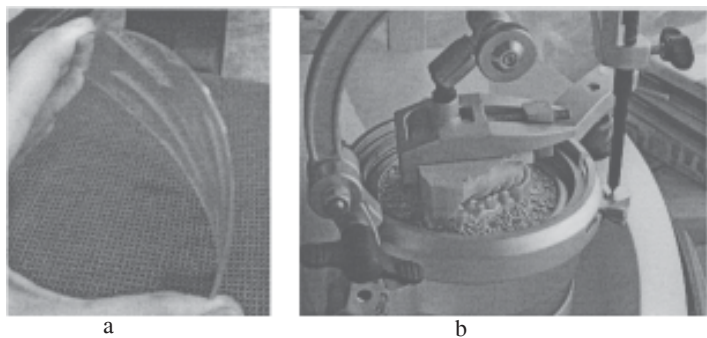


Fig. 1. The hard PETG disc (a) thermoformed on the working cast using the Erkoform – 3d device (b).

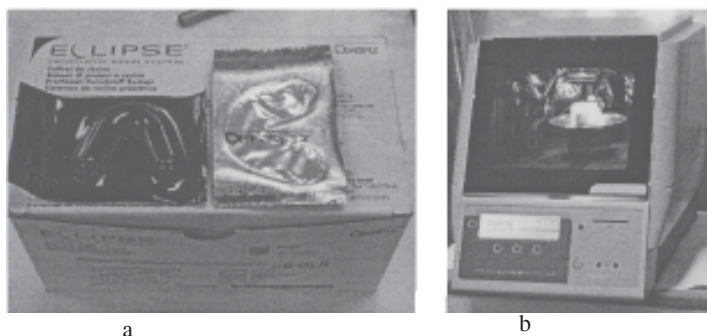


Fig. 2. The hard urethane oligomers appliance (a) cured in the Eclipse® Processing unit II (b)

- urethane oligomers, free of methyl, ethyl, propyl or butyl monomers (Eclipse visible light polymerizable prosthetic resin system from Dentsply) (fig. 2) [10,12].

The subjects wore each appliance for 2 weeks. At the end of the study period, the subjects were invited to select one of the three appliance materials and to explain their choice.

### Results and discussions

16 of the 30 investigated subjects had variable degrees of sleep bruxism. The prevalence of the parafunction was 53,33% in our study. Unfortunately, only 9 of the bruxing subjects were aware of their habit (fig. 3), namely those with the highest „B scores” on the BiteStrip devices.

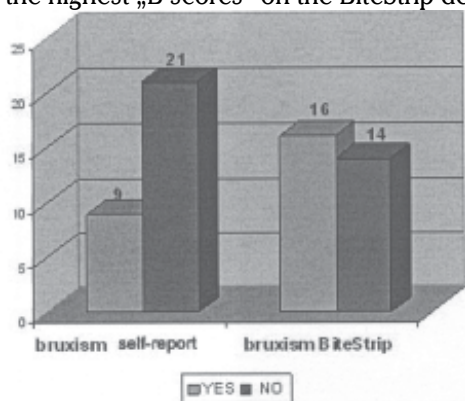


Fig. 3. Subjects aware of bruxing habit

	N	Mean	Std. Deviation	Minimum	Maximum
SELF-REPORT	30	,30	,466	0	1
BITESTRIP	30	,53	,507	0	1

		N	Mean Rank	Sum of Ranks
BITESTRIP – SELF-REPORT	Negative Ranks	0	,00	,00
	Positive Ranks	7	4,00	28,00
	Ties	23		
	Total	30		

		BITESTRIP – SELF-REPORT
Z		-2,646
Asymp. Sig. (2-tailed)		,008

The Wilcoxon signed ranks test was used to compare the results of the self-reports with those of the BiteStrip investigations (tables 1 - 3). The value of  $p = 0.008$  demonstrated statistically significant differences between the two diagnostic methods.

Each of the 16 bruxing subjects chose one of the three appliance materials and described the reasons that made it a preference (fig. 4).

Eleven bruxing subjects liked the PETG coated with TPU, because it offers an increased comfort during insertion/removal and during sleep; subjects with misaligned teeth and/or fixed partial dentures reported tooth sensitivity after wearing PETG and urethane oligomers.

Other 3 subjects with bruxism preferred the PETG, because it has a better retention than the PETG coated with TPU.

The last 2 bruxing subjects chose the urethane oligomers; they are characterized by an intense parafunction („B score” of 3) and have a history of numerous worn-out or perforated PMMA and PETG appliances. In our experience, the urethane oligomers have a higher hardness and wear resistance than the PETG.

The dental literature proposes several methods for the diagnosis of active bruxism and the associated occlusal overload [2]. We used portable EMG devices (BiteStrips) to record the masseter muscles activity during 3 nights. This disposable device efficiently detects the existence and the intensity of bruxism. Because the damage caused

Table 1  
DESCRIPTIVE STATISTICS

Table 2  
Ranks

Table 3  
WILCOXON SIGNED RANKS TEST

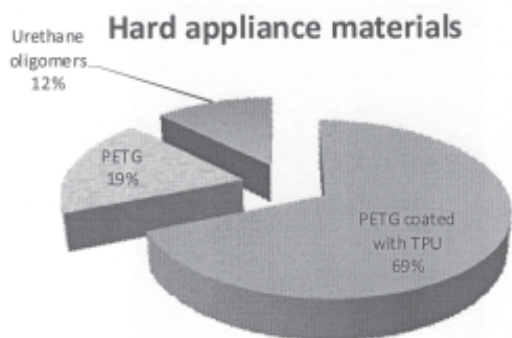


Fig. 4. Distribution of the three hard occlusal appliance materials.

Properties	Polyester – based TPU	Polyether – based TPU
Abrasion resistance	excelent	good
Chemical resistance	excelent	good
Microbial resistance	very poor	poor
Low temperature flexibility	acceptable	excelent
Adhesion to polar substrates	good	acceptable

**Table 4**  
DIFFERENCES BETWEEN THE  
TWO MAIN GROUPS OF TPU [13]

by bruxism is cumulative over time, it is important to test our subjects for bruxism on a regular basis. Unfortunately, more than half of our bruxing subjects were not aware of their parafunction; questionnaires are useless in such cases.

The occlusal muscle relaxation appliances decrease the frequency and the intensity of bruxing events. They also protect the teeth and the restorations against the large occlusal forces generated by this parafunction. The therapeutic efficacy of appliances is conditioned largely by the correct material choice.

Most subjects preferred the PETG coated with TPU, because it combines the advantages of a hard material with those of a resilient one. Thermoplastic polyurethane is a multiphase block copolymer obtained by chemical reaction of a polyol or a long – chain diol, a chain extender or short-chain diol and a diisocyanate. The soft TPU appliance layer is polyester – based and has many advantages over the polyether – based TPU (table 4) [13]. Excelent abrasion and chemical resistance are important features for an occlusal appliance material. Unfortunately, the flexible polyester – based TPU has a very poor resistance to fungi and bacteria; the microbial enzymes can split the ester bond. In time, the resilient TPU layer stains and cracks faster than the mere PETG and the urethane oligomers and must be replaced. The load bearing capacity of the TPU layer is also affected.

### Conclusions

Appliance therapy depends largery on the right selection of the occlusal appliance material. The PETG coated with TPU appliance was preferred, because it combines the advantages of a hard material with those of a resilient one, namely flexural strength and an excelent abrasive, chemical and high – impact resistance. The PETG coated

with TPU must be replaced sooner than the PETG and the urethane oligomers due to the very poor microbial resistance of TPU.

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