Study Regarding the Toxic Effects of Resin-based Dental Materials

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The aim of the study is to highlight the toxic effects occurred following the dental treatments with materials containing acrylic products such as composite resins used for crown restoration and acrylic materials entering the structure of conventional dental prostheses. To attain this objective, we elaborated our own questionnaire containing 11 questions that was sent for filling in to 81 experienced dentists specialized in different medical fields. Among these, only 61 (75%) encountered side effects to the materials under analysis during their activity in the dental room. The results obtained show that stomatitis and the manifestations caused by conventional prostheses followed by the inflammations of the dental pulp caused by the treatment of the dental cavities with composite resins were most frequently reported. In the context of appearance of a large diversity of dental materials in recent years having esthetic and mechanical improved properties, but also a much diversified chemical structure, the dentist must understand that these may also have toxic effects. Although there is no ideal completely biocompatible material, we may reduce the toxic effects if we take into account the specifications of each product used, the patients' clinical, local and general particularities, the observance of the clinical protocol and the avoidance of mistakes during the lab stages.

Keywords: resin-based dental materials, toxic effects, prevalence

We have been witnessing a fast and revolutionary evolution in the field of materials used in the dental practice, especially the resin-based composites. These have multiple applications in dental medicine, both as crown restoration materials, sealants for grooves and fissures, and as cementing materials for prosthetic restorations. Dental composites are composed of a wide variety of components with different chemical composition: organic composition (matrix material), made by dimethacrylate monomer, another inorganic material, (filler material) such as silica glass (SiO_2), alumina glass (Al_2O_3), and silane coupling agents ensures covalent coupling between filler and resin matrix. During the curing process, polymerization, monomers are linked to each other forming long chains of polymers, cross-linked in a three-dimensional network [1].

The history of resins started as early as 1960's, when *Bowen* developed the monomer, Bisphenol A-glycidyl methacrylate (bis-GMA), also used nowadays in the structure o many materials. In the 1970's, they developed another monomer with superior properties, namely urethane dimethacrylate (UDMA) [2]. Other composite materials contain 2-hydroxyethyl methacrylate (HEMA), triethylene glycol dimethacrylate (TEGDMA), and ethoxylated bisphenol A glycol dimethacrylate (Bis-EMA) [3-5]. There is currently a wide variety of state of the art composite materials such as polyacid-modified composites (compomers), organic resin-modified (ormocers), the ones having antibacterial properties or fluoride release ones [6-9]. This evolution of the composite materials aimed at improving certain properties such as the colour, translucidity, the resistance to wear and masticatory forces, the adherence to dental structures, the insolubility into the oral fluids [10]. The issue of biocompatibility is still being discussed in the specialized literature [11]. Biocompatibility is a requirement that must be met by all dental materials coming into contact with the oral cavity. A material is biocompatible if it is not toxic and does not interfere with the oral tissue. In the case of composite materials, they may release unpolymerized monomers in the oral environment that may become toxic [12]. We quote from literature the toxic effect of these types of materials on the dental pulp, gingival fibroblasts, carcinogenic effects, teratogenic effects, genetic mutations or even system effects such as allergic reactions or anaphylactic shock [13-15].

Another category of acrylic materials that may become toxic by the excess of monomer released into the oral cavity are the ones used to make conventional methyl methacrylate dentures [16-17]. Resin based materials made from liquid - methyl methacrylate mixed with polymethacrylate powder are the most commonly polymers used in prosthodontics. Experimental and clinical studies have documented that monomers may cause a wide range of adverse health effects such as irritation to skin, eyes, and mucous membranes, allergic dermatitis, stomatitis, asthma, neuropathy, disturbances of the central nervous system, liver toxicity, and fertility disturbances [18-19]. The etiology of these lesions is often difficult to appreciate, a reason for which there are no concrete data regarding their prevalence among the population. The aim of this paper is to highlight the frequency and type of oral lesion caused by the toxic components of the acrylic materials used in dentistry, namely resin-based composites used to treat dental cavities, and the acrylic materials entering the structure of dental prostheses.

Experimental part

Material and method

The cross-sectional study was carried out by the use of our own questionnaire elaborated in order to find out the lesions at the level of the oral mucosa caused by the toxic effects of the acrylic products in the dental materials. This questionnaire was sent to 95 dentists of Iasi; out of these only 81 accepted to participate in the study, the response rate being 85%. 29 of them (36%) are specialists in dental-alveolar and maxillofacial surgery, and 52 (64%) in general dentistry; as for the experience in the medical activity, most of them, namely 53 (65%) have more than 10 years of service, the rest of 28 (35%) being resident physicians having an experience below 10 years.

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The questionnaire used in our study contains 11 questions referring to the following aspects: the frequency, the clinical aspect and the morphological type of oral lesion, the time when toxic effects occurred, the type of allergen discovered and the dental material incriminated for the occurrence of phenomena.

Data were analyzed with the SPSS 18.0 system for Windows (SPSS Inc. Chicago, IL, SUA). Statistical significance of the bivariate analysis was assessed by the Pearson chi-square at the 0.05 level. For testing the psychometric characteristics of the questionnaire we calculated Cronbach alpha and Intraclass correlation coefficients, obtaining the following values: Cronbach alpha = 0.704, Intraclass Correlation = 0.702, with variations of the trust interval between 0.655 and 0.787. These values indicated a good level of reliability.

Results and discussions

At the level of the oral cavity there is a series of physical and chemical aggressions triggering inflammatory, immunological and allergic reactions that vary depending on the toxic element incriminated: from stomatitis caused by incorrectly made prostheses to inflammatory lesions of the dental pulp and even lichenoid lesions of the oral mucosa.

The results of the study on the toxicity of acrylic materials presented in table 1 show the existence of these phenomena at the level of the oral cavity. During their activity, 61 dentists (75%) showed that they had diagnosed lesions caused by the toxic effects of the acrylic dental materials, and in the last year these have been signaled by only 23 dentists (28%) of the participants to the study. We may notice that 24 dentists (30%) cannot specify precisely the etiology of the disorder due to the fact that, besides the incriminated effects there may be other factors as well, and they are iatrogenic factors most of the time. in case of the materials used for the treatment of dental cavities, iatrogenies may occur through the inobservance of the rules for preparation of the dental cavities, the lack of the protective material for the dental pulp, the preparation of cavities at high speeds or the erroneous curing necessary to the hardening of the material. In case of the lesions caused by the monomer in the prosthesis structure, we may incriminate the traumatic and infectious factors.

Depending on the moment of onset 45 dentists (56%) mentioned a short period of time of up to 24 h since the contact with the material, and 16 dentists (20%) encountered such phenomena after a longer period of more than 10 days. Significant statistical differences were registered for all the questions, $p < 0.05$.

In the case of resin-based composites, the cytotoxic mechanism is explained by the existence of the residual monomer remained after the curing, though the effect must be corroborated with other factors as well, such as the permeability of dentin, the saliva composition, the oral microorganisms, the mechanical factors, such as the short curing time [20]**.** Some authors consider that the degree of conversion of composite biomaterials is never complete and that it varies between 50 and 70% [21].

As for the toxic effects caused by methyl methacrylate monomer existing in the composition of dental prostheses, the cytotoxic mechanism is explained by the presence of monomer remained uncured, with differences depending on the type of resin used. Based on the polymerization method, acrylic resin can be classified as heat-polymerized, microwave-polymerized, light-polymerized and auto-polymerized, the latter being the most common in dental practice [22]. In a review regarding cytoxicity of acrylic resin for denture bases and its components, made on 19 studies, Goiato, concluded that auto-polymerized resin is more cytotoxic than heat-polymerized resin because of its higher quantity of residual monomers which cause cell and tissue changes in the oral mucosa [23].

The most frequent oral manifestations presented in table 2 were the following: burning mouth syndrome was reported by 13 dentists with a frequency of 21.3% followed

Questions	Yes		No		p value
	Nr	%	Nr	%	
Identification of toxic effects of the acrylic materials during the dental activity	61	75	20	25	0.012
Certainty of lesion etiology	57	70	24	30	0.037
Frequency of lesions reported in the past year	23	28	58	72	0.033
Moment of lesion occured:					
- within 24 ore;	45	56	36	44	0.024
- after 10 days	16	20	65	80	

Table 1
TOXIC EFFECT OF RESIN-BASED DENTAL MATERIALS

Oral manifestation	Resin composite restorative materials		Conventional methyl methacrylate dentures	
	No.	%	No.	%
Pulpal inflamation	12	19.67	0	0.00
Gingival inflamation	3	4.91	2	3.27
Denture stomatitis	2	3.27	10	12.3
Burning mouth syndrome	2	3.27	13	21.3
Allergic reaction	4	6.55	4	6.55
Mucosal inflammation and ulceration	1	1.63	8	13.11
Total: 61	24	39.3%	37	60.6%

Table 2
ORAL MANIFESTATION OF TOXIC EFFECT OF RESIN OF RESIN-BASED DENTAL MATERIALS

by the pulp inflammatory lesions as a side effect to restoration composite resins, 12 dentists (19.6%) and denture stomatitis reported by 12.3% dentists.

As for the prevalence of lesions caused by the toxic effects of the dental materials, we may quote few studies in the literature. We mention the study carried out in Sweden where 36 out of 618 patients were found out to have possible reactions to resin-based dental materials, what represents a percentage of 5.9%. In this study, most problems were intraoral such as oral ulcers, burning mouth, followed by cutaneous disorders occurred within the first 24 h after the dental treatment [24].

Allergic reactions to dental materials especially resin-based dental materials have been reported since 1965 by Crissey. These reactions are mainly denture stomatitis due to allergy to polymethyl methacrylate (PMMA) denture base material dental materials have been reported since 1965 [25].

As for the prevalence of this type of lesion, the studies performed in Romania by Scutariu *et al* reported a frequency of 14.5% [26]. The results of another study carried out in Norway for a 4-year period on a lot of 296 patients show a 8% frequency of allergic reactions to the resin-based dental materials [27].

Reduction of acrylic material toxicity

The diversification of the dental materials for restoration having a more and more complex chemical composition also increases the risk of occurrence of diverse reactions. The dentist must know very well the structure of the dental materials used and to choose them not only for their esthetic and physical qualities, but also by biocompatibility, knowing that the level of cytotoxicity differs according to the existing monomer, the most incriminated ones being those having in their structure monomers like TEGDMA and HEMA [28]. The observance of the clinical protocol for the insertion and chemical initiation for material hardening may reduce the occurrence of the residual monomer responsible for the cytotoxic effects on the oral tissues.

In case of the acrylic dental prostheses, due to the toxicity of the residual monomer, there is currently the trend of using flexible prostheses made of thermoplastic materials that do not contain toxic monomers and which are better tolerated by the oral tissues as an alternative method [29].

In their practice, the dentist encounters every day the issue of biocompatibility of the materials used, which is why they must know and understand the reactions occurred at local and general level so as to carry out a high quality dental treatment in conditions for the patient.

Conclusions

Out of the 61 dentists that participated to the study, 28% of them diagnosed in the past year lesions caused by side effects to the dental materials. Their frequency ranges between 21.3% for *burning mouth syndrome* caused by methyl methacrylate monomer in conventional prostheses to 19.6% for the inflammations of the dental pulp, following the toxicity of composite resins up to much lower frequencies below 5% for other oral manifestations, such as gingival inflammation, mucosal inflammation and ulcers, and allergic reaction.

Although current researches are trying to improve the biocompatibility of dental materials, there is no material that may contain all biological, physical and mechanical properties. That is why the knowledge of clinical requirements for manipulation as well as of the properties of the materials used must represent a basic component of the dental treatment.

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