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Research Paper

Tensile and microindentation properties of maxillofacial elastomers after different disinfecting procedures

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ABSTRACT

Statement of problem: Daily disinfection of maxillofacial prosthesis may reduce their service-life and lead to replacement.
Purpose: The purpose of this study was to evaluate possible alterations in the mechanical behavior of two maxillofacial elastomers after application of four different disinfection procedures.
Material and methods: The materials tested were two maxillofacial elastomers, a commercially available polydimethylsiloxane (PDMS) and an experimental chlorinated polyethylene (CPE). Different disinfection procedures such as microwave exposure, hypochlorite solution, neutral soap and a commercially antimicrobial solution, were applied for a period which simulates one year of a real service life. Mechanical behavior was investigated through tensile and microindentation tests in various depths. Mathematical models were fitted to tensile curves. Alterations in tensile parameters (maximum stress, maximum strain, elasticity and viscoelasticity parameter) were subjected to two way ANOVA and Tukey's post hoc tests ($\alpha = .05$).
Results: Most of the tensile parameters presented significant alterations among different disinfection procedures and maxillofacial materials which became also harder. Microwave exposure caused greater changes in PDMS and CPE elastomer whereas commercial antimicrobial solution and neutral soap did not significantly affect them. Microindentation and tensile tests revealed similar changes in materials' elastic modulus and hardness whereas the observed changes were greater into smaller depths.
Conclusions: Tensile and microindentation properties of PDMS and CPE elastomers presented changes after disinfected with four different procedures. Changes in the surface of

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both materials were more intense than in the bulk of the materials. Microwave exposure affected most the two elastomers, so concerning the findings of this study is not recommended for the disinfection of the examined PDMS and CPE elastomers. Moreover, microwave exposure and hypochlorite solution caused greater changes in the surface (3 μm) of CPE samples as indicated by microindentation results. PDMS affected less from the commercial antimicrobial agent and CPE from neutral soap, which seems to be the most suitable disinfection techniques.

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1. Introduction

Facial elastomers have been widely investigated the last decades due to their significant use in prostheses restoring facial regions of patients (Hecker, 2003). Facial prosthesis' replacements every 12–18 months, is required mostly due to deterioration of elastomers used (Hooper et al., 2005), and caused during service life from several reason such as solar radiation and environmental conditions in general (Eleni et al., 2009; Goiato et al., 2012a; Haug et al., 1999; Sampers, 2002), skin secretions (Polyzois et al., 2000) and care of prosthesis from the patient, such as the disinfection procedures (Goiato et al., 2010a, 2009a).

Patients have to disinfect their prosthesis every day for 3 to 5 min and be gently while brushing their prosthesis (Goiato et al., 2010a). Disinfection is essential not only for microorganisms protection of the prosthesis itself but also for the surrounding tissues (Goiato et al., 2010a). There are several disinfection procedures that can be chosen and the most suitable is crucial since prosthesis beyond its hygiene should also maintain stable, concerning its properties and behavior (Goiato et al., 2010c). The most popular disinfection procedures include the use of commercial available chemical cleansers, microwave exposure (Kiat-amnuay et al., 2005), hypochlorite solutions, neutral soaps, etc. (Goiato et al., 2010a, 2009c; Machado et al., 2005). Many chemical antimicrobial agents, such as effervescent denture cleansing tablets and other commercially available antimicrobial solutions (Goiato et al., 2012b; Hatamleh et al., 2011), have been used for disinfecting maxillofacial elastomers. A wide range of hypochlorite solutions has been used to disinfect dental prosthetic materials but also maxillofacial elastomers (Kiat-amnuay et al., 2005; Machado et al., 2005; Polyzois et al., 1995; Rohrer and Bulard, 1985). To avoid extraction of their compounds during disinfection procedures, the solution concentration used, must be carefully selected. Ferreira et al. (2009) have been reported that hypochlorite solution 0.5% w/w is suitable for disinfecting maxillofacial prostheses. Neutral soaps have been lately examined as antimicrobial agents for the same purpose (Goiato et al., 2009b). Microwave exposure has been also used to sterilize medical devices made of plastic, silicone, and rubber (Kiat-amnuay et al., 2005).

Mechanical properties of maxillofacial elastomers have to be similar with the facial part or tissue which are replaced and remain stable during service life, since their deterioration is directly linked to prosthesis aesthetics leading finally to its replacement (Goiato et al., 2012b). Desirable mechanical properties include, among others, elasticity and dimensional stability (Goiato et al., 2012a). A few authors have reported on Shore A hardness, surface roughness and deterioration through visual analysis of photomicrographs from scanning electron microscopy, of materials after different disinfection procedures (Goiato et al., 2012b, 2009a). It is possible that materials could be affected on the surface rather in the bulk due to disinfection. Thus, it could be interesting to investigate not only the mechanical behavior of an elastomer through e.g. tensile tests (Hatamleh et al., 2011), but also its surface alterations through microindentation tests, a technique which has been widely used in polymers and recently to detect alterations in maxillofacial elastomers (Eleni et al., 2011). Microindentation is the most commonly used technique to obtain local mechanical properties of engineering materials. Elastic–plastic properties and stress–strain curves can be deduced by indentations. When adopting the sharp indenters, at least two indentations with different tip angles have to be performed at a certain distance, thus increasing the uncertainties of the results and further complicating the application for nonhomogeneous materials (Charitidis and Dragatogiannis, 2013; Pelletier, 2006).

The purpose of the current study was to evaluate alterations in PDMS and CPE maxillofacial elastomers after disinfected with various disinfection procedures i.e. microwave exposure, hypochlorite solution, neutral soap and commercial antimicrobial agent. Mechanical behavior was investigated through tensile and microindentation tests. Mathematical models were fitted to experimental tensile tests involving maximum stress (σ_{max}), maximum strain (ε_{max}), elasticity parameter (E) and viscoelasticity parameter (p). The null hypotheses tested, was that no differences presented among material and disinfection procedure groups.

2. Materials and methods

2.1. Materials

The materials examined were a medical grade polydimethyl siloxane (PDMS) and a chlorinated polyethylene (CPE) as presented in Table 1. PDMS samples were cured at 100 °C in stone molds for 2 h whereas CPE samples offered by the University of Louisville (Gettleman et al., 2004). For each material 15 rectangular specimens (15 × 20 × 35 mm), and 15 dumb-bell, type II (ISO 37, 2005), specimens were fabricated. Three rectangular and three dumb-bell type specimens from each material were used in each disinfection procedure.

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