Available online at www.sciencedirect.com
ScienceDirect
Medical Engineering & Physics 31 (2009) 314–319
Medical Engineering & Physics
www.elsevier.com/locate/medengphy

Analysis of stresses in complete upper dentures with flat teeth at differing inclinations

Anthony E. Prombonas [a,*], Dimitris S. Vlissidis [b]

[a] Department of Dental Technology, Technological and Educational Institute of Athens, Greece
[b] Department of Dentistry, University of Athens, Greece

Received 30 August 2007; received in revised form 8 June 2008; accepted 22 June 2008

Abstract

This study measures the effect of the inclination of the occlusal surfaces of flat teeth, on the magnitude of exerted stresses in a model of the complete upper denture (CUD), in order to estimate which inclination could be more beneficial for the stressed denture.

Three groups of dentures were produced, with three different inclinations of their posterior flat teeth on the buccolingual direction: group 1 with an inward inclination of flat posterior teeth on the buccolingual direction (anti-Monson arrangement), group 2 with flat occlusion (no inclination) and group 3 with outward inclination (Monson arrangement). Using commercial edentulous molds and standardized procedures, six identical CUDs were produced for each group. Two rosette strain gauges were cemented onto the midline of each denture specimen, for measuring the stress magnitudes. The use of flat teeth with outward inclination may prolong the lifetime of the denture, by reducing the detrimental stresses (tensile principal and maximum shear stress). When flat posterior teeth with inward inclination are used, the reinforcement of CUD is necessary, to withstand the significant increase of the developed stresses ($p < 0.05$).

Keywords: Complete upper denture; Flat teeth; Stress pattern; Stress analysis; Denture deformation; Principal stresses; Maximum shear stress; Rosette strain gauge

1. Introduction

Many types of experimental stress analyses have been used to examine deformation of the complete upper denture (CUD). From the above studies, which were mostly clinical in nature, it can be concluded that the stress values are higher in the anterior palatal area of a CUD [1–13] and that the stress pattern of the CUD varies between individuals [3–9,11]. Two recent studies used rosette strain gauges to study the effects of the positions of artificial cusped teeth and load levels on stress patterns in the CUD and complete lower dentures (CLDs) [14,15].

Changes in the occlusal design due to wear affects occlusal balance and predisposes the denture base to fracturing [16]. It has also been shown that the use of flat teeth reduces stress developed in CLDs [16–19].

Many mechanical structures experience multiaxial cyclic loading during their service life due to complex applied loading, which can lead to changes in the directions of principal stresses [20–22]. The most well known method for predicting fatigue life is based on maximum tensile principal stress, in which it is assumed that cracks develop at points that experience the greatest tensile cyclic stress [23]. Tensile mean stress has a detrimental effect on fatigue life, whereas in general, a compressive mean normal stress has a beneficial effect [24].

Studies on the stability of CLD and studies of primitive skulls led to the use of flat artificial teeth in an anti-Monson arrangement, which resulted in a more stable CLD without locking teeth into an exclusive and obligatory centric occlusion [25–27]. Moreover, a technique has been introduced for setting nonanatomic (flat) teeth on a curve (Monson arrangement) generated by the patient [28]. However, the influence of flat teeth with different inclinations on the buccolingual direction, namely an inward inclination (anti-Monson arrangement) or an outward inclination (Monson

* Corresponding author at: Skiathou 44, Glyfada, Athens 16561, Greece. Tel.: +30 1 9634492.
E-mail address: aprob@teiath.gr (A.E. Prombonas).

1350-4533/$ – see front matter © 2008 IPEM. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.medengphy.2008.06.008

arrangement), on the stress pattern of the CUD has not been estimated.

The purpose of the present work was to study the influence of using flat teeth at different inclinations of their occlusal surfaces, on the magnitude and directions of principal stresses, exerted in the CUD. Furthermore, the study aimed to determine which inclination of flat teeth has the most beneficial effect on stressed CUD.

2. Materials and methods

The following three groups of CUDs were constructed (Fig. 1): group 1 with flat posterior teeth on the crest of the ridges, in an inward inclination on the buccolingual direction (anti-Monson arrangement), group 2 with flat posterior teeth on the crest of ridges in a flat occlusion (without inclination) and group 3 with flat posterior teeth on the crest of ridges, in an outward inclination on the buccolingual direction (Monson arrangement).

Two commercial molds of edentulous jaws were used in the present study, one of the upper and one of the lower jaw (Edentulous molds, size 55; Columbia Dentoform, Long Island, NY, USA). Using these molds, two prototype casts were constructed of the upper and lower jaw. The casts of the present study were fabricated using type III dental stone (Hydrock; KerrLab, Orange, California, USA). Two guidelines were drawn on the prototype upper cast to coincide with the longitudinal axis of the residual ridge crest. Two lines were also drawn on the lateral surfaces of the casts (lateral guide lines), to indicate the level of the residual ridges.

For the bases of the casts to be parallel to the level of the residual ridges, a trimmer for orthodontic casts was used (3/4 HP Wet Model Trimmer, Whip Mix Co., Fort Collins, Colorado, USA) equipped with a metallic sliding guide (for accurate vertical cutting) on its work table. The casts were placed on the worktable in a manner that the crest of their residual ridges came in to contact with the metallic plate of the guide. The guide was slid on its worktable until the base of the cast came in to contact with the trimming disk. Given that the metallic plate of the guide was parallel to the disk, the bases of the casts were trimmed parallel to the level of the residual ridges, in order to be used as reference point for the formation of occlusion rims and consequently for the placement of the teeth.

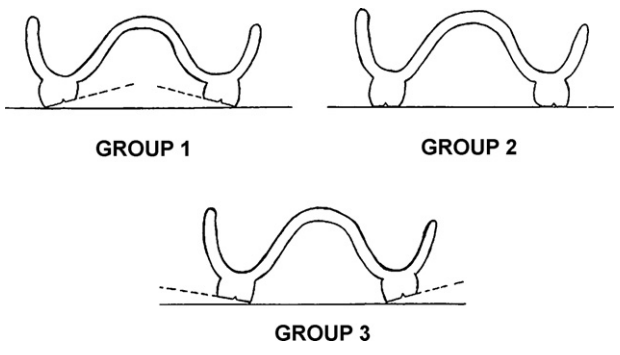

Fig. 1. Teeth arrangements in the three groups.

On these casts, two wax denture bases of uniform thickness (3 mm) were constructed, using wax denture sheets (Tenatex; Associated Dental Products, Wiltshire, UK). With the aid of the longitudinal and lateral guide lines, the rims were placed so that their long axes coincided with the crest of the residual ridges, while their occlusal surfaces were parallel to the level of the residual ridges and the bases of the casts. The two occlusion rims were adjusted and contoured to their final shape and size (8 mm in high and 8 mm in width) and they were positioned into contact, representing the centric occlusion [29].

To construct the wax prototype CUD of group 1, the upper artificial teeth (Upper Anterior, Uhler Dental Supply Inc., Chicago, Illinois, USA) were arranged on the upper occlusion rim. The anterior teeth were arranged according to standard procedures [29]. Flat posterior teeth (Upper Posterior, 0 degrees, Uhler Dental Supply Inc., Chicago) were placed with the central groves of their occlusal surfaces coinciding with the guidelines and the buccal edges of the occlusal surfaces in contact with the occlusal plane, with palatal edges at a distance of 1.5 mm. Two silicone keys (impressions) of the posterior teeth were fabricated for the left side and for the right, to record the position of these teeth. Using the silicone keys and the guidelines it was easy to change the inclination of the flat posterior teeth on the wax CUD, maintaining their initial position on the crest of the ridge.

The corresponding wax CLD was then constructed in the standardized vertical dimension of occlusion, using the corresponding lower flat teeth (Lower Posterior, 0 degrees, Uhler Dental Supply Inc., Chicago, Illinois, USA). The wax CUD was removed from the upper cast of the articulator and was mounted on a new upper cast. This wax CUD was used for the construction of a two-piece mold to reproduce the six identical standardized CUD of group 1. The six identical wax CUDs of group 1 were obtained by placing the artificial teeth and the cast in their respective positions in the mold (in the upper and lower half of the mold respectively), and then pouring molten base plate wax (Tenatex, Associated Dental Products, Wiltshire, UK) into the intervening space.

The wax prototype CUDs of group 2 and group 3 were produced by changing the inclination of the occlusal surfaces of flat teeth on the wax prototype CUD of group 1. For group 2 the occlusal surfaces were in full contact with the occlusal plane while for group 3 the palatal edges of their occlusal surfaces were in contact with the occlusal plane and the buccal edges at a distance of 1.5 mm. For each one group the corresponding wax CLD was constructed in the standardized centric occlusion. A new upper half (silicone) of the mold was constructed for each one of the groups 2 and 3. The six identical denture specimens of each group were constructed using the same methodology as in group 1.

The above described procedure yielded eighteen CUDs and three CLDs which were then flasked using an acrylic resin