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Considerations Regarding the Lifetime of Dentures

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Abstract

Failure and fracture mechanisms of structures such as fixed dentures, made of metal alloys with aesthetic veneering material, are very complex and difficult to generalize. Besides the individual patient's masticatory stereotype, a decisive influence is the fundamentally differing loads for static and variable stresses. Starting from these considerations, we developed a concept and we present an experimental research method (photoelasticity) to analyze variable loads or fatigue, in order to determine the temporal behavior of the complex dentoparodontal support denture.

Key words: *dentures, fatigue, stress, strain, ultimate states, fissure*.

Introduction

Breakage or failure by fatigue of dentures is a set of complex phenomena largely known and understood, but which still has many uncertainties. The main stress is caused by the forces that occur during the process of mastication. An overview of the fatigue fracture is illustrated in a case study on a clinical case of partial lateral maxillary edentation, prosthetic restored with an aggregate bridge on two abutments (first premolar and third molar).

The semiphysiognomic prosthetic denture made of chromium-nickel alloy with acrylic facets was cemented in June 2003 (fig. 1).

Fig. 1. The analyzed clinical case

Chewing is one of the main functions of the dental apparatus, physiological, but voluntary and also having an automatic component.

During mastication occurs a mechanical a process of trituration of food between dental arches and a physical-chemical process by which food is mixed with saliva to form the food bowel and initiate the chemical digestion of food.

The masticatory process involves all components of the dental apparatus (teeth, bones, muscles, temporo -mandibular joint, salivary glands).

Mastication is a series of chewing (masticatory) cycles, and in turn the masticatory cycle consists of a sequence of jaw (mandibular) cycles. A masticatory cycle sums all successive functional mandibular movements, from the incision or food prehension until the swallowing of the food bowel. The mandibular cycle is a sequence of the masticatory cycle which includes the opening and closing movement of the mouth in the maximum intercuspidal position (centric position).

The masticatory cycle lasts 10-20 seconds and comprises a number of 18-25 jaw cycles lasting 0.5-0.6 seconds [2]. People with average masticatory occlusal force develop a force of about 855N. The highest values of masticatory forces occur during the 194 ms of maximum intercuspidal position [3]. The mandibular masticatory cycle begins with a phase of mouth opening and a laterality move toward where the bolus is, followed by lifting the jaw, by sliding sideways on tearing slopes in the maximum intercuspidal position, thus being described as a form of drop (fig. 2).

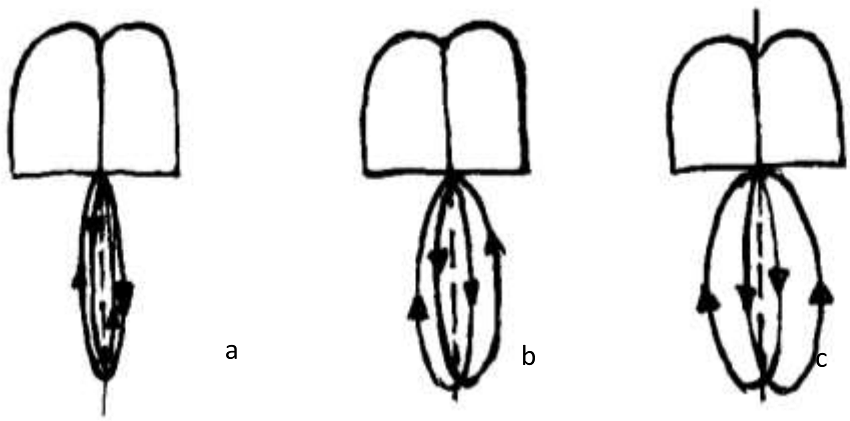

Fig. 2. Masticatory stereotypes: a. minced; b. mixed; c. rubbed

Masticatory cycles after the prevalent movement types consist of vertical masticatory movements specific for the crusher type (fig. 2.a.), horizontal masticatory movements specific for the rub type (fig. 2.c.) and combined masticatory movements specific for the mixt masticatory type (fig. 2.b.).

The masticatory movements' configuration is influenced by the size and consistency of food, the status of dental arcades (full, edentulous, prosthetic or non-prosthetic) and the occlusal relationships (functional or dysfunctional) with the emergence of adaptive processes. Masticatory cycle configuration may change over the life due to the action of pathological factors such as dental caries, tooth loss, presence of incorrect prosthetic parts, but also by social customs.

After the hemiarcades used in mastication there are described the following types of mastication: bilateral alternative mastication, unilateral restrictive mastication and concomitant mastication. The unilateral restrictive mastication is adaptive, being caused by edentulous, mobile teeth, pulpitis, periodontitis, or incorrect prosthetic restorations [2, 3].

These considerations can be represented in a system (mastication forces, time) for the analyzed clinical situation.

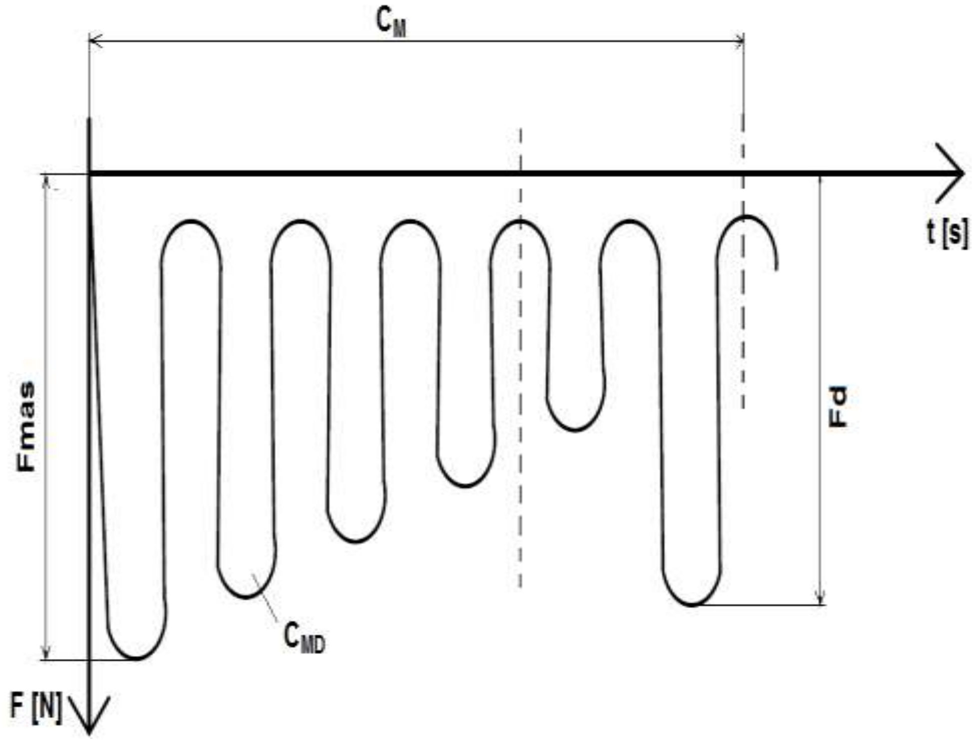

Fig. 3. Masticatory cycle: C_M – masticatory cycle; C_{MD} – mandibular cycle; F_{mas} – masticatory force; F_d – swallowing (deglutition) force

The occurrence of cracks in the denture was supervised directly. The patient was warned that with the advent of cracks, the denture is clinically required to be removed due to further complications. To behavior of the whole denture - dental-periodontal support was observed with regular monthly medical checks. This approach to the problem is similar to the behavior analysis of structures using the concept of damage tolerance, which is the property of a structure with cracks or other defects to keep the functional role a time.

Description of the Experiments

The stresses were random or non-stationary random and occurred between variables limits after certain laws. This is the real situation of the majority of in service stresses of dental work and to be able, under the circumstances, to develop methods and computational models, registrations must be done in real operating conditions, of the quantities which can provide information to calculate the fatigue.

It is known that conventionally the "lifetime" is long - for N between 10^6 and 10^7 or more, average for N between 10^4 and 10^5, short - for N between 10^2 and 10^3 or less. The clinical analyzed denture behaved properly for a number of 85.10^4 masticatory cycles.

Using Photoelasticity in Analyzing the Behavior of the Stressed Denture Structure

The loads applied to the models had the same nature as the forces that may stress dentures.

Fig. 4. Fractured fixed prosthesis in the mouth (limit state)

The surface forces were applied to the model by mechanical devices that satisfy the following conditions: they reproduce without any change in the actual nature real loads, load is carried out in steps, the ensure the separate or simultaneous load during the model deformation, the direction of the applied force is not changed nor additional forces do arise, each charge can be measured.

The shape of the photoelastic model is identical to a longitudinal slice obtained by cutting the jaw and the dental work

The model was obtained by machining a plate with a thickness of 6 mm molded from as optically active polymerization resin (dinox).

From the same batch there were made: samples to determine the elastic modulus and others in the form of a disc with a diameter of 70 mm for determining the photoelastic constant, all with a thickness of 6 mm.

To illustrate the method of determining the variation of stresses in the healthy dental complex as opposed to the one with defects, using photoelasticity, there are presented the most suggestive cases by viewing the izocromate field.

Tension is distributed so that the two teeth poles are balanced (fig. 5).

Another example is the representation when the denture is all cracked and the loading is still central. There is an overload of the base of the two support pillars (fig. 6).

Models loaded only on the two teeth poles are shown in Figures 7 and 8.

Photoelastic method was used to reveal how the tension field develops for different situations that occurred during the loading of the denture. Using this method can determine the tension produced after the cracking of the denture and the damage of the link between the tooth and jaw bone. From izocromate field analysis, we can predict where there can appear break sections (fractures) when loads are extreme.

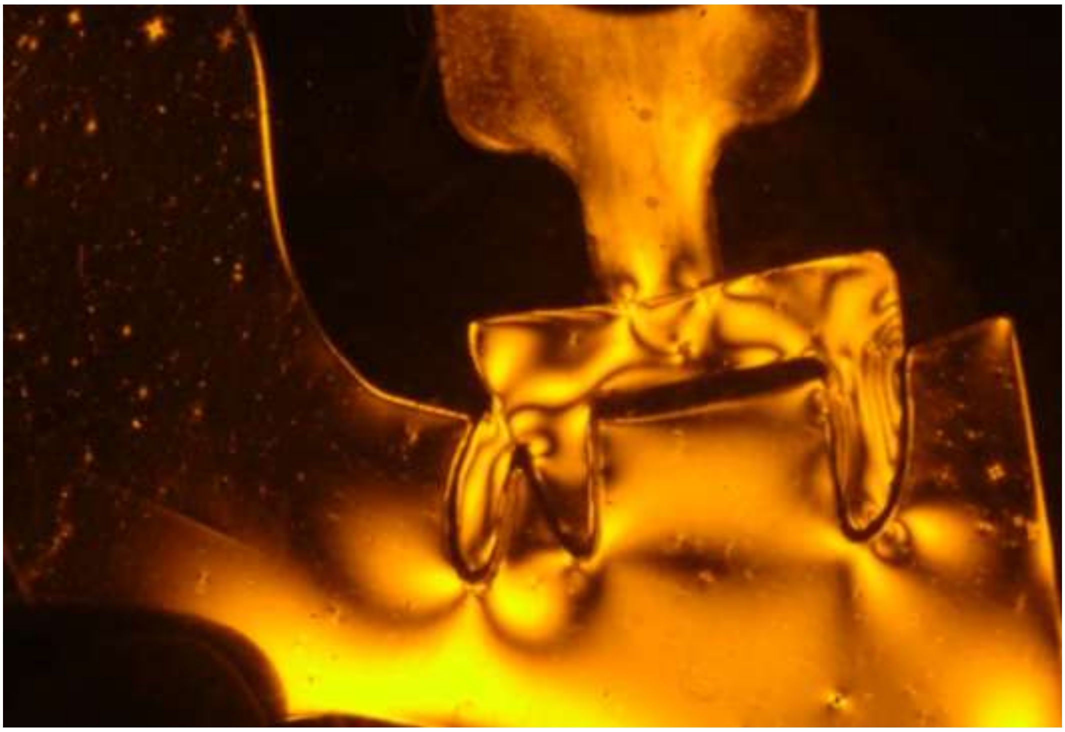

Fig. 5. Integral denture loaded centrally

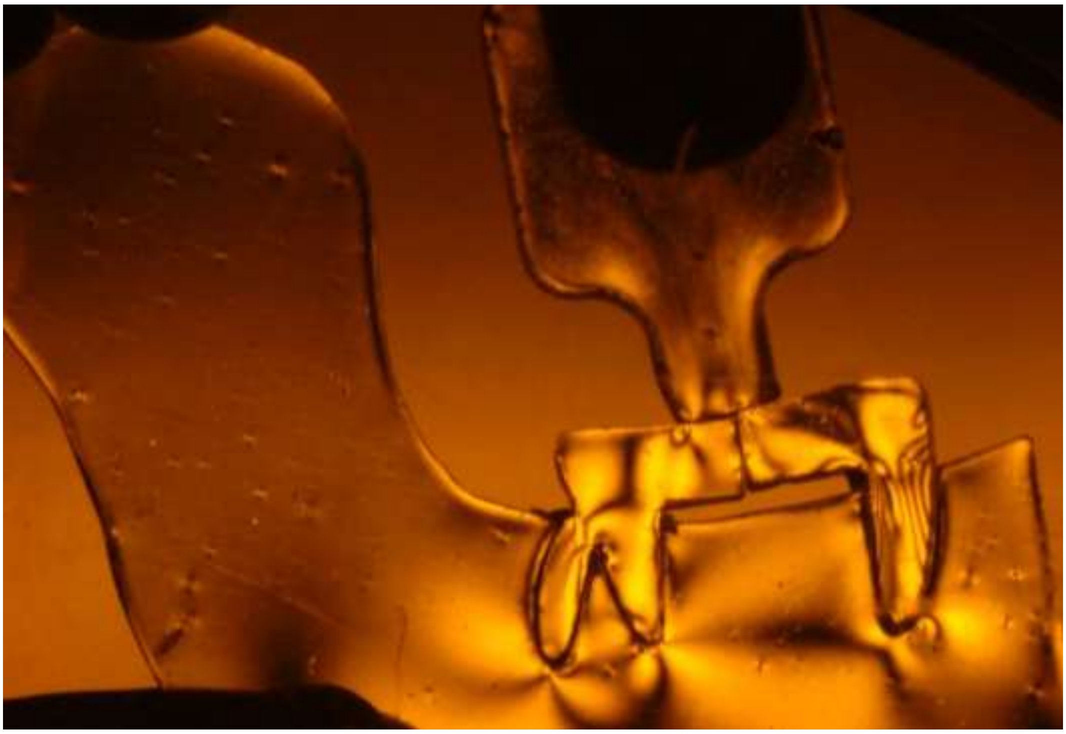

Fig. 6. Fissured denture loaded centrally

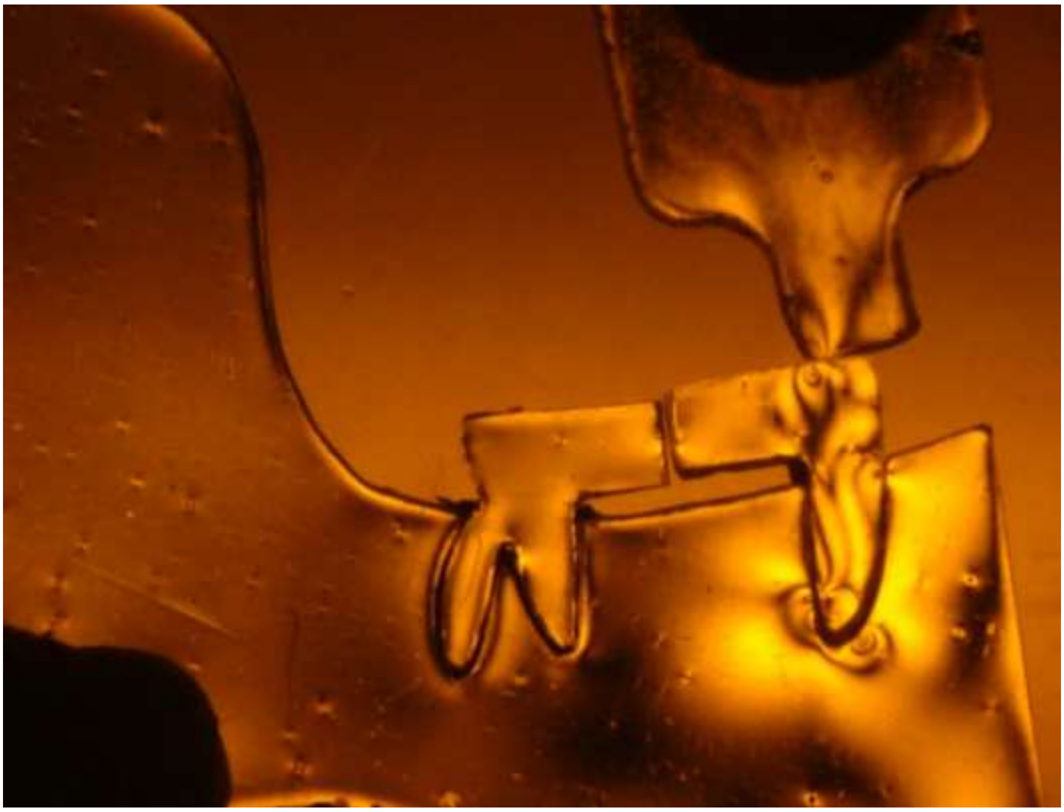

Fig. 7. Loading the mesial tooth, fissured denture

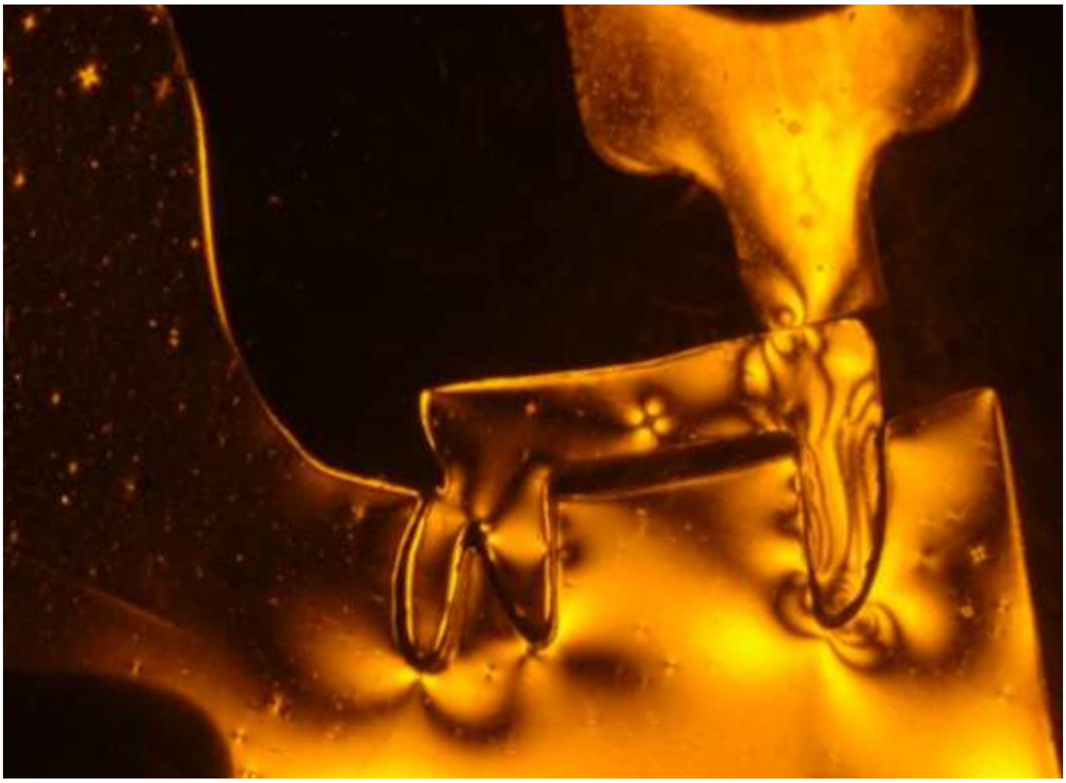

Fig. 8. Loading the mesial tooth, integral denture

Conclusions

1. The physical behavior of fixed prostheses is determined by the mechanical characteristics of the materials they are made of, but biological factors are also involved and features such as individual masticatory type and quality dental periodontal support.

2. The failure of fixed prostheses treatment may be influenced by many causes. After a period of 8-10 years after cementing the prosthetic work, the degradation is due to the fatigue fracture of the denture which is subject to about 85.10^4 masticatory cycles (fig. 9).

Fig. 9. Fatigue breaking section

3. Modeling and fatigue analysis of the dental prosthesis showed that the frequency of cycles of variable loads is influencing in a very small extent its behavior. In other words there are more important the number of cycles n and not their frequency or time.

4. The fracture of the denture as in the clinical case study requires its removal because as observed clinically but also from the photoelasticity study it appears a strong and uneven stress on the pole tooth which supports the extension, trending to tilt the prosthetic work and mobilize pole tooth (fig. 10).

Fig. 10. Fractured fixed denture with unrecoverable pole tooth

5. These clinical and experimental observations lead to the conclusion that in order to prolong the life of the bridge abutment teeth is recommended that prosthetic parts to be removed before it reaches the limit state, even if apparently functional.

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Consideraţii privind durata de viaţă a protezelor dentare

Rezumat

Lucrarea prezintă modele materiale care permit abordarea comportării la oboseală a lucrărilor protetice. S-a utilizat şi metoda fotoelasticităţii pentru ca aceasta pune în evidenţă starea de tensiune în cazul acestei probleme ce nu poate fi rezolvată prin alte metode. În situaţia de faţă modelele sunt şi de altă natură fizică, decât sistemele originale. Informaţiile obţinute în urma determinărilor experimentale conduc la adoptarea unor soluţii care optimizează tratamentul medical. Observaţiile clinice şi experimentale conduc la concluzia că pentru a prelungi durata de viaţă a dinţilor stâlpi de punte se recomandă ca piesele protetice să fie îndepărtate înainte de a se ajunge la starea limită, chiar dacă aparent sunt funcţionale.