論　文　内　容　要　旨

Finite-element analysis and optimization of the mechanical properties of polyetheretherketone (PEEK) clasps for removable partial dentures.

（ポリエーテルエーテルケトン(PEEK)を用いた義歯用クラスプの有限要素分析と機械的特性の最適化）

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Globally, the number of people aged 65 years and above has increased substantially in recent years, particularly in Japan. Owing to the "8020 Campaign" of 1989, tooth loss in Japanese people occurs later in life and the rate of edentulism has rapidly decreased in the past few decades. With this background, it is therefore expected that the need for removable partial dentures (RPDs) will increase in the future even among the previous generations that had mostly used full dentures.

The rapid developments in digital technology and materials science have led to the introduction of polyetheretherketone (PEEK), a high-performance thermoplastic polymer, to restorative dentistry, as a candidate for replacing metallic components in dental prosthesis. The mechanical properties of PEEK do not change during the sterilization process and its elastic modulus is similar to those of human bone, enamel, and dentin, suggesting it to be a suitable restorative material. PEEK features stable chemical properties, and is biocompatible, wear resistant, stable at high temperatures, insoluble in water. This material also presents low reactivity with other materials, is non allergic, and has lower plaque affinity than other materials such as metals and resins. Furthermore, PEEK can be processed using computer-aided design and computer-aided manufacturing (CAD/ CAM), rendering it easily reproducible in the event of failure, and easily relined in the case of resorption. If PEEK material can be applied clinically to RPDs, all the denture frameworks can be totally free of metals. This new material can improve the quality of life of patients owing to its improved safety and better patient satisfaction.

In this study, we explore the application of polyetheretherketone (PEEK) an alternative clasp material. Shape optimization of the PEEK clasp was performed via the finite element method analysis, and the constant displacement fatigue test was further performed to determine the amount of deformation and retention force after repeated insertions and removals of the clasp. Finally, the feasibility of applying the new esthetic materials for the clasp was analyzed as well as whether these materials have sufficient strength to withstand clinical application.

When PEEK was used for the clasp, the results of shape optimization indicated a maximum stress concentration consistently located at the base of the specimen. There was a correlation between mean load values and the thickness when the latter was greater than that of the width, as well as a correlation between the taper ratio and mean load values. Fatigue testing showed that although PEEK specimens exhibited significantly lower average load values than that of the Co-Cr alloy specimens, these were sufficient for clinical use (1.6 N). All specimens exhibited significant deformation during the first period of cycling; however, there was no significant difference in the deformation between the two materials after fatigue testing.

This study discusses the feasibility of using esthetic materials to replace traditional Co-Cr alloy in the clasp. PEEK clasps provide adequate retention and satisfies esthetic demands, indicating that PEEK clasps present a promising alternative to conventional Co-Cr alloy clasps. Besides, the superior flexibility and lower elastic modulus of PEEK, which ensure a deeper undercut than that of the Co-Cr alloy but exert lower stresses on abutments, suggest that PEEK clasps are appropriate for use in RPDs. Removable partial dentures with PEEK clasps are recommended in clinical cases with sufficient residual tooth, esthetic concerns, or even predominant concerns about periodontal health. The benefits of PEEK clasps include low maintenance for periodontal health, satisfying esthetic demands, and improvement in the patient quality of life.