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Original article

A new occlusal surface design for artificial posterior teeth to achieve high masticatory performance

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ABSTRACT

Purpose: The low masticatory efficiency of denture prostheses impairs the ability of wearers to consume high-fiber foods. Hence, artificial teeth with high masticatory efficiency are required. This study aimed to establish an occlusal surface design for posterior artificial teeth in denture prostheses that is compatible with the existing artificial teeth arrangement and that has high masticatory efficiency for the comminution of raw vegetables.

Methods: A masticatory simulator for occluding complete dentures was used to evaluate the masticatory efficiency of four occlusal surface designs, i.e., with parallel grooves occluding at right angles to the opposing teeth, groove depths of 1 and 0.5 mm, and inter-groove distances of 1, 2, and 3 mm. Raw carrots, rice, raw lettuce, chicken breasts, and peanuts were used as test foods to evaluate food comminution.

Results: Grooved occlusal surface designs with a 1-mm groove depth and a 2- or 3-mm inter-groove distance demonstrated significantly greater masticatory efficiency than the conventional occlusal form ($p < 0.05$).

Conclusions: The superiority of grooved designs over the conventional design was particularly evident for lettuce and raw carrots in this study, both of which are considered difficult foods to chew with complete dentures.

1. Introduction

As the population ages worldwide, there are increasing reports of functional limitations in speaking and eating that result from tooth loss and that affect quality of life [1]. Masticatory function in edentulous patients is often affected by the condition of the alveolar ridge. The number of masticatory cycles required to chew a standard piece of food progressively increases with age, with less comminution achieved in a longer chewing sequence [2]. Studies using food questionnaires reveal that tooth loss leads to dietary modifications as people choose foods that are easier to chew [3]. Furthermore, elderly edentulous people avoid many types of food, particularly raw vegetables, which they cannot effectively chew with conventional complete dentures [3].

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Although the number of patients undergoing oral rehabilitation with the use of osseo-integrated implants has increased [4], conventional complete dentures remain the most common treatment for edentulous patients [5]. The occlusal surface design of artificial teeth plays an important role in the masticatory efficiency of complete dentures. Hence, many kinds of occlusal surface and the functional differences among them have been reported to date [6,7]. Bladed teeth are one of the most common and effective non-anatomical designs [6,8]. However, bladed teeth are not available for all edentulous patients worldwide because of lack of commercial availability and expense. Therefore, occlusal surface designs that can easily be manufactured and that markedly improve mastication would greatly benefit edentulous patients and could influence the properties of future denture prosthodontics.

As Levin describes [8], occlusal facets cut fibrous food, which is then pulverized. The efficiency of mastication depends on the exact interactions between numerous small, sharp-edged facets on opposing teeth. When designing occlusal surfaces, the most important aspect is their potential compatibility with any existing artificial tooth arrangements, i.e., full-balanced occlusion, lingualized occlusion [9], or even the heavily worn occlusal surfaces of old dentures. We recently reported [10] a new design for a molar occlusal surface, which is a simple grooved design, to fulfill the above necessity for denture prostheses in elderly patients.

The purpose of this study was to evaluate the properties of different occlusal surface groove designs to determine the best design for improving masticatory efficiency.

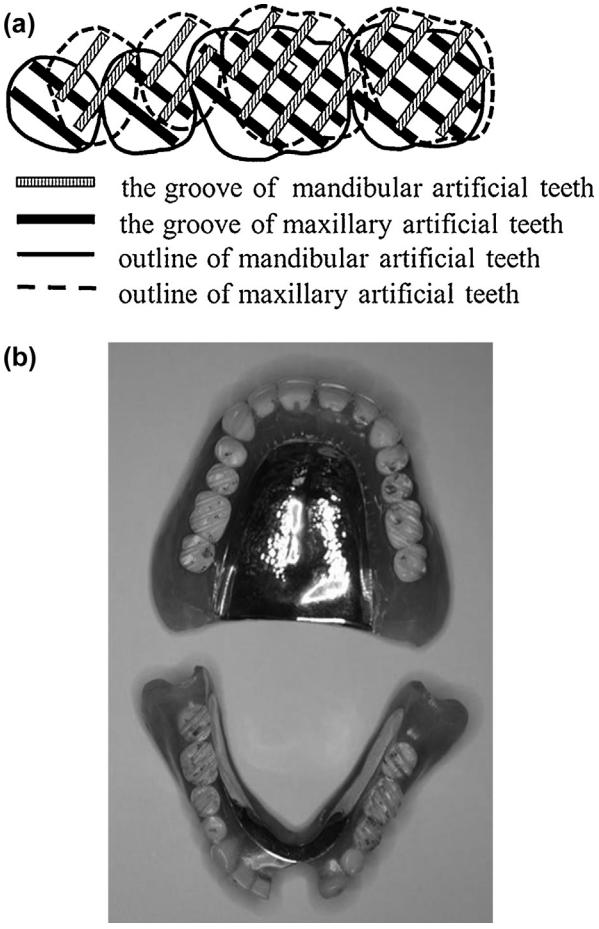

Fig. 1 – Grooves ground on artificial teeth. (a) Schematic diagrams of the grooves on the occlusal surfaces of artificial teeth. (b) Example of a clinical case with grooves on artificial teeth, after 1.5 years of use. Note that the grooves are angled at 45° to the dental arch and the grooves on the artificial teeth are orthogonally oriented to the opposing grooves when occluded.

2. Materials and methods

2.1. *Occlusal surface design*

Experimental upper and lower complete dentures were designed to mount on a masticatory simulator. The artificial teeth (A5A-500; Nissin Dental Products, Inc., Kyoto, Japan) were screw-retained to experimental complete dentures and were exchangeable to allow direct comparisons between artificial tooth designs. The artificial teeth were made of melamine resin with a Vickers hardness of 44.0 HV, and a Knoop hardness of 50 GPa. The experimental dentures were first mounted onto a stone cast on a semi-adjustable articulator, where the maxillomandibular relationship and slot adjustment were made equivalent to those of the masticatory simulator. Selective grinding of the artificial teeth was performed on the articulator to achieve lingualized occlusion. The articulator was adjusted as follows: horizontal condylar path angle, 15°; sagittal condylar path angle, 30°; incisal guide, 0°. After selective grinding and milling-in using carborundum-glycerin paste, parallel grooves were prepared at a 45° angle to the dental arch, as shown in Fig. 1, for each subsequently described groove design group. The direction of grooves on the maxillary molars was designed to be orthogonally oriented to those on the mandibular molars when occluded (Fig. 1a). Fig. 1b shows an example of a clinical case of dentures with grooved teeth.

Five occlusal surface designs were used to evaluate masticatory performance. After the selective grinding and milling-in described above, grooves were prepared on the occlusal surfaces with a diamond disc (H362F080; Mokuda Dental Co., Ltd., Kobe, Japan) and a milling machine (FF230; Kiso Power Tool. Mfg. Co. Ltd., Osaka, Japan). The width of each groove was 1 mm. Three different inter-groove distance conditions, namely 1 mm (G1), 2 mm (G2), and 3 mm (G3), were used. The depth of the grooves for G1, G2, and G3 was 1 mm at the buccolingual center of each artificial molar tooth, and 0 mm at the buccal and lingual edges of the occlusal surface. To evaluate the effects of groove depth, the G2(0.5) condition was also used, in which the groove depth was 0.5 mm at the buccolingual center of each artificial molar tooth, and 0 mm at the buccal and lingual edges of the occlusal surface. As a control, artificial molar teeth were used after selective grinding with no groove prepared (G–).

2.2. *Masticatory simulator*

The masticatory performance of complete dentures with each artificial tooth design was evaluated using a masticatory simulator. As shown in Fig. 2a, a semi-adjustable articulator

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