The Influence of Reinforcement on Strain in Maxillary Complete Dentures: A Preliminary Report

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The purpose of this study was to test intraorally the effect of a cobalt-chromium cast reinforcement embedded in the denture base of a maxillary complete denture on the distribution of stress. Eight subjects were selected randomly, and three designs of a cobalt-chromium alloy bar were embedded in the dentures. A strain gauge was attached at three positions around the midline of the polished surface of each denture. Strain in the reinforced dentures was significantly less than strain in dentures without reinforcement. These observations suggest that a cast cobalt-chromium reinforcement reduces strain and could contribute to fracture avoidance deformation in maxillary complete dentures. *Int J Prosthodont 2011;24:273–276.*

Fracture and deformation of complete denture bases can pose significant clinical problems. Darbar et al[1] reported that 29% of denture repairs were midline fractures and were more common in maxillary complete dentures. Various methods have been suggested to prevent such fractures, including chemical modification of the denture base, development of new materials, and mechanical reinforcement.[2]

Most reported studies were conducted in vitro where experimental conditions were simplified and not readily extrapolated to the clinical situation.[3] Since dentures vary greatly in both their morphologic features and the diverse functional and parafunctional forces they receive clinically, this preliminary study was designed to test the relative short-term effect of reinforcements in maxillary complete dentures worn by patients in a laboratory setting.

Materials and Methods

A convenience sample of four men and four women (age range: 55 to 83 years, mean: 72.5 ± 7.4 years) who wore maxillary complete dentures were selected randomly as subjects from the patient pool attending the Department of Prosthodontics and Oral Rehabilitation, Osaka University Dental Hospital, Osaka, Japan. Their opposing dentitions were as follows: One subject had no missing teeth, six subjects wore distal extension partial dentures, and one subject wore a complete denture. All subjects had used their maxillary complete dentures for at least 6 months and they were functioning successfully. The protocol of the study was approved by the ethical committee of Osaka University Graduate School of Dentistry, and informed consent was obtained from all subjects.

A duplicate maxillary complete denture was made for each subject using acrylic resin (Palapress Vario, Heraeus Kulzer). Three types of reinforcements (4-mm wide, 0.5-mm thick) were made from a cast cobalt-chromium alloy (Cobaltan, Shofu).

Four types of experimental dentures were tested: one without reinforcement (design C), one with reinforcement from first molar to first molar across the palate (design I), one with reinforcement on the top of the residual ridge (design U), and one with reinforcement from first molar to first molar across the palate and on the top of the residual ridge (design D) (Fig 1). All reinforcements were customized for each subject.

Strain gauges (KFG-1-120-D17-11L1M3S, Kyowa Electronic) were attached at the labial, middle, and posterior positions on the midline of the polished surface of each experimental denture and were connected to the center of a metal bar used to measure the occlusal force of each subject (Fig 2). All strain gauges were connected to sensor interfaces (PCD-300A, Kyowa Electronic) controlled by a personal computer (Dynabook SS N10, Toshiba).

Subjects sat upright in a chair with their heads and necks stabilized by the headrest to maintain

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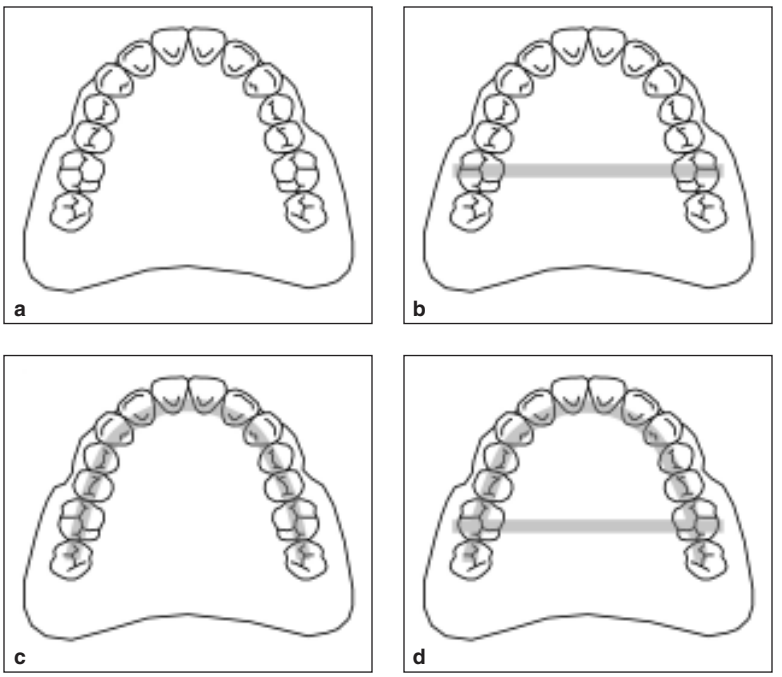

Fig 1 Schematic illustrations of the experimental dentures: **(a)** no reinforcement (C), **(b)** reinforcement from first molar to first molar across the palate (I), **(c)** reinforcement on the top of the residual ridge (U), and **(d)** reinforcement from first molar to first molar across the palate and on the top of the residual ridge (D).

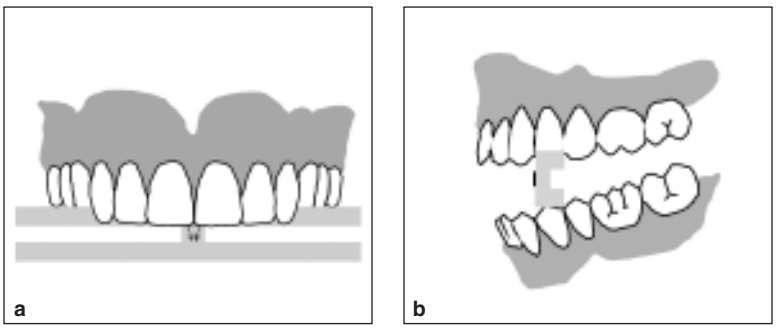

Fig 2 Schematic illustrations of loads: **(a)** frontal and **(b)** lateral views. A strain gauge was attached to a metal bar to measure occlusal force. Subjects bit down on the bar with 49 N of force at the first premolar and first molar sites (first premolar shown).

the Frankfort plane parallel to the floor. Each experimental denture was inserted, and the metal bar was used to apply a force of 49 N at the first premolar and first molar teeth bilaterally for 10 seconds (Fig 2). All measurements were repeated three times for each denture. The strains were measured for each subject and the mean strains of all subjects were calculated. Comparisons were made using analysis of variance.

Results

All of the reinforced designs reduced the strain significantly in all subjects ($P < .05$). At both loading positions, designs U and D were each associated with less strain than designs C or I (Fig 3). Similarly, the mean strain with designs U and D was less than those with designs I or C in the posterior region under the load at the first premolar and in the middle and posterior regions with loading at the first molar (Fig 4).

Discussion

Beyli and von Fraunhofer[4] reported that the most promising approach to prevent fracture appears to be reinforcement in the anterior portion of the denture palate. In this study, the strains of dentures with the designs U and D were smaller than that of dentures with design I. This result also suggested that the reinforcement that ran in the anterior portion of the palate prevented midline fracture of the denture base.

el Ghazali et al[5] reported that greater strain in dentures was associated with shallow in contrast to deep or high palatal vaults and that reinforcement of dentures with a cobalt-chromium plate was more effective in the shallow palate. The strain of the dentures in subjects whose palate was shallow might therefore tend to be large, and the strain of design D might tend to be smaller than that of design U in this study.

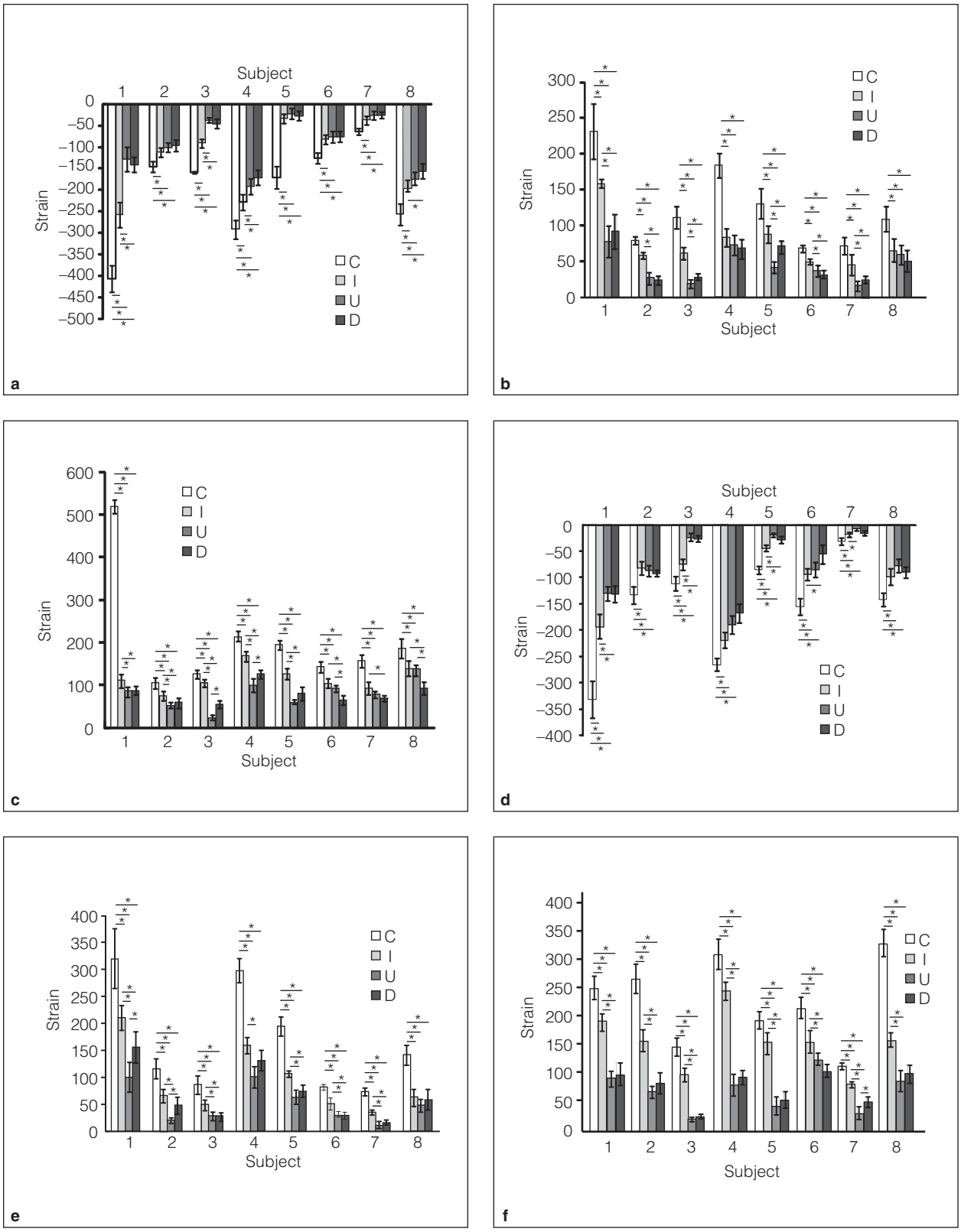

Fig 3 Bar graphs of the strain on the denture base in each subject. **(a)** Measurement position: labial, loading position: first premolar; **(b)** measurement position: middle, loading position: first premolar; **(c)** measurement position: posterior, loading position: first premolar; **(d)** measurement position: labial, loading position: first molar; **(e)** measurement position: middle, loading position: first molar; and **(f)** measurement position: posterior, loading position: first molar. *$P < .05$.

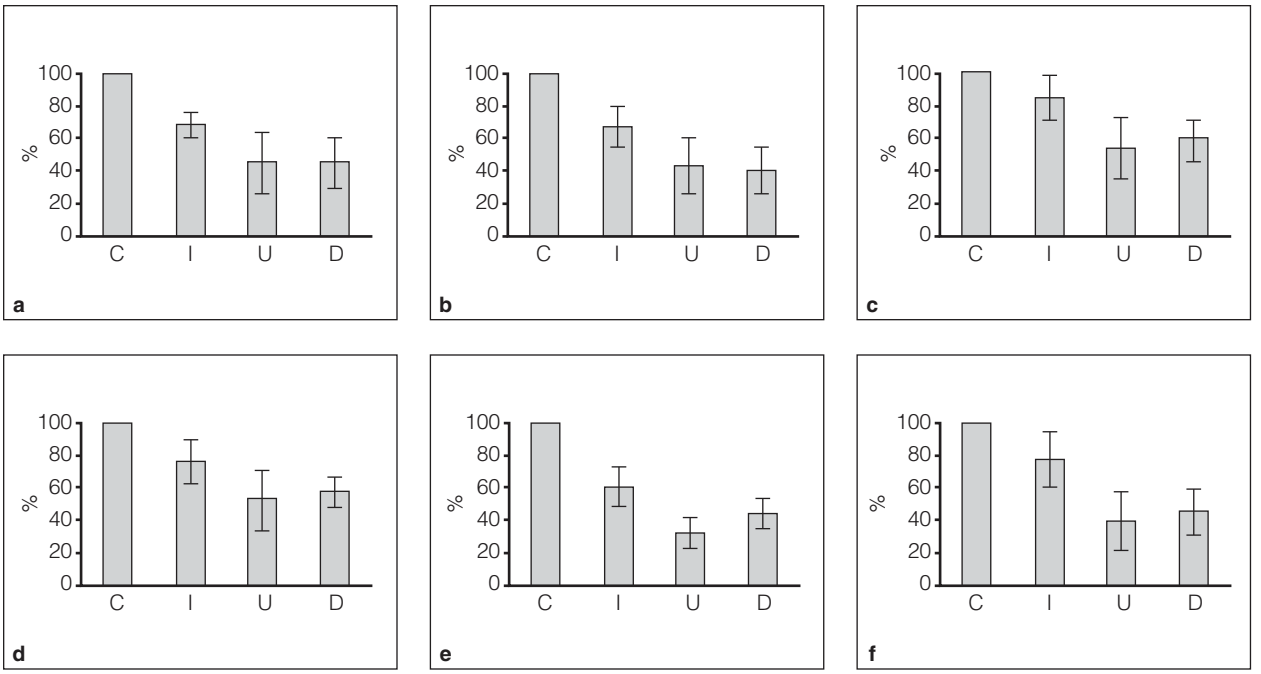

Fig 4 Bar graphs of the mean strains of all subjects. The strain of design C was considered to be standard (100%), and the strains of the other three designs were calculated relatively in percentages and averaged for all subjects. **(a)** Measurement position: labial, loading position: first premolar; **(b)** measurement position: middle, loading position: first premolar; **(c)** measurement position: posterior, loading position: first premolar; **(d)** measurement position: labial, loading position: first molar; **(e)** measurement position: middle, loading position: first molar; and **(f)** measurement position: posterior, loading position: first molar.

The effort to design a clinically relevant study was limited to using human subjects to generate a predetermined occlusal force. The subjects served as analogs for a laboratory articulator simulation, and relevant determinants such as the edentulous site's size, morphology, and tissue resiliency, as well as functional considerations, were not considered at this preliminary stage of the research design. These limitations demand that the results be interpreted with caution and that the necessary additional work that addresses the preliminary implications of the study be undertaken.

Conclusions

The following conclusions may be made from this preliminary study:

- A customized, embedded cast cobalt-chromium reinforcement decreased the strain at the midline of maxillary complete dentures.
- The reinforcement was optimal when placed on the top of the residual ridge.

References

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