

Pressure distribution of mandibular complete denture using soft lining materials

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Purpose: This study evaluated the effectiveness of pressure distribution under dentures using two types of soft lining materials to improve denture stability and comfort.

Materials and Methods: Two experimental dentures were duplicated from an existing complete mandibular denture. Denture base resin was shaved from the basal surface of each denture to allow for 1- and 2-mm thick acrylic (COE-Soft) or silicone (Soft Relining) lining materials to be affixed. Four microminiaturized pressure sensors were fixed to the intaglio surface of the denture bases to monitor bite pressure at four locations, namely, the bilateral first molars and first premolars. Each degree of bite pressure was measured five times under 49, 98, 147, and 196 N loads for 5 s. All data were statistically analyzed using ANOVA/Tukey's test at $\alpha=0.05$.

Results: As the loads increased, the total pressure at the four locations proportionally increased for both thicknesses. The 2 mm-thick silicone lining showed a significantly lower pressure burden than the 1 mm-thick silicone lining ($p<0.05$). However, there was no difference in the pressure burden between the 1- and 2-mm acrylic lining materials ($p>0.05$).

Conclusion: Acrylic lining materials should be used for difficult cases of mandibular edentulous patients when sufficient lining space is not available. (Int Chin J Dent 2010; 10: 17-21.)

Key Words: complete denture, pressure distribution, soft lining material

Introduction

The number of elderly people in Japan has increased over the years, and this circumstance has led to an increasing number of severely edentulous patients. In these patients, the alveolar ridge bone height tends to decrease with the thinning of the mucosa. Because such conditions are likely to cause pain, the masticatory pressure must be dispersed and/or decreased. For this purpose, clinical countermeasures, namely, increasing the size of the denture base, decreasing the vertical dimension, and using lingualized occlusion, have been applied.¹ However, there are some patients whose pain does not diminish even if normal clinical procedures are carried out.

Soft lining materials are often affixed to denture base intaglio surfaces in order to distribute the occlusal force more evenly during mastication and to reduce the overall pain. Silicone and acrylic soft lining materials are currently available for long-term use. The use of soft lining materials is not a new concept, and various studies focusing on bacteriology²⁻⁴ and physical science⁵⁻⁸ have been reported. However, there is little detailed information regarding the use of soft lining materials and the effectiveness of pressure distribution under various loads of biting force.^{9,10} The purpose of this study was to evaluate the effectiveness of pressure distribution using two different thicknesses of two types of materials. Four pressure sensors were placed on a complete mandibular denture, and the pressure was measured under several loads of biting force using a simulation model.

Materials and Methods

Experimental denture construction

Using Copy Flask H.T. (Towa Giken, Tokyo, Japan), two experimental dentures were duplicated from an existing denture that the selected patient had been wearing for five years. Following the manufacturer's instructions, an autopolymerized resin (PalaXpress, Heraeus Kulzer, Hanaeus, Germany) was poured and cured

at 55°C at an atmospheric pressure of 0.27 kPa for 30 minutes. The two duplicate dentures were mounted on an articulator (EM Relining Articulator, YDM Corp., Tokyo, Japan). An imaginary occlusal plane for experimental dentures was created parallel to the articulator's basal surface. The duplicate dentures were removed from the articulator after their proper positions were recorded, and 1 mm of basal resin was then removed from the intaglio surface of one denture and 2 mm was removed from the intaglio surface of the other denture. Four miniature pressure sensors (PS-10KA, Kyowa Electronic Instruments Co., Ltd., Tokyo, Japan) were positioned in four locations: left molar (LM), left premolar (LP), right premolar (RP), and right molar (RM), as shown in Fig. 1.

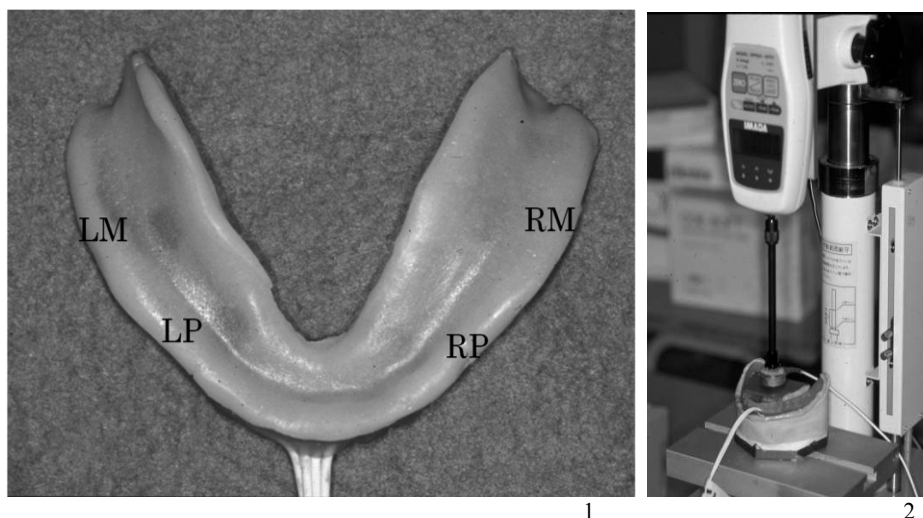


Fig. 1. Experimental denture. Pressure sensors were placed in four locations: left molar (LM), left premolar (LP), right premolar (RP), and right molar (RM).

Fig. 2. Loads were applied to the experimental dentures using a digital force gauge.

Two soft lining materials were used in this study (Table 1). Autopolymerized lining materials were used due to the ease of sensor installment at lower temperatures. The soft lining materials were applied to the target areas and mounted on the articulator again so that the 1- and 2-mm thick lining materials were uniformly attached to the intaglio surface. All lining materials, i.e., the 1- and 2-mm-thick acrylic and silicone, were polymerized at 35°C.

Table 1. Materials used in this study.

Material	Code	Type	Manufacturer	Curing Type	Batch No.	Batch No. (Primer)
COE-Soft	CS	Acrylic	GC America, USA	Self cured	802211 70320	-
Soft Relining	SR	Silicone:ad.	Tokuyama, Tokyo, Japan	Self cured	77268	76868

Measurement of pressure distribution

A brass plate (2 mm thick) was fixed to the experimental denture parallel to the occlusal plane. Using a digital force gauge (DFG-50, Imada Co., Ltd., Toyohashi, Japan), loads simulating various biting forces were applied at the intersection of the midline and the line of the bilateral first molars on the plate (Fig. 2). Each load was measured under each weight phase in 49 N increments of 49, 98, 147, and 196 N for 5 s. Each measurement was performed five times, and the sensor results were monitored using a personal computer (9153C, Hewlett

Packard, Palo Alto, CA, USA). All the data were analyzed using a two-way analysis of variance and Tukey's multiple comparisons test at a significance level of $\alpha=0.05$.

Results

The pressure distribution at all loading phases of the 1-mm-thick CS acrylic and SR materials is shown in Fig. 3. Similarly, comparisons of the 2-mm-thick lining materials are depicted in Fig. 4. Figure 5 shows the mean pressure of the four sensors at all loading phases of the 1- and 2-mm-thick CS and SR silicone lining materials.

Regarding the pressure distribution of the 1-mm-thick materials, the silicone showed remarkable differences in the highest and lowest reading for each sensor, whereas the 1-mm acrylic material demonstrated only small differences. The tendency for the pressure distribution for the 2-mm-thick silicone and acrylic lining materials was similar to that of the 1-mm lining materials.

The overall pressure burden for both the 1- and 2-mm soft lining materials proportionally increased as the load weight increased (Fig. 5). The total pressure of the SR silicone lining was significantly greater than that of CS at all loads ($p<0.05$). The two-mm-thick SR showed significantly less mean pressure than the 1-mm-thick SR ($p<0.05$). Little variance in pressure burden was found using the acrylic material after analyzing both the 1- and 2-mm lining materials ($p>0.05$) (Fig. 5).

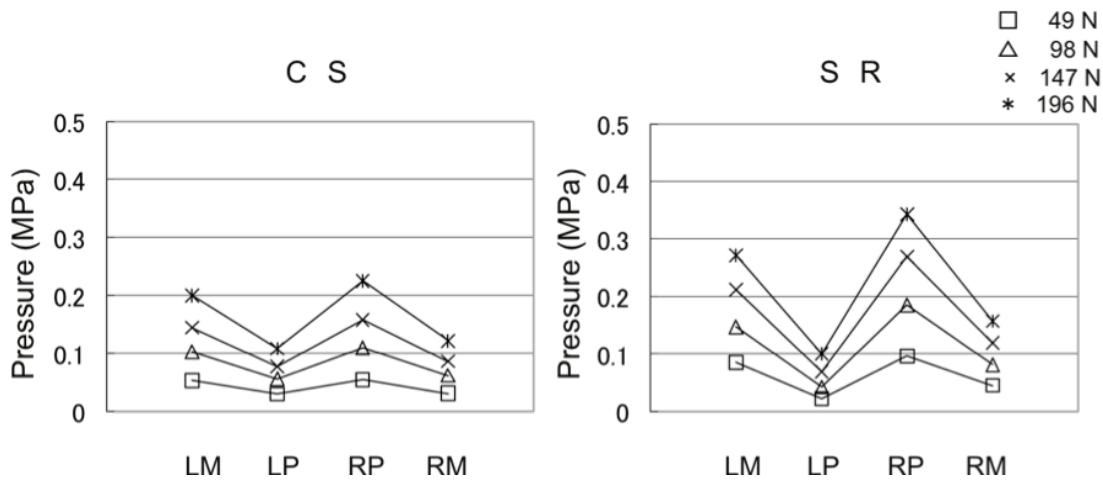


Fig. 3. Comparison of pressure distribution for 1-mm-thick CS and SR materials. Left: CS acrylic, Right: SR silicone.

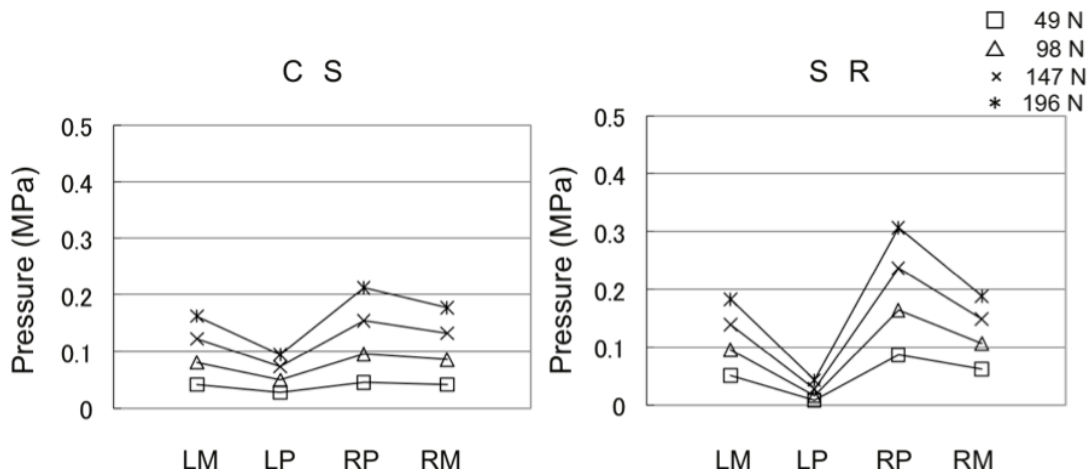


Fig. 4. Comparison of pressure distribution for 2-mm-thick CS and SR materials. Left: CS acrylic, Right: SR silicone.

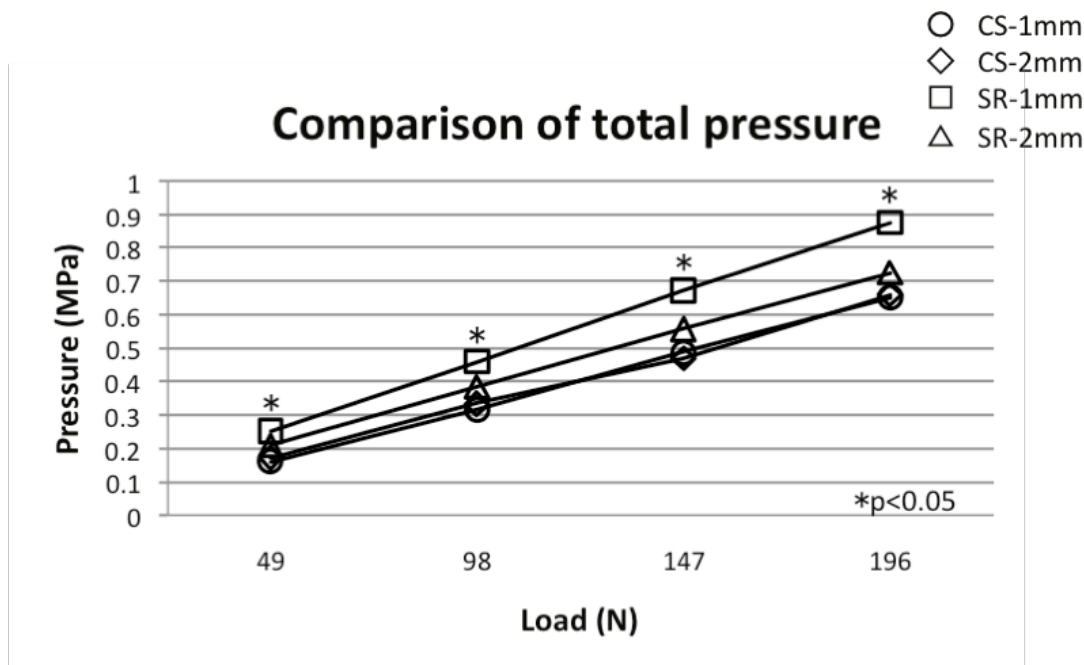


Fig. 5. Total pressure of the four sensors at all loading phases of the 1- and 2-mm-thick CS and SR lining materials.

Discussion

For fully or partially edentulous patients who have thin mucosa and height loss of the alveolar ridge bone, both relief from pain and denture stability have resulted from the use of soft lining materials.^{9,10} If patients have a low pain threshold, attaching soft lining materials with different thicknesses would provide even more pressure distribution and pain reduction. In particular, the viscoelasticity of the soft lining material would contribute to improving the pressure distribution and pain reduction.^{9,10} The soft lining materials used in this experiment have general viscoelasticity for long-term use and are commercially available. The occlusal force of the average denture wearer is approximately 294 N;¹¹ however, the load pressure used in this study was set at a 196 N max-load pressure because edentulous patients have a lower pain threshold.

In this study, the four miniature pressure sensors were placed on the intaglio surface of the experimental dentures, and the soft lining materials were then attached using an articulator. This laboratory procedure can accurately reproduce the alveolar ridge shape and provide a uniform lining. A patient with a flat alveolar ridge was specifically selected because the flat shape allowed the sensors to be easily installed. Furthermore, the flat ridge also helped make it easy to compare the pressure distribution of both lining materials. The angle of the sensor positioning on dentures, either flat or at a slight angle, caused variations in the overall sensor pressure value. As for the data recorded using the 1-mm-thick silicone material, the pressure distribution was not sufficient. The 2-mm silicone material might have given adequate comfort, but not as much comfort or pressure distribution compared to both the 1- and 2-mm acrylic linings. The acrylic material generally provided a higher level of support for both comfort and pain reduction. Both the 1- and 2-mm acrylic linings showed nearly the same pressure distribution, producing similar levels of comfort. Moreover, for patients who don't have sufficient denture space, using even a 1-mm thick acrylic lining can make a big difference in overall denture comfort.

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