The impression procedure is an important step in complete denture fabrication for ensuring adequate fit, retention, and function of the denture, but may also be critical for preventing bone resorption underneath the denture base. Various theories and techniques for achieving an ideal impression have been proposed, but most of them differ with respect to the concept of the force distribution on the residual ridge. The most common procedures currently used typically involve the creation of a preliminary impression with which to fabricate a study model, followed by the creation of a customized tray on the model for border molding and a secondary (final) impression.

The mucosa-covered alveolar bone exhibits a wide variety of shapes and sizes that can be visualized using dental computed tomography. Because the mechanism of pressure distribution on the bone surface during impression procedures has not been clearly demonstrated, the details of this mechanism must be speculated using the residual ridge morphology of study models.

A clinical randomized trial comparing two impression methods—namely selective pressure and non-selective pressure—indicated a patient preference for selective pressure. However, how pressure is distributed during the impression procedure remains unclear. Most previous reports about impression pressure have focused on physical factors, such as the tray design, properties of the impression materials, and positions in the arch. Less focus has been placed on the residual ridge morphology, where individual differences are usually found. Most previous reports also focused on the maxillary arch, not on the mandibular arch, where severe bone resorption is often found.

The purpose of this study was to clarify the influence of the morphology of the residual alveolar ridge, including different mucosal thicknesses and alveolar bone shapes and sizes, on the pressure distribution during impression procedures.

Influence of Mandibular Residual Ridge Morphology on Pressure Distribution During Impression Procedures: A Model Experiment

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Purpose: To clarify the relationship between residual ridge morphology and pressure distribution of the alveolar bone surface during dental impression procedures. Materials and Methods: Seven experimental models of the mandibular posterior residual ridge with the same ridge morphology but different mucosa (ie, silicone material) thicknesses and bone (ie, plaster) shapes and sizes were fabricated. The pressure on the bone surface was recorded using a pressure sensor sheet. The data from each model were compared using the Kruskal-Wallis test, and $P < .05$ was considered statistically significant. Results: Even with the same ridge morphology, the distribution of the impression pressure on the bone surface differed according to the mucosal thickness and bone shape and size. Pressure tended to concentrate on sharp edges and prominences of a slope and became more widely distributed as the mucosal thickness increased.

Conclusion: Within the limitations of this experimental study, the morphology of the residual alveolar ridge (bone and mucosa) appears to be a significant influencing factor for the pressure distribution during impression procedures. Int J Prosthodont 2018;31:370–374. doi: 10.11607/ip.5719

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Materials and Methods

Mandibular Residual Alveolar Ridge Models

The molar areas of mandibular residual alveolar ridge models (30 × 18 × 11 mm) were fabricated with the top section exhibiting a blunt shape according to Class III of Cawood’s classification (Fig 1).16,17 Seven models were fabricated with the same outer morphology, but with different artificial mucosal thicknesses (Fit Checker, GC Corporation) and alveolar bone shapes and sizes (Fujirock EP, GC Corporation). Models 1 to 4 were fabricated to achieve the same residual ridge morphology with a uniform mucosal thickness of 1 to 4 mm (Model 1 = 1 mm; Model 2 = 2 mm; Model 3 = 3 mm; Model 4 = 4 mm) on different bone sizes. Models 5 to 7 were fabricated to achieve the same residual ridge morphology with different bone shapes and sizes (Model 5 = sharp 70-degree angle; Model 6 = narrow, flat top; Model 7 = wide flat top) and different mucosal thicknesses at the top area (1, 3, and 4 mm, respectively).

Pressure Sensor

A pressure sensor sheet (10 × 10 mm; I-Scan system, Nitta Corporation) was placed on the bone surface of each model along the midline of the ridge. The sensor sheet could detect pressure of 20 to 250 kPa with a sensitivity of ± 0.2 kPa.

Loading Apparatus and Impression Tray

Figure 2 shows the loading apparatus, including a rod and platform, for placing a model. To ensure the same thickness of the impression material, the platform was set in a position where there would be at least 1.40 mm of clearance between the model surface and tray when the tray was in the final seating position with a 4.0-N load, including the rod.

A customized tray 20 mm in length was fabricated on the model with a sheet of wax relief (1.40-mm-thick Base Plate Wax, GC Corporation) with auto-polymerizing resin (Tray Resin, Shofu). To maintain the same tray position relative to the residual ridge model, the margin of the tray was set 2 mm from the bottom of the model.

Impression Procedure

As a preliminary study, the impression pressure distributions between the tray with and without border molding on Model 2 were compared. The results indicated a more evenly distributed pressure with the border molding than without it. Based on this finding, the following impression procedure was employed: First, polyvinyl siloxane material (Virtual Heavy Body, Ivoclar Vivadent) was applied to the tray for border molding and maintained in the seating position until it set. The excess material was trimmed until 2 mm was left on the tray border. Next, 8 g of light-body polyvinyl siloxane material (Virtual Light Body; Ivoclar Vivadent) was applied to the tray for the secondary impression procedure and maintained in the seating position until it set.

Pressure Measurements

The time point at which mixing of the light-body material began was designated the starting time. The
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Influence of Mandibular Residual Ridge Morphology on Impression Pressure Distribution

The results among models with the same residual ridge morphology but different bone shapes (Models 5, 2, 6, and 7) are shown in Fig 4. The pressure distribution on the bone surface varied with bone shape. Generally, the pressure was more concentrated around the prominences of the slope or the sharp edge area. For the area close to the midline of the bone, a significantly higher pressure was found in Model 5 and a lower pressure was found in Models 6 and 7 compared to the corresponding Models 1, 3, and 4, respectively, with same mucosal thicknesses in this area.

Discussion

Impression Procedure

More evenly distributed pressure was found during the preliminary measurement of the impression pressure with the border molding than without it. The pressure around the border area became heavier when the space of the impression material between the mucosa and tray in that area became thinner. This may be a counterexample of the mechanism of relief on the tray to reduce the pressure; however, further studies are needed to clarify the fluid mechanics of impression materials with and without a sealing space (border molding).

Pressure Measurement

Various methods have been employed for measurement of the impression pressure. Since the report by Frank in 1969 regarding pressure measurement...
during maxillary edentulous impression procedures, similar studies using a pressure gauge embedded in a maxillary edentulous cast as part of the mucosa surface have been performed to compare impression pressures in different positions and using different materials and tray designs. In 2013, Nishigawa et al developed an alternative method for indirectly measuring pressure by measuring the volume of impression material extruding from escape holes and grooves in the tray. In 2016, Iwasaki et al embedded pressure sensors underneath the pseudomucosa to compare various impression materials and relief thicknesses. Most of the above-mentioned techniques involve measurement of the pressure at a specific position around the arch or in an area of the mucosal surface. As reported by Kubo et al, a pressure sensor sheet makes it possible to measure the pressure distribution underneath a removable partial denture base more reliably and practically in vivo.

Most studies have focused on technical factors such as tray designs and impression materials; comparatively few have focused on the biologic factors that influence the pressure (whether from an impression or in function), such as the bone morphology or mucosal thickness. In 2001, Kawasaki et al used three-dimensional finite element analysis to examine the influence of the ridge morphology in different resorption patterns on the pressure generated from a denture. The present study focused on the molar area of the edentulous mandibular ridge and tried to clarify the influence of the residual ridge morphology. To accomplish this, the sensor sheet was placed on the model bone surface, and the residual ridge morphology, including the shape and size of both the mucosa and bone, were considered in the analyses.

The data from Model 2 were set as the control group, which had an even mucosal thickness of 2 mm. These data and those from Models 1, 3, and 4 (Fig 3) were then combined into one group for comparison of different mucosal thicknesses, and the results showed that the pressure distribution became more even as the mucosal thickness increased. Models 5, 2, 6, and 7 (Fig 4) comprised another group in which the bone shapes and sizes differed but the outer morphology of the residual ridge was the same. In this group, the pressure distribution varied with different bone shapes and sizes, while the stress was concentrated at the point where the slope of tangent lines changes drastically, but not necessarily in the area close to the midline. In this group, not only the thickness but also the shape and size of the mucosa were the variable factors in each area, along with bone shape and size.

Figure 5 shows the mean and SD pressure in each one-fifth area of the sensor sheet from the midline to the border in the two above-mentioned groups. The SD of the five areas on the sensor sheets of Models 5, 2, 6, and 7 were all larger than those of corresponding Models 1, 2, 3, and 4, respectively, implying that the difference in bone shape and size had a larger influence on the pressure distribution, causing wider variation in the pressure than the thickness of the mucosa.

When the mean pressure within the area close to the midline of the bone (Fig 6) was focused on, the group comprising Models 1 to 4 showed a mild decrease in pressure \( (P = .015) \) while the group comprising Models 5, 2, 6, and 7 showed a significant increase in Model 5 and a significant decrease in Models 6 and 7 \( (P < .001) \) compared to the corresponding Models 1, 3, and 4, even with the same mucosal thicknesses and the same position of each model. This implies that the influence of the mucosal thickness is smaller than the influence of the bone shape and size on the pressure distribution during the impression procedure. These results suggest that bone morphology (shape and size) should be more carefully examined before taking an impression by manual inspection or computed tomography, if available.

The main limitations of this study were its use of in vitro models and lack of assessment of impression tray design characteristics, such as the amount of relief or escape holes. Additionally, the definition of impression pressure was based on the hypothesis that the distribution of pressure by a denture is similar to its impression pressure to a certain extent. However, there is no evidence to clarify the relationship between the pressure from the impression material and the corresponding denture. This topic requires further study.
The authors report no conflicts of interest.

Conclusions

Within the limitations of this experimental study, the following conclusions were obtained:

- Pressure was concentrated on the sharp edges and inflection points of a slope of bone surface during the impression procedure.
- Pressure was more evenly distributed when the mucosal thickness increased, while the distribution pattern varied with the bone morphology.
- The bone morphology underneath the mucosa can have a larger influence on the pressure distribution during the impression procedure.

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References