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ORIGINAL ARTICLE

Investigating the maxillary buccal vestibule

Jen-Hao Chen [a,b,f], Huey-Er Lee [a,b], Jeng-Huey Chen [a,c], Fu-Hsiung Chuang [a,c], Hong-Sen Chen [a,d], Tsau-Mau Chou [a,b,e], Chia-Hui Weng [b*]

[a] Faculty of Dentistry, College of Dental Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan
[b] Department of Prosthodontics, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[c] Department of Conservative Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan
[d] Graduate Institute of Dental Sciences, Kaohsiung Medical University, Kaohsiung, Taiwan
[e] School of Dentistry, University of Missouri-Kansas City, Kansas City, MO, USA
[f] Dental Department, Kaohsiung Municipal Hsiaokang Hospital, Kaohsiung, Taiwan

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Abstract *Background/purpose:* Improper assessment of the maxillary buccal vestibular space can contribute to the fabrication of maxillary dentures with inadequate buccal flange extensions. The purpose of this study was to determine whether a significant difference existed between the anatomic dimensions of the buccal vestibules and the corresponding buccal flanges of maxillary complete dentures in an edentulous population.
Materials and methods: The anterior, middle, and posterior depth and width of the maxillary buccal vestibules in 100 randomly selected subjects were measured with a periodontal probe. Corresponding measurements of the buccal flanges of the subjects' existing dentures were recorded. The differences between buccal vestibule widths and depths and denture flange widths and lengths were statistically compared according to site.
Results: The difference in the mean depth between the vestibules and the flanges in the posterior area (6.4 mm and 10.3 mm, respectively) was approximately 38% ($P < 0.001$). The difference in the mean width between the vestibules and the flanges in the posterior area (3.3 mm and 7.9 mm, respectively) was approximately 58% ($P < 0.001$).
Conclusion: The study revealed statistically significant differences between the anatomic depth and width of the buccal vestibules and the corresponding flange dimensions of the existing dentures.

* Corresponding author. Department of Prosthodontics, Kaohsiung Medical University Hospital, 100 Shih-Chuan 1st Road, Kaohsiung 80708, Taiwan.
E-mail address: jehach@kmu.edu.tw (C.-H. Weng).

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Introduction

Denture retention is the result of the collective influence of a number of different physical factors working in concert. The most significant are: adhesion, cohesion, intimate tissue contact, neuromuscular control, hydrostatic pressure gradient, and border seal. Jacobson and Krol[1] argue convincingly that the surface tension, created in the fluid meniscus at the peripheral denture border, sustains a pressure gradient between atmospheric pressure and the reduced pressure in the fluid—film interface between the tissue and the intaglio. In order to maintain this pressure gradient, the border seal must prevent ingress of air into the fluid layer. Consequently, the border seal becomes the guardian of the retentive pressure gradient.

The maxillary buccal vestibule is the area bounded by the alveolar gingiva, the buccal mucosa, the buccal frenum, and the hamular notch.[2] The range of vestibular width and depth can vary considerably among different individuals.[3] Since resorption of the posterior maxillary edentulous arch begins from the buccal side,[4] as the edentulous residual ridge continues to atrophy, the vestibule becomes wider and shallower and the elliptical curvature of the vestibular fornix becomes less acute. In addition, the shape and form of the coronoid process and the buccinator muscle create an anatomic scaffold for the buccal mucosa. Consequently, subjects with flaring coronoid processes will have substantially wider buccal vestibules than subjects with vertical coronoid processes.[5]

When fabricating a maxillary denture, the buccal flange of the denture should fit into and fill the vestibular space.[6] An accurate fit will enhance the border seal of the denture and increase retention. In cases with severely resorbed buccal alveolar bone and/or flaring coronoid processes, the flange dimensions will often need to be wider to provide an optimal border seal and prevent the accumulation of debris in the vestibular space.[7]

Mismanagement of the maxillary vestibular space can result in a number of significant problems for the denture patient. Hayakawa[8] has mentioned that if the maxillary buccal flange is not formed properly, the denture may lose its peripheral seal when the patient laughs and opens their mouth widely. When the denture teeth are set in an alignment similar to the position of the original natural teeth, and the buccal flanges of the denture have inadequate width, the inward pressure of the buccinator muscle will act to displace the denture. If the width of a broad buccal vestibule is inadequately determined, the only location where the artificial teeth can be placed is on the residual ridge, potentially jeopardizing the neutral zone[9] and causing gagging.

Consequently, the assessment and management of the unique size and shape of this space require careful attention during denture fabrication. Because this space is difficult to see, clinicians traditionally rely on approved impression techniques to capture the dimensions of this space. In addition to obtaining impressions, Kluth recommends assessing the space by having the patient open moderately and then measuring the vestibule with a mouth mirror and periodontal probe.[10]

Although there is some debate regarding the value of optimal denture flange extensions in the maxillary buccal vestibules, the authors were not able to find any studies in the literature that report the differences between denture flange length and width when compared with the equivalent anatomic measurements of the maxillary buccal vestibule. Therefore, the purpose of this preliminary research project was to sample the magnitude of maxillary denture flange/maxillary buccal vestibule difference by measuring and statistically comparing the lengths and widths of denture flanges with the corresponding dimensions of the maxillary buccal vestibule in a group of denture subjects.

Materials and methods

Measurement

Two authors clinically examined 100 randomly selected subjects with complete dentures, fabricated within the past 2 years. The subjects were patients in private dental clinics in Kaohsiung, Taiwan. Since this was a preliminary investigation, detailed demographic and denture history information was not collected. In addition, clinical denture analysis and patient satisfaction were not considered. Informed written consent was obtained from all subjects prior to the investigation and approval was obtained for the clinical research from the Human Ethics Committee of Kaohsiung Medical University (KMUH-IRB-960229).

The depth and width of the maxillary buccal vestibule of each subject was measured at three locations: anterior (1 mm posterior to the buccal frenum), middle (at the center of the anterior—posterior length), and posterior (1 mm anterior to the hamular notch).

The anterior, middle, and posterior locations were marked with a disposable color transfer applicator (Dr Thompson's Color Transfer Applicator; Great Plains Dental Products, Kingman, Kansas, USA). The denture was then inserted and the reference marks were transferred from the alveolar residual ridges to the denture. Next, each subject was instructed to open their mouth half way and the cheek was illuminated with a mouth mirror. The depth of the vestibule was measured from the crest of the residual alveolar ridge to the fornix of the buccal vestibule with a periodontal probe, and the width of the buccal vestibule was measured from the mucogingival junction to the buccal mucosa, perpendicular to the vertical axis of the vestibule (Fig. 1). The width and length of the buccal flanges at the corresponding location on the subject's maxillary denture were also measured (Fig. 2). The corresponding anatomic and prosthetic measurements were recorded and the findings statistically analyzed.

Statistical analysis

The differences between the dimensions of the maxillary buccal vestibule and the corresponding buccal flanges were analyzed by paired *t* tests. The differences between the sexes were compared by two sample *t* tests. The significance level was set at $P < 0.05$, and the data were analyzed with the statistical program JMP 7.0 software (SAS Institute Inc., Cary, NC, USA).

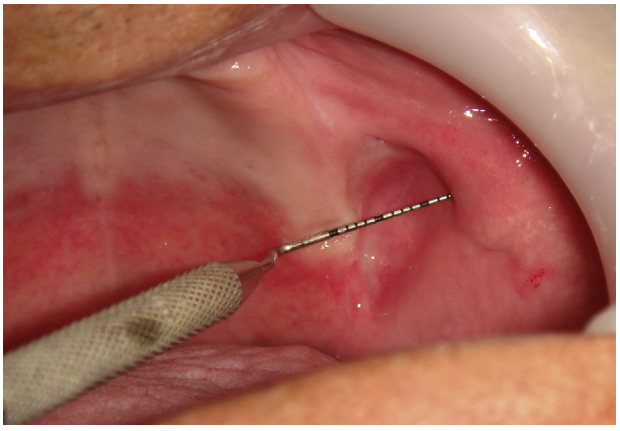

Figure 1 Measuring the width of the maxillary buccal vestibule with a periodontal probe.

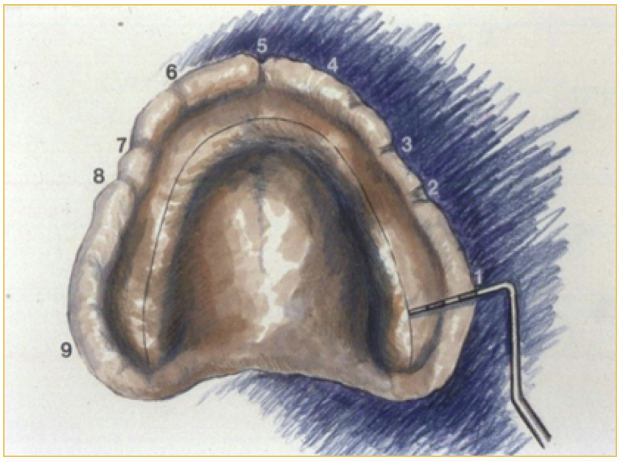

Figure 2 Measuring the depth of the maxillary buccal flange with a periodontal probe.

To assess the reliability of the data, two examiners performed the measurements on 20 randomly selected subjects in a prior pilot study. The correlation coefficient was approximately 0.8, indicating a high level of reproducibility between the two examiners (JMP 7.0 software).

Results

A total of 100 subjects (47 men, 53 women) were included in this study. As shown in Tables 1 and 2, the mean depth and width of the buccal vestibule increased from the anterior to the posterior region of the vestibule, and the width of the buccal vestibule ranged from 2.5 mm in the anterior to 10 mm in the posterior region. The statistical mean results for each corresponding anatomic and prosthetic location demonstrated significant differences in depth and width. The difference in the mean vestibular depths and flange length in the posterior area was nearly 38% (10.3 mm and 6.4 mm, respectively) ($P < 0.001$), and the difference in the mean vestibular and flange width in the posterior area was approximately 58% (7.9 mm and 3.3 mm, respectively) ($P < 0.001$). In addition, significant statistical differences were observed in the mean depths of the buccal vestibule between male and female subjects. However, there were no statistically significant differences in the widths of the buccal vestibule between male and female subjects (Tables 3 and 4).

Discussion

The maxillary buccal vestibule is a anatomic structure key in maintaining the border seal of a maxillary denture. Data analysis from this study revealed discrepancies that were not only statistically significant but also substantial. The 38% deficiencies in posterior flange length and 58% deficiencies in posterior flange width, when compared to the anatomic vestibule, indicated that serious methodological errors occurred during the denture fabrication process. Although some of the discrepancy in width can be explained by progressive alveolar ridge resorption, the discrepancies between the length of the denture flange and the depth of the vestibule cannot. The flange length discrepancies were mainly the result of procedural error and/or clinician and technician error during the clinical and fabrication process. Whether the errors occurred during one specific step in the procedure (such as the initial impression, individual impression tray fabrication, border molding, final impression, or at the laboratory) or were accumulated during each

Table 1 Buccal vestibule and denture depths according to site.

	Depth of buccal vestibule, mean ± SD (mm)	Depth of denture flange, mean ± SD (mm)	P (paired *t* test)	Extension difference (%)
Anterior				
Right	7.5 ± 2.4	5.0 ± 2.0	<0.0001	33.3
Left	7.4 ± 2.4	4.8 ± 2.0	<0.0001	35.1
Combined	7.5 ± 2.0	4.9 ± 1.6	<0.0001	34.6
Middle				
Right	8.3 ± 2.5	6.2 ± 2.4	<0.0001	25.3
Left	8.9 ± 2.4	6.3 ± 2.4	<0.0001	29.2
Combined	8.6 ± 2.1	6.3 ± 2.1	<0.0001	26.7
Posterior				
Right	10.3 ± 2.9	6.4 ± 2.2	<0.0001	37.8
Left	10.2 ± 3.0	6.3 ± 2.5	<0.0001	38.2
Combined	10.3 ± 2.0	6.4 ± 2.0	<0.0001	37.8

Table 2 Buccal vestibule and denture widths according to site.

	Width of buccal vestibule, mean ± SD (mm)	Width of denture flange, mean ± SD (mm)	P (paired *t* test)	Extension difference (%)
Anterior				
Right	3.3 ± 0.6	2.0 ± 0.8	<0.0001	39.3
Left	3.3 ± 0.7	2.0 ± 0.8	<0.0001	39.3
Combined	3.3 ± 0.6	2.0 ± 0.8	<0.0001	39.3
Middle				
Right	4.6 ± 0.7	2.2 ± 0.8	<0.0001	52.1
Left	4.3 ± 0.6	2.0 ± 0.8	<0.0001	53.4
Combined	4.5 ± 0.5	2.1 ± 0.7	<0.0001	53.3
Posterior				
Right	8.0 ± 1.4	3.4 ± 1.2	<0.0001	57.5
Left	7.8 ± 1.3	3.3 ± 1.0	<0.0001	57.6
Combined	7.9 ± 1.2	3.3 ± 0.9	<0.0001	58.2

step of the fabrication process is irrelevant to this study. The fact remains that significant errors occurred and the average patient received a denture that was significantly deficient.

Subjects with flaring coronoid processes and substantial buccal alveolar bone resorption may have buccal vestibules that are unusually wide. If the discrepancy between the width of the buccal vestibule and the buccal flange is substantial, the patient may experience compromised support and retention because the buccal mucosa is unable to adhere closely to the lateral side of the denture flange. This reduction in surface contact area will reduce the ability of the border seal to sustain the surface tension in the meniscus, resist ingress of air into the thin fluid interface, and potentially jeopardize the retentive pressure gradient. In addition, when there is a reduction in surface contact area, the patient may experience diminished neuromuscular control of the denture by the buccinator muscle.

Two probable sources of error include the impression procedure and the fabrication process at the laboratory. The increase in flange/vestibule error that was observed from anterior to posterior suggested that the most likely problem involved the impression technique. In addition, the largest error in width and length was observed in the posterior region which was the most difficult area for the clinician to visualize. The authors suggest that carefully measuring the critical vestibular dimensions with a periodontal probe at the initial diagnostic appointment can provide additional topographic information helpful in formulating a retentive design for each edentulous patient. Periodontal probe measurements at the initial appointment can help improve the flange dimensions of the individual impression tray prior to obtaining the final impression. Kluth[10] reported that measurement of sulcus depths with a periodontal probe was a positive method of evaluating the border extensions of impression trays, and can reduce the amount of time spent in making flange adjustments after the dentures are completed.

Laboratory technicians are accustomed to adjusting the flange thickness to approximately 2–3 mm. In patients with wide anatomic vestibules, 3 mm thick denture flanges would not fill the vestibule properly and would minimize maxillary denture retention. Evidence from this study

Table 3 Depths of buccal vestibule and denture according to sex.

	Depth of buccal vestibule, mean ± SD (mm)	Depth of denture, mean ± SD (mm)	P (paired *t* test)
Anterior			
Men	8.2 ± 1.9	5.2 ± 1.8	<0.0001
Women	6.8 ± 1.8	4.6 ± 1.4	<0.0001
P (*t* test)	0.0007	0.0782	
Middle			
Men	9.7 ± 2.2	6.8 ± 2.3	<0.0001
Women	7.5 ± 1.8	5.7 ± 1.8	<0.0001
P (*t* test)	<0.0001	0.001	
Posterior			
Men	10.8 ± 2.6	6.7 ± 2.1	<0.0001
Women	9.8 ± 2.5	6.0 ± 2.1	<0.0001
P (*t* test)	0.003	0.056	

Table 4 Buccal vestibule and denture widths according to sex.

	Width of buccal vestibule, mean ± SD (mm)	Width of denture flange, mean ± SD (mm)	P (paired *t* test)
Anterior			
Men	3.3 ± 0.5	2.1 ± 0.8	<0.0001
Women	3.3 ± 0.5	2.0 ± 0.7	<0.0001
P (*t* test)	0.7586	0.4525	
Middle			
Men	4.4 ± 0.5	2.1 ± 0.7	<0.0001
Women	4.5 ± 0.6	2.0 ± 0.6	<0.0001
P (*t* test)	0.8314	0.6173	
Posterior			
Men	8.0 ± 1.1	3.3 ± 0.8	<0.0001
Women	7.8 ± 1.3	3.4 ± 1.1	<0.0001
P (*t* test)	0.3151	0.6913	

suggests that a 3 mm flange width would be appropriate for the anterior portion of the vestibule, but significantly inadequate for the posterior portion of the vestibule. The anterior, middle, and posterior flange width measurements (3.4 mm, 3.3 mm, and 3.3 mm, respectively) did not replicate the increasing anterior to posterior width measurements of the vestibule (3.3 mm, 4.5 mm, and 7.9 mm, respectively).

The large range of vestibular widths (2.5—10 mm) suggests that a substantial morphological difference in the anatomic structures that define the vestibular space (coronoid process shape, buccinator muscle, and alveolar ridge) existed among the subjects in this study. The magnitude of dimensional differences in vestibular space, the difficulty in visualizing during assessment, and the marked difference in vestibule and flange dimensions observed in this study suggest that additional attention to this anatomic area by the clinician is indicated.

The authors acknowledge that vestibular measurement with a periodontal probe has limitations. Proper probe angulation and visual accessibility can be problematic. Vestibular measurements for patients with narrow vestibules were more difficult to obtain than measurements for patients with wide vestibules. Consequently, the measurements in this study should be treated as relative values rather than exact representations. Although the authors were able to demonstrate a high level of reproducibility between the two examiners, the aim of this study was not to offer specific mean vestibular dimensional standards, but rather the goal was to determine if significant dimensional differences existed between the anatomic maxillary buccal vestibules and the maxillary denture posterior buccal flanges. As mentioned earlier, the posterior region of maxillary buccal vestibule is often difficult to see. The increasing anterior to posterior difference between flange width and length when compared to vestibular width and depth confirms the difficulty clinicians have in accurately copying the vestibular space. The high level of reliability (80%) demonstrated in the pilot study between the two examiners suggests that use of a periodontal probe when assessing the vestibular space would help improve the clinician's denture fabrication results.

We believe that periodontal probe measurement method has two potential benefits: (1) the discipline of measuring the vertical and horizontal components of the vestibule will help remind the dental student and the general dentist that the horizontal as well as the vertical dimensions need to be carefully considered; and (2) preliminary vestibular measurements will provide sound relative guidelines for assessing the dimensions of the final impression as well as the buccal flanges of the fabricated denture.

As this was a preliminary study, a functional assessment of the dentures was not conducted and the impact on personal well-being was not considered. The authors did not investigate the changes in retention and stability following buccal flange modifications in this study. However, it is our opinion that optimizing the length and width of the buccal flanges would have significantly improved maxillary denture retention for the average patient. The authors recommend that a robust investigation be conducted to evaluate changes in maxillary denture retention following optimal modification of the maxillary denture buccal flanges. This study should include before and after appraisal of subjects' oral health-related well-being and functional denture assessment analyzed in a time-dependent functional manner.

At each location, there was a statistically significant difference in the depth and width of the maxillary buccal vestibule when compared with the corresponding regions of the existing denture among the 100 subjects. The difference in the mean depth between the vestibules and the flanges in the posterior area (10.3 mm and 6.4 mm, respectively) was approximately 38% ($P < 0.001$). The difference in the mean width between the vestibules and the flanges in the posterior area (7.9 mm and 3.3 mm, respectively) was approximately 58% ($P < 0.001$). The range in buccal vestibular width observed in our study was considerable (2.5—10 mm) (not included in Table 2) and coincided with the potential anatomic latitude of the structures that define the vestibular space. The buccal vestibular flanges of the maxillary dentures were significantly inadequate in mimicking the width and depth dimensions of the maxillary buccal vestibule.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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