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Actual dimensions, design, and fabrication of readymade posterior palatal seal for completely edentulous patients

Dimensões reais, design e fabricação de vedação palatina posterior pronta para pacientes completamente edêntulos

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ABSTRACT

Objective: To obtain the actual measurements of the posterior palatal seal area to assist in designing and fabricating a readymade posterior palatal seal for maxillary complete dentures. **Material and Methods:** Twenty-five completely edentulous patients were included in the present investigation, 13 females and 12 males with a mean age of 57.5 years. After making the definitive impressions and construction of the definitive casts, three-dimensional digital models of the maxillary completely edentulous arches were obtained with an intraoral scanner. The actual curved and linear line measurements of the posterior palatal seal area on the digital maxillary models were acquired with MEDIT LINK 3.0.4 software package. **Results:** There was a higher mean for the actual curved dimensions than the linear line dimensions. The design and fabrication of a readymade posterior palatal seal were accomplished depending on the percentage of difference (11.17%). **Conclusion:** The difference between the actual and the linear line measurements of posterior palatal seal area was used for designing and fabricating a readymade posterior palatal seal that could be used in the manufacturing of the complete denture.

KEYWORDS

Complete, denture; Dentists; Denture retention; Edentulous.

RESUMO

Objetivo: Obter as medidas reais da área do selamento palatino posterior para auxiliar no desenho e fabricação de um selamento palatino posterior pronto para próteses completas maxilares. **Material e Métodos:** Vinte e cinco pacientes completamente edêntulos foram incluídos no presente estudo, 13 do sexo feminino e 12 do sexo masculino, com uma idade média de 57,5 anos. Após a realização das impressões definitivas e a construção dos moldes definitivos, foram obtidos modelos digitais tridimensionais das arcadas maxilares completamente edêntulas com um scanner intra-oral. As medidas reais das linhas curvas e lineares da área de selamento palatino posterior nos modelos digitais maxilares foram obtidas com o pacote de software MEDIT LINK 3.0.4. **Resultados:** Verificou-se uma média mais elevada para as dimensões curvas reais do que para as dimensões da linha linear. O desenho e a confeção de um selamento palatino posterior pronto foram realizados em função da porcentagem de diferença (11,17%). **Conclusão:** A diferença entre as medidas reais e as medidas da linha linear da área do selamento palatino posterior foi utilizada para desenhar e fabricar um selamento palatino posterior pronto a ser utilizado na fabricação da prótese completa.

PALAVRAS-CHAVE

Dentadura completa; Dentistas; Retenção de dentadura; Edêntulos.

INTRODUCTION

The retention of the maxillary denture is one of the important properties necessary for the acceptance of a successful prosthesis for edentulous patients. Many factors influence this property including the anatomic characteristics of the edentulous ridge, adequate extension and fit of the denture base, arch form, impression materials and techniques, in addition to other aspects [1-3].

The denture base undergoes polymerization shrinkage, during processing, creating space between the intaglio surface and the palatal soft tissue in the posterior palatal seal (PPS) area. In addition, a gap may be generated due to movement of the palatal soft tissues in that area with loss of retention of the maxillary prosthesis. Therefore, a good border seal at the PPS area is necessary for maintaining maxillary prosthesis retention [4].

There are several methods used for preparing the PPS in the maxillary denture. The conventional technique involves carving of the PPS along the previously transferred vibrating lines from the patients mouth to the master cast. As for the physiological method, also known as the fluid wax technique, the PPS is done with mouth temperature impression waxes immediately after the secondary impression and before pouring of the master cast. In the selective loading impression technique, the post dam adaptation is done on the custom tray by green stick modeling compound during final impression making. While, the least accurate non-physiological technique is the arbitrary scraping of the cast in which the vibrating lines are determined by examining the patient's mouth and approximately marking the lines on the master cast [5].

The PPS of the maxillary denture at the posterior border has a major effect on the retention of the prosthesis and patient comfort. It is usually extended to the PPS area [5]. The PPS area is defines as "the soft tissue area at or beyond the junction of the hard and soft palates on which pressure, within physiologic limits, can be applied by a complete removable denture to aid in its retention" [6]. This pressure is a result of the PPS which functions to enhance the retention of the maxillary prosthesis. Also, the PPS strengthens the posterior section of the maxillary denture which can add to the previous attempts by researchers to enhance the strength of the denture base [7,8].

The location of the posterior border of the maxillary denture continues to be a highly debated issue, although most agree that the posterior border should extend to the vibrating line [5]. This line could be observed at the junction of the movable and immovable tissues of the soft palate and its location may vary according to the contour of the soft palate [9,10].

Determining PPS is a significant clinical step during maxillary denture manufacturing. Though, there is some hesitation by dentists concerning this aspect and pass this step onto the dental technician resulting in arbitrarily marking and carving the PPS on the cast [11].

Different types of PPSs were applied during different steps of complete denture construction. No design was superior over the other and they enhanced the retention irrespective of the design. In general, it was stated that the seal could be wider in areas more than in other areas and its width should be around 2 mm in the hamular notch area [12]. Also, the width in the midline should be no more than 2 mm [13]. In the literature, the butterfly pattern was the most common design advocated [7].

Previous studies suggested that the maximum depth of the soft tissues at the posterior border of the PPS area should be 1-1.5 mm decreasing to 0 mm at the anterior bounder. Others stated that the usual depth of the PPS area at its posterior border ranged from one to four millimeters and this depended on the total possible displacement of the tissues at certain points. In general, it was suggested that the maximum depth of displacement of the tissues for the PPS area should be no more than one-half to two thirds of this displacement [12-15].

Lim et al. [16] measured the palatal mucosal thickness in the PPS area of the maxillary edentulous arch by using computed tomography. They stated that the palatal mucosal thickness increased progressively towards the posterior border of the PPS area with different thicknesses lateral to the midline of the palate, increasing and decreasing. Their limitation was that the dimensions were taken in a flat plane and not according to the actual concave palate.

The first objective of this study was to calculate the actual curved measurement of

PPS area between the hamular notches passing through the vibrating line on the maxillary completely edentulous casts. The second objective was to calculate the percentage of difference in the length between the actual and the linear line measurements of the PPS area. The third objective was to design and fabricate the readymade PPS according to these actual measurements.

MATERIAL AND METHODS

The study was conducted from October 2022 to January 2023 at the teaching hospital in the Department of Prosthodontics, College of Dentistry according to the ethical approval project no. 358221, date: July 6, 2021. Twenty-five completely edentulous subjects were included in the present investigation. The age range for the participants was 40-70 years, 13 of which were females and 12 were males. They all were seeking for treatment of completely edentulous maxillary and mandibular arches. The total sample size needed was 12 according to G*Power 3.1 software program (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) and actual power equal to 0.97.

Patients who participated in the study had normal healthy mucosa and those with acquired and congenital craniofacial abnormalities, cleft palate, or any pathology of the oral cavity were excluded. Informed consents were given to the selected participants.

The definitive impression was made for the maxillary edentulous arch with an acrylic custom fabricated impression tray and zinc oxide eugenol impression material (Impression Paste, SS White Group, Gloucester, UK) [17]. After that, each participant was asked to open his/her mouth widely and directed to say the “ah” sound in a normal manner repeatedly during which an indelible pencil was used for registering the vibrating line [9]. This line was later transferred to the definitive impression after reinsertion into the mouth. From this impression the definitive cast was obtained and the vibrating line was transferred to the cast after pouring with dental stone type III (Elite model, Zhermack S.p.A., Rovigo, Italy). The casts were finally disinfected with HOCl acid disinfectant [18].

The twenty-five maxillary completely edentulous definitive casts were scanned with a three dimensional (3D) intraoral scanner (MEDIT i600, Medit, Seoul, South Korea) with a reported manufacturing full arch accuracy of 10.9 μm ± 0.98. The 3D data was dealt with in the MEDIT LINK 3.0.4 software package (Medit, Seoul, South Korea). Two main measurements were obtained, the first measurement was taken from a linear line drawn from the crest of the right hamular notch to the crest of the left hamular notch passing through a plane (Figure 1). The second measurement represented the actual curved length and was done by slicing the cast in an angle to pass through right to left hamular notch, and the curvature of the vibrating line.

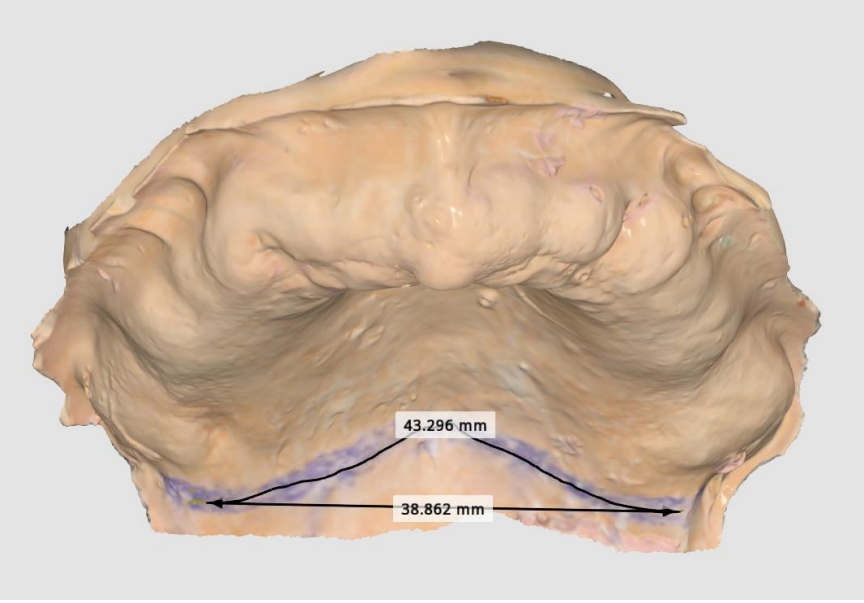

Figure 1 - Measurements of linear line and actual curved line passing through the vibrating line from right to left hamular notch on 3D scan of cast.

The length of this slice across the vibrating line of the palate from right to left hamular notch was measure. Three readings for the linear and curved lines were recorded for each cast to obtain a mean reading for each of the two measurements with a time interval of 30 minutes between each measurement [19].

The percentage of difference in length was calculated by the formulas [20] mentioned below (1 and 2) in which the mean of linear line measurement is represented by (M1) and the mean of actual measurements is represented by (M2).

$$percentage\,of\,difference = \left(\left(M2 - M1\right)\right) / M1\,x100 \qquad (1)$$

The estimated dimensions were obtained with the following formula [20] in which the percentage of difference is represented by (P) and the linear dimensions between the selected points presented by Lim et al. [16] presented in (L).

$$estimated\,dimension = \left(\left(L\right) / 100\,xP\right) + L \qquad (2)$$

The data was statistically analyzed with a statistical software program (IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.). The descriptive statistics used included the mean.

RESULTS

The means of the linear line measurements and the actual curved measurements between the crests of the hamular notches are shown in Table I. The higher mean was for the actual length while the lower was for the linear line length.

The percentage of difference in length was obtained from the above-mentioned formula. The result was an actual length more than the linear length by 11.17% for the distances between the hamular notches. The estimated dimensions were obtained from the previously mentioned formula (Figure 2) (Tables II and III).

The anterio-posterior dimensions, stated by Lim et al. [16], were maintained and there was no need to multiply with the percentage of difference in length for dimensions P – A0 and P- A1 (Table IV). The dimensions for P – A2 and P – A3 were determined from previous studies [9,13] because they were not mentioned by Lim et al. [16].

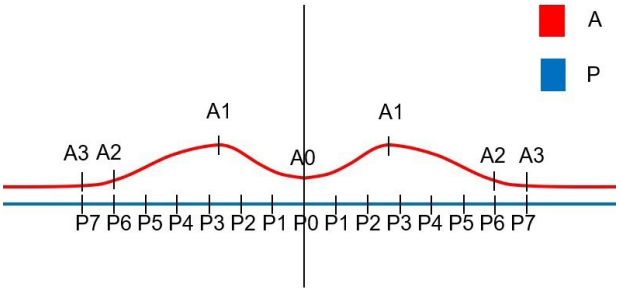

Figure 2 - Measurements for points on anterior border of PPS. A = anterior border; P = posterior border.

Table I - Mean values of the linear and actual curved dimensions for all participants

Treatment groups		N	Mean
Participants	Linear line (Total)	25	44.83
	Actual curve line (Total)	25	49.83

Table II - Conversion from average linear dimensions (mm) for anterior border of PPS area for right and left sides to estimated curved dimensions by 11.17%

	Distance from point to point		
	A0-A1	A0-A2	A0-A3
Linear dimension Lim et al. [16]	7.1	18.0	21.0
Estimated curved dimension	7.9	20.0	23.3

Table III - Conversion from average linear dimensions (mm) for posterior border of PPS area for right and left sides to estimated curved dimensions by 11.17%

	Distance from point to point						
	P0-P1	P0-P2	P0-P3	P0-P4	P0-P5	P0-P6	P0-P7
Linear dimension Lim et al. [16]	3.0	6.0	9.0	12.0	15.0	18.0	21.0
Estimated curved dimension	3.3	6.7	10.0	13.3	16.7	20.0	23.3

Table IV - Dimensions (mm) from posterior border to anterior border of the PPS area

	Dimensions from point to point			
	P-A0	P-A1	P-A2	P-A3
Linear dimensions	2	5	2	1.5

The suggested depth of the posterior border of the PPS (Table V) was obtained from half of the thickness of the mucosa [13].

These new dimensions were used for designing and fabricating a readymade PPS pattern. A silicone mold was constructed from the PPS pattern and the wax pattern was constructed by pouring molten base plate wax into the silicone mold. After cooling, the wax pattern was removed

Table V - Depth of posterior border of PPS area (mm), as labeled in Figure 2

Point	Average mucosa thickness of right and left sides Lim et al. [16]	Compressibility of ½ thickness of mucosa	Depth of the PPS
P0	4.32	2.2	2.0
P1	5.00	2.5	2.5
P2	6.00	3.0	3.0
P3	6.50	3.3	3.0
P4	6.10	3.1	3.0
P5	4.90	2.5	2.5
P6	3.80	1.9	1.5
P7	3.80	1.9	1.5

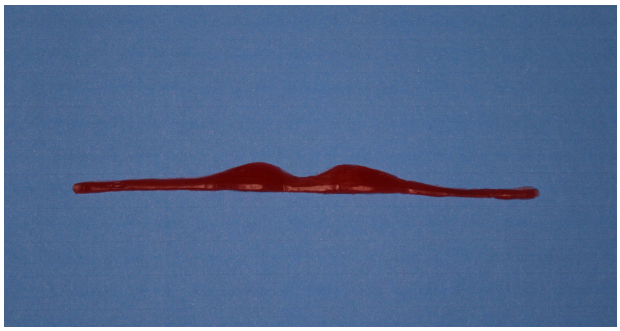

Figure 3 - Readymade PPS wax pattern.

from the silicone mold to obtain the readymade PPS (Figure 3). This pattern was suggested for use in the steps of construction of the maxillary complete denture.

DISCUSSION

The extent and design of the PPS affects the retention of the maxillary denture by compensating for the volumetric shrinkage of the acrylic resin and maintaining the denture-tissue interface [21-23]. The correct determination of the PPS location in addition to marking and carving the adequate depth and width is not the dental technician's responsibility, but it is the dentist's obligation [5,7]. However, the dentist's fear from loss of retention and denture failure were some of the reasons why this step was passed on to the dental technician [11]. Thus, there was a need for designing and fabricating a readymade PPS that could make this step easier for the dentist to overcome this problem.

There are several methods for achieving the PPS. Some are more beneficial than others, although each method has its drawbacks. The conventional method depends entirely on the experience of the dental practitioner and dental technician in determining the location and the dimensions. Their judgment plays a significant role in how deep and wide the PPS is carved on the casts. This is a great burden that some practitioners try to avoid. The fluid wax technique depends on the physiology to prevent compression of tissues and achieve good retention. However, this technique is time consuming and handling of material is not easy. To overcome the time consumption by the previously mentioned techniques, the Selective loading impression technique could be employed. This technique is less time consuming and easier for handling of materials used. Arbitrary scraping of cast technique may frequently develop a denture with the least accurate PPS that over compresses the palatal tissues [5].

A previous study by Lim et al. [16] was conducted to determine the dimensions and their relation to the thickness of the palatal mucosa. Their study was a 3D analysis of the thickness of the soft tissue at the PPS area. Although it was a 3D analysis study, they depended on three planes perpendicular to each other and mentioned as reference planes; coronal, sagittal, and horizontal plane. The distribution of the thicknesses was according to the distances between slices which were distributed in the horizontal plane in correspondence to the distances between the slices in anterior posterior direction and the medio-lateral direction. This resulted in 93 crossing points all in the horizontal plane. Thus, these dimensions were in a flat plane and not associated with the curved and concave palate. The thickness of the palatal mucosal in Lim et al. [16] was assessed according to the distance from the hamular notch and the midline in the horizontal plane. The mean thickness differed depending on specific sections of the PPS area. Thus, this present study converted these dimensions on the flat plane to the curved and concave palate to obtain the estimated dimensions needed for designing and constructing a readymade PPS that could be applied to the curved palate for the different mucosal depths at the different areas of the palate.

Previous researchers measured the distance between the hamular notches like Silverman [24] who accomplished this with a flexible metal or plastic millimeter ruler to the contours of the impression. His mean distance (35.8 mm) differed from that of this study (49.8 mm) in which it was smaller in length. The method of measurement differed and depended on the flexible rulers which

measured the distance on the impression with the possibility of space between the impression surface and the measuring ruler. In addition, the flexible ruler may have not been well adapted to the surface of the impression, unlike the method adapted by this present study which was more accurate and took the measurements exactly from the surface of the scanned maxillary casts. Also, the genetic variance imposes different anatomical variations between the participants of this study and those of the Silverman [24] study which may have played a role in such a large difference in the measurements [25].

The linear dimensions and the actual measurements of the PPS on the maxillary completely edentulous casts were different. An explanation for this could be the fact in physics that "the straight line is shorter in distance than curve line" [26]. Therefore, by precise calculation of the actual curved dimensions and thicknesses of the mucosa of the PPS area, more accurate and clinically effective readymade PPS could be designed and fabricated.

Lim et al. [16] studied the mucosal thickness of the PPS area and suggested the different depths of the mucosal tissue on the palate. Their measurements were presented from the midline of the palate moving laterally and from the posterior border moving anteriorly, but they stated all this in a flat plane. This study aimed to make use of these measurements and suggested a readymade PPS for the curved palate. Thus, the mucosal thickness was needed to be distributed to its exact areas by converting the measurements from a flat plane to a curved plane. These measurements that need conversion were those from the midline to the lateral of the palate. As for the measurements from the posterior to the anterior, they were relatively small and the differences between the linear dimensions in a flat plane with those actual curved dimensions was unnoticeable and would be clinically insignificant.

Several researchers discussed the compressibility of the mucosal tissues on the palate. Some stated that these tissues were compressible up to two third their thickness [14,15]. While, others stated that the compressibility was one-half the thickness [12]. This study depended on the one-half thickness compressibility because this would be safer and less traumatizing to the tissues. In addition, it was within most depths suggests by previous literature for the PPS in complete dentures ranging from about one to four millimeters [15].

The fabrication of a readymade PPS wax pattern from the previously suggested design could be included in the construction of conventional removable dentures after completion of the maxillary final impression. The vibrating line would be transferred from the palate of the patient to the final impression. Then, the readymade PPS wax pattern would be adhered along the vibrating line on the impression before pouring with dental stone to make the definitive cast. Thus, resulting in a definitive cast with the PPS previously incorporated in the cast without the need for carving by the dental practitioner or dental technician. It would also provide an accurate depth and width of the PPS with elimination of individual judgements and estimations.

CONCLUSION

The percentage of difference in length obtained from the difference in dimensions between the linear and actual curved dimensions for the PPS on the cast assisted in designing and fabricating a readymade PPS wax pattern. The newly designed and fabricated readymade PPS could be used to obtain a definitive cast with a properly incorporated PPS without any waste of time and effort by the dentist or the dental technician. Thus, the wax readymade PPS could be useful for application in the conventional steps for construction of a complete denture.

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Author's Contributions

BSK: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing, Visualization, Supervision, Project Administration, Funding Acquisition. SMA: Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing. TKJ: Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing.

Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

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Regulatory Statement

This study was conducted in accordance with the approval project no. 358221, date: July 6, 2021 obtained from the Research Ethics Committee of the College of Dentistry.

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