

Manometric Evaluation of Oral Pressures in Dentulous and Edentulous Patients: An *in vivo* Study

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ABSTRACT

Objectives: This *in vivo* study was done to provide reliable, substantial, diagnostic, and predictive data on perioral and tongue pressures in dentulous and edentulous subjects to aid in prosthodontic rehabilitation. This study had compared the oral pressures between the dentulous and edentulous subjects, and, thereafter, 3 months postinsertion of dentures in the same edentulous subjects and, thereby, established a normal range of perioral and tongue pressures in dentulous and edentulous patients.

Materials and methods: A total of 140 subjects were selected who satisfied the inclusion and exclusion criteria of the study, of whom 70 were assigned to dentulous and edentulous groups. The study measured the tongue pressures, left and right cheek pressures, and lip pressures of edentulous and dentulous subjects. The pressures produced by the tongue and perioral musculature were measured with a bulb probe connected to a digital manometer. Each reading was recorded for 30 seconds and from which maximum pressure was selected. These readings were recorded in standard values, i.e., Pascal.

Results: The study results were analyzed with Student's *t*-test and it was found that there is significant difference in oral pressures of edentulous and dentulous subjects ($p < 0.001$). The oral pressures of edentulous subjects were statistically compared with the same group after prosthetic rehabilitation for 3 months and revealed that there is significant increase in the oral pressures of edentulous subjects ($p < 0.001$).

Conclusion: The study showed that the tongue pressure of dentulous individuals is thrice that of edentulous individuals. The cheek pressures of dentulous individual showed a value, i.e., twice as that of edentulous individual. There is

only a slight difference in lip pressure between edentulous and dentulous subjects. There is significant increase in the oral pressures of edentulous subjects after 3 months of prosthetic rehabilitation. The study also found a definite range of oral pressures that may be used for diagnostic purpose in prosthetic rehabilitation.

Keywords: Manometer, Oral pressures, Tongue pressures.

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INTRODUCTION

The tongue and perioral musculature plays a crucial or central role in the functioning of the stomatognathic system. Their opposing, yet synergistic and balancing neuromuscular coordination is ubiquitous in daily functions of swallowing and mastication. The tongue also aids in the maintenance of proper dental alignment and arch stability¹ and plays an accessory role in upper airway patency during sleep.² Hence, measurement of tongue and perioral muscle pressure is useful for evaluating the biomechanical and neuromuscular performance of the tongue and may be predictive to assess the normal functional movements.

In prosthodontics, the success of a denture relies solely on its retention and stability. The tongue and perioral (cheek and lips) muscles constitute an important factor in stability of complete dentures.³⁻⁶ It has not, however, been identified as to what extent the force of the tongue and perioral muscles can directly influence the stability of dentures. Assessment of dislodgement forces on the denture worn by the patients shows a significant dependence on the tongue pressure and efficiency to maintain stability. In the past, most patients have become edentulous young enough to adapt well to complete dentures, even when their dentures departed from accepted standards of design. The clinical challenge now is that such loss occurs later in life when the patient's ability to develop the neuromuscular skills necessary to wear dentures successfully is reduced.

Most dental professionals accept the theory of neutral zone,⁵ which asserts that opposing forces or pressure

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from the lips and cheeks on one side and the tongue on the other determine the position of the teeth. The technical skills and protocol that the prosthodontist uses to assess these forces may determine the ultimate success of prosthodontic rehabilitation and treatment. Though modalities like neutral zone recording have attempted at harnessing these pressures to provide for denture stability, the assessment of such muscular pressures and the design of a predictive scale for such measurements are as yet wanting. Attempts have been made to record tongue and perioral muscular pressures by several methods, such as handheld balloon probe with manometer,⁷ handy probe,⁸ and Iowa oral performance instrument.⁹ To our knowledge, tongue and perioral pressures accuracy has not previously been studied in elderly edentulous individuals, particularly before and after wearing dentures. Hence, this study aims to record, assess, and compare the difference in oral pressures in dentulous and edentulous patients wearing complete dentures to provide reliability and substantial data for diagnostic and prosthodontic rehabilitation purposes.

MATERIALS AND METHODS

A total of 140 subjects were taken, of whom 70 were dentulous and 70 were edentulous (Graph 1). The subjects were taken randomly from the Department of Prosthodontics. The pressures produced by the tongue and perioral musculature were measured with a bulb probe and a digital manometer. The probe comprises a bulb as the pressure sensor made from medical-grade latex, which is connected to the digital manometer, and the readings were recorded directly on a computer via a universal serial bus (USB) cord. The armamentarium used for the study is shown in Figure 1. This probe has

the same physical properties and sensitivity as the model TPS-350 in a similar study done by Tsuga et al.⁷

There are three groups in this study, which are the dentulous group, edentulous group, and after 3 months of denture wearing in the same edentulous subjects. The measurement was recorded in pound per square inch (PSI) directly to the computer. These readings were converted to SI unit, i.e., kPa, by multiplying 6.894 to each reading as 1 PSI is same as 6.894 kPa. For each patient, disposable latex cover on the bulb was provided as sterilization procedure. Each reading was recorded for 30 seconds and from which maximum pressure was selected. For the measurements, the subjects were made to sit in a relaxed position and the bulb probe was placed in their mouth at four designated sites, i.e., on tongue, lip, and right and left cheek sites. In this study, oral pressures were taken.

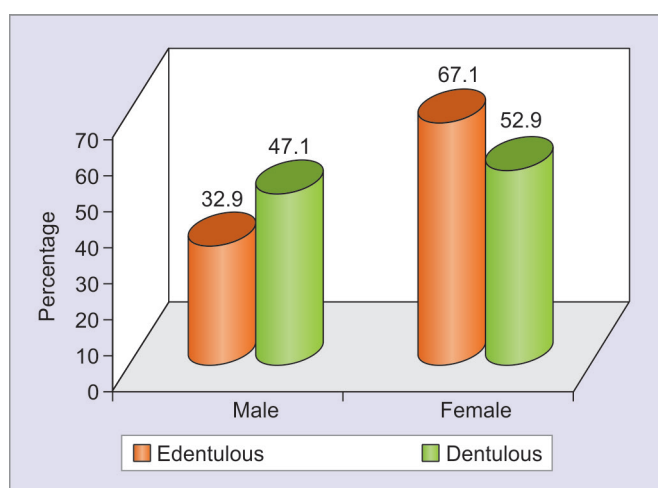
Methodology

Tongue Pressure

The tongue pressures or maximal tongue pressures were measured in dentulous and edentulous subjects by positioning the bulb above the tongue and patients were instructed to press the tongue onto the bulb with the lips in relaxed position. The subjects were then asked to protrude their tongue and compress the bulb (Fig. 2).

Cheek Pressure

In dentulous subjects, the balloon was positioned in the space between the upper and lower first molars and the buccal mucosa on one side. The subjects were then asked to close their lips and compress the bulb against the buccal surface of the molars. Similarly, other cheek sides were recorded (Fig. 3).



Graph 1: Comparison of distribution of patients selected for the study according to gender



Fig. 1: Armamentarium for recording oral pressures



Fig. 2: Compression of bulb for tongue pressure in edentulous subjects



Fig. 3: Compression of bulb for right cheek pressure in edentulous subjects



Fig. 4: Compression of bulb for lip pressure in edentulous subjects

In edentulous subjects, cheek pressures were assessed by placing the bulb of manometer between the ridges of edentulous arch and cheek on the other side. The subjects were then asked to close their lips and compress the bulb against ridges of edentulous arch.

Lip Pressure

In dentulous subjects, the balloons were centered in front of the upper central incisors to measure lip pressure. The subjects were then asked to close their lips and compress the bulb between the lips (Fig. 4). In edentulous subjects, lip pressures were assessed by placing the bulb of manometer in front of ridge of upper central incisors and patients were then asked to close their lips and compress

the bulb between the lips. The data derived were analyzed statistically by Student's t test (paired t test).

RESULTS

The distribution of subjects taken in the present study according to gender for dentulous is 33 males (47.1%) and 37 females (52.9%), and for edentulous is 23 males (32.9%) and 47 females (67.1%) respectively. On follow-up, after 3 months of prosthetic rehabilitation of edentulous patients, 12 patients did not report back to the department.

The methodology followed in this study derived the following results:

- The study found that there is significant decrease in oral pressure of edentulous when compared with dentulous subjects with mean \pm standard deviation (SD) of 2.4 ± 1.3 and 8.3 ± 3.3 respectively, in tongue pressure (Table 1), mean \pm SD of 2.3 ± 1.8 and 3.1 ± 0.9 respectively, in lip pressure (Table 2), mean \pm SD of 1.9 ± 1.3 and 5.2 ± 2.9 respectively, in left cheek pressure (Table 3), and mean \pm SD of 3.1 ± 3.7 and 4.5 ± 1.8 respectively, in right cheek pressure (Table 4).
- The oral pressures of edentulous subjects were statistically compared with the same group after wearing of complete denture prosthesis for 3 months and revealed that there is significant increase in the oral pressures of edentulous subjects ($p < 0.001$) (Tables 5 to 8).
- The study also found a range of oral pressures that may be used for diagnostic purposes in prosthetic rehabilitation, which are as follows:

Table 1: Comparison of tongue pressure between the edentulous and dentulous groups

	Edentulous	Dentulous
Mean \pm SD	2.4 ± 1.3	8.3 ± 3.3
Median	2.103	7.377
Minimum	0.758	4.274
Maximum	5.653	15.374

Table 2: Comparison of lip pressure between the edentulous and dentulous groups

	Edentulous	Dentulous
Mean \pm SD	2.3 ± 1.8	3.1 ± 0.9
Median	1.689	3.206
Minimum	0.758	0.965
Maximum	7.721	4.412

Table 3: Comparison of left cheek pressure between the edentulous and dentulous groups

	Edentulous	Dentulous
Mean \pm SD	1.9 \pm 1.3	5.2 \pm 2.9
Median	1.517	4.619
Minimum	0.827	0.965
Maximum	5.102	12.892

Table 5: Effectiveness of complete denture prosthesis on tongue pressure in edentulous group

Tongue	Mean	SD	n	Mean difference	Paired t	p-value
Pre	2.516	1.359	58	0.340	7.81*	p<0.001
Post	2.856	1.326	58			

*Significant at 0.01 level

Table 7: Effectiveness of complete denture prosthesis on left cheek pressure in edentulous group

Left cheek pressure	Mean	SD	n	Mean difference	Paired t	p-value
Pre	1.939	1.224	58	0.310	8.67*	p<0.001
Post	2.249	1.230	58			

*Significant at 0.01 level

Table 4: Comparison of right cheek pressure between the edentulous and dentulous groups

	Edentulous	Dentulous
Mean \pm SD	3.1 \pm 3.7	4.5 \pm 1.8
Median	1.724	4.619
Minimum	0.827	0.827
Maximum	14.477	8.686

Table 6: Effectiveness of complete denture prosthesis on tongue pressure in edentulous group

Tongue	Mean	SD	n	Mean difference	Paired t	p-value
Pre	2.516	1.359	58	0.340	7.81*	p<0.001
Post	2.856	1.326	58			

*Significant at 0.01 level

Table 8: Effectiveness of complete denture prosthesis on right cheek pressure in edentulous group

Right cheek pressure	Mean	SD	n	Mean difference	Paired t	p-value
Pre	3.093	3.735	58	0.351	8.82*	p<0.001
Post	3.443	3.743	58			

*Significant at 0.01 level

For dentulous subjects, the range of oral pressures are:

- Tongue pressure: 4.274–15.374 kPa
- Lip pressure: 0.965–4.412 kPa
- Right cheek pressure: 0.827–14.477 kPa
- Left cheek pressure: 0.965–12.892 kPa

DISCUSSION

As aging increases, deterioration of oral functions are identified, which induces dysphagia. Koshino et al.¹⁰ reported dysphagia in complete denture wearers, which is a critical life-threatening problem, as it might be due to lack of coordination between tongue and perioral muscles. Dentists, who are responsible for regaining oral function through prosthetic rehabilitation, should understand these coordinations, especially tongue pressures during mastication and swallowing, as they are likely to treat more patients with dysphagia in the elderly population.

The findings in this study concur with previous studies done by Robbins et al.,¹¹ Crow and Ship,⁹ Nicosia et al.,¹² Stierwalt and Youmans,¹³ and Utanohara et al.,¹⁴ particularly in relation to oral pressures with advancing age. The study also has found validated values of pressures of tongue and perioral muscles that have not been well documented in previous studies.

This study used a digital handheld balloon probe, which is similar to the device used in the studies conducted by Utanohara et al.¹⁴ and Tsuga et al.⁷ This device was useful in the study as the readings were directly transferred to the computer (via USB cord). Also, it

provided an accuracy of $\pm 0.3\%$ measurement of oral pressures as provided by the manufacturer.

This study attained a range of oral pressure values for dentulous group and edentulous group, which when compared showed that there is decrease in overall pressure in edentulous group ($p < 0.001$). But, when oral pressures of edentulous group are compared with the same group after replacement of teeth, a significant increase of oral pressure is attained. From this study, it could, therefore, be hypothesized that the rehabilitation of prosthetic denture for edentulous individuals has helped in regaining the oral functions and coordination of tongue and perioral pressures. These values of oral pressures of dentulous subjects were found to be comparable with the values found by Tsuga et al.⁷ The values of tongue pressure of edentulous subjects before prosthetic rehabilitation of complete denture were comparable with that found by Tamine et al.¹⁵ The study also showed that the tongue pressure of dentulous individuals is 3.46 times that of edentulous individuals. However, cheek pressures of dentulous individual demonstrate a value, i.e., 2.7 times as that of edentulous individuals. But notably, there is only a slight difference in lip pressure between edentulous and dentulous subjects. Quite interestingly, this study demonstrated a significant difference in right and left cheek pressures of each individual. This difference is much more obvious in the edentulous group, which might be attributed to the individual predominantly using unilateral patterns of mastication. Furthermore, the difference in the cheek pressure of edentulous subjects after 3 months shows a decrease, suggesting that

the individual might have attained an equal or bilateral pattern of mastication through dentures.

The prosthetic relevance of this study is that it has found a link between coordination in the neuromuscular functions of the oral cavity relating to the success of stable, complete denture prosthesis. The results of oral pressures in edentulous individuals, after 3 months of prosthetic rehabilitation, show an approximate equal balance between tongue pressure and the perioral pressures, which supports the concept of neutral zone. According to Fish,⁵ "neutral zone is the potential space between the lips and cheeks on one side and the tongue on the other, that area or position where the forces between the tongue and cheeks or lips are equal."

The limitations of the study were that the subjects were taken randomly according to subjects in need for prosthetic rehabilitation, the distribution of males to females in edentulous group was 23 males (32.9%) and 47 females (67.1%). Also the recall of edentulous subjects after prosthetic rehabilitation was 3 months, which could be included as limitation as these months are the adapting period of complete denture wearers. This could explain the slight differences in oral pressures. For further validating these findings, a continuous recall of subjects for recording of the oral pressures at regular intervals would be more illustrative and substantiated.

Moreover, the manometric evaluation of oral pressures provides isolated measurements of individual groups, which may be different from the measurements of oral pressures during masticatory cycles. However, within the limitation of the study, definitive conclusion related to the values of tongue and perioral pressures can be gleaned as diagnostic data. Hence, this study has recorded, assessed, and compared the differences in oral pressures in dentulous and edentulous wearing complete dentures and, thereby, provided a reliable and substantial data for diagnostic and prosthodontic rehabilitation purpose.

CONCLUSION

In this study, it can be concluded that the balance of oral pressures, such as tongue, lip, and cheek pressures are significantly important for the proper functioning of complete dentures. Also, it validates Fish theory of neutral

zone, which is the fundamental of stability of complete denture. Furthermore, the values of oral pressures can be used as diagnostic and prosthodontic rehabilitation data in prosthodontics.

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