

# A comparative analysis of salivary factors and maxillary denture retention in different arch forms: An *in vivo* study

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## Abstract

**Aims:** This study aims to find the effect of change in different salivary factors before and after complete denture insertion and to measure the maxillary denture retention in different arch forms.

**Materials and Methods:** Thirty completely edentulous individuals (10 each of square, tapered, and ovoid arch form of maxilla) belonging to the age group of 40–70 years were selected. Salivary factors (flow, density, pH, viscosity, and total protein) were evaluated before and after denture insertion. Retention of maxillary denture was measured in all the different arch forms.

**Statistical Analysis:** Student's independent sample's *t*-test was applied. The correlation was analyzed by Pearson's correlation analysis.

**Results:** While mean flow rate and pH of saliva increased, mean viscosity, total protein, and density of saliva decreased after maxillary complete denture insertion. A positive correlation was found between retention and total maxillary basal surface area. Retention value was found to be greatest in square type and least in tapered type.

**Conclusions:** Complete denture acts as a mechanical stimulant thus increasing flow rate and pH immediately after complete denture insertion. Density, total protein, and viscosity of saliva decreased after complete denture insertion which may be due to increase in water content of saliva. The retention of maxillary complete denture does not seem to depend on the rate of change of the salivary factors, before and after complete denture insertion. Total basal surface area and maxillary denture retention values were highest in square arch form and least in tapered arch form.

**Keywords:** Complete denture, edentulism, retention, saliva, viscosity

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## INTRODUCTION

Saliva, an oral fluid, is often neglected and ignored by physicians and dentists. It is critical for retention of dentures and provides comfort while wearing removable prostheses. It has been defined as “a clear, tasteless,

odorless, slightly acidic, viscous fluid, consisting of secretions from the parotid, sublingual, submandibular salivary glands, and mucous glands of the oral cavity.”<sup>[1]</sup>

Among the physical factors that influence denture retention are (1) adhesion and cohesion, (2) negative atmospheric

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pressure under the denture, (3) capillarity, and (4) the viscosity of saliva.<sup>[2]</sup>

Retention of denture not only depends on physical factors but is also related to the flow of saliva. The composition of saliva varies greatly in different individuals and in the same individual under different circumstances and stimulations.<sup>[3]</sup>

The total protein content of human saliva averages about 300 mg/ml, but may vary widely. Total protein content may affect density, flow, and pH of saliva and may thus affect retention of denture. Saliva is usually acidic in pH (6.02–7.05); on standing or boiling, it loses CO<sub>2</sub> and becomes alkaline.<sup>[4]</sup>

The ratio of the basal seat area of the ridge to the basal seat area of the palate in the maxilla has been measured by Luthra.<sup>[5]</sup> The purpose of this study was to determine the flow rates, amount, pH, viscosity, and the total protein content of unstimulated whole saliva, before and after prosthetic treatment in complete denture wearers. Denture retention and basal surface area were measured in different arch forms (square, tapering, and ovoid) of the maxilla. An apparatus based on the principle of “force application at right angle to the denture base to evaluate denture retention” as stated by Skinner and Chung was used to measure the value of denture retention.<sup>[6]</sup> To activate accurate dislodging force, “spindle-handle mechanism” was also incorporated in the apparatus as stated by Kumar and Thombare in their study.<sup>[7]</sup>

## MATERIALS AND METHODS

### Inclusion criteria for patient

Thirty completely edentulous individuals (10 each of square, tapered, and ovoid arch form in the maxilla) of age group 40–70 years were selected. Individuals with severe bilateral undercuts and having arch size either very small or very large were not included in the study.

### Exclusion criteria

- Where the period of edentulism of the patient was <1 year
- Severely resorbed ridges
- Individuals having loss of neuromuscular control, for example, patients suffering from CNS disorders and parkinsonism.
- Presence of tori
- Presence of flabby tissue
- Severe undercut
- Individuals on any medication which alters salivary factors

- Patients on radiotherapy
- Diabetic patients.

Salivary factors (flow, density, pH, viscosity, total protein) were evaluated before and after denture insertion. Retention of maxillary denture was measured in different arch forms (square, tapered, and ovoid).

### Flow rate

Flow rate was measured by the following formula:

Salivary flow rate =

$$\frac{\text{Total volume of saliva collected}}{\text{Collection period}} = \dots \text{ml/min}$$

### Viscosity

Kinematic viscosity of saliva was measured using “Ostwald type” [Figure 1b] of glass viscometer. Viscosity coefficient of liquid according to Ostwald is:

$$\eta_1 = \frac{\rho_1 \times t_1 \times \eta_2}{\rho_2 \times t_2} = \dots$$

Poise

$\eta_1$  = Viscosity coefficient of saliva

$\eta_2$  = Viscosity coefficient of water at 20°C (0.01 C. G. S. Unit)

$\rho_1$  = Density of saliva

$\rho_2$  = Density of water (1 g/c. c)

$t_1$  = Time taken to reach saliva from upper mark of tube to lower mark

$t_2$  = Time taken to reach pure water from upper mark of tube to lower mark.

pH – pH was measured using digital pH meter (“Hanna Digital pH Meter”) [Figure 2] of each sample collected by the above method.



**Figure 1:** (a) Collection of saliva by spitting method (b) Ostwald viscometer tube with stand

### Total protein content

Total protein content was measured using “spectrophotometer” in g%. Autozyme total protein kit was used to measure total protein content. Salivary protein estimation was done based on the biuret method. Protein forms a colored complex with cupric ions in alkaline medium. Based on this principle, salivary protein estimation was done by mixing undiluted saliva with the reagent (45 g of Rochelle salt and 15 g of copper sulfate in 400 mL of 0.2 N sodium hydroxide) to form a colored complex. Five grams of potassium iodide was added to make up to 1 L with 0.2 N sodium hydroxide. Total protein content in colored product formed was measured using a photoelectric colorimeter at a wavelength of 546 nm. Standard solution of 6 g of bovine albumin dissolved in 100 mL of normal saline containing 0.1 g/dl sodium azide was used.<sup>[8]</sup>

Different arch forms were analyzed and measured by the method used by Kawabe [Figure 3]<sup>[9]</sup>

1. Square arch form - Where the distance between canines is wider and posterior ridge are more parallel than the other types, and in addition, the curvature of anterior ridge is mild
2. Ovoid arch form - Where the distance between the canines is narrower and the curvature of the anterior ridge is more than square arch form
3. Tapering arch form - Where the distance of canines is narrower and the curvature of the anterior arch is more severe than other arches.

Elastomeric impression material of putty consistency was adapted over the master cast in a thin layer. After complete polymerization, the impression material was removed from the cast and ensured that there was no distortion. The impressions of the colored lines on the cast were reproduced in the elastomeric base. Graph paper marked in tenths of a centimeter was used for making the measurements. The two parts of the ridge and the palatal portion of the set elastomeric impression were lightly pressed on the graph paper. The outlines of each part were drawn on the graph paper.

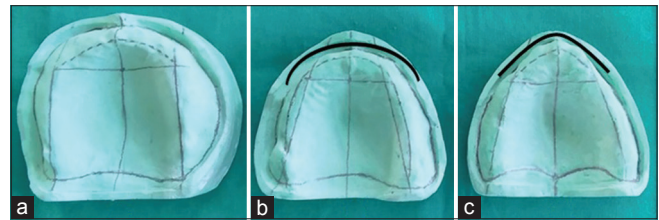
The squares included in each outline were counted three times to minimize the counting error. From the average number of squares, the basal seat area of the impressions was calculated in square centimeter. The combined averages calculated for the two parts of the impression gave the total basal seat surface area.<sup>[10]</sup>

### Apparatus for measuring retention

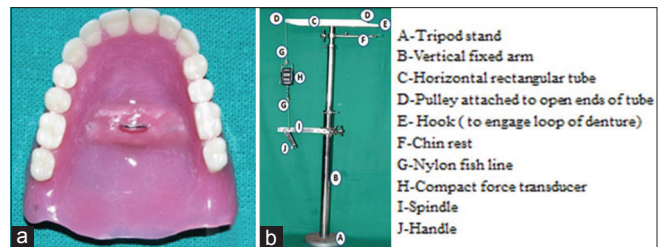
Specially designed apparatus [Figure 4b] based on the principle stated by Skinner was fabricated and was used to



**Figure 2:** Instruments used in the study for measurement of salivary factors



**Figure 3:** Different arch forms of maxilla (a) square, distance between canines is wider and posterior ridges are more parallel; (b) ovoid, distance between the canines is narrower and the curvature of the anterior ridge is more; (c) tapered, distance of canines is narrower and the curvature of the anterior arch is very severe



**Figure 4:** (a) Maxillary complete denture with hook (b) Specially designed apparatus to measure retention with description

measure the values of denture retention for each maxillary base.<sup>[11]</sup> The selected individual was positioned on a chair and was advised to rinse his or her mouth with water, for cleaning the deposits and mucoid secretions. The wet denture base was then firmly seated over the foundation and was kept in position for 2 min. The individual’s head was positioned, keeping the Frankfort horizontal plane parallel to the floor using a cephalostat. The apparatus was then adjusted vertically at the required height and horizontally for locating the hook of nylon fishing line perpendicular to the loop fixed at the center of the palatal portion of denture base. The chin support was adjusted in a vertical and horizontal direction.

The wire loop attached at the center of the denture base [Figure 4a] was then engaged by wire hook of nylon fishing line. A dislodging force was then created and applied at a right angle to the denture base by rotating the handle in a clockwise



direction. Each time, half a turn was given till such a time that the individual experienced a stretching force. The intensity of force was then increased slowly by giving a quarter turn to the handle, and then, slow rotation was given till the denture base dislodged from the foundation. The readings recorded in compact force gauge transducer (gram) were the values of retention. Similar procedure was followed to obtain the values of retention of all the maxillary dentures.

**Statistical analysis of data**

For statistical analysis, data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS 20.0.1 and GraphPad Prism version 5 (IBM). Student’s independent sample’s *t*-test was applied to compare normally distributed numerical variables. The correlation was analyzed by Pearson’s correlation analysis. Once a *t* value was determined, a *P* value was found using a table of values from Student’s *t*-distribution. If the calculated *P* value was below the threshold chosen for statistical significance (usually the 0.10, 0.05, or 0.01 level), then the relationship between two groups was considered statistically significant.

**RESULTS**

Difference between means of flow rate, viscosity, pH, total protein, and density of saliva before and immediately

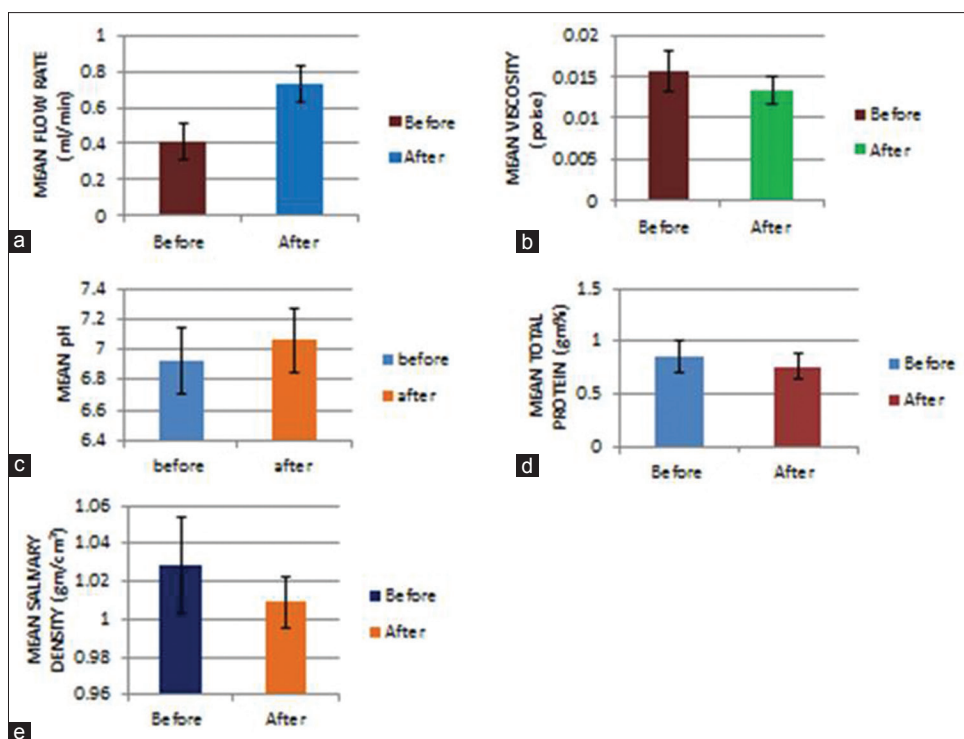
after maxillary complete denture insertion was found to be statistically significant [Table 1]. Mean viscosity, total protein, and density of saliva after maxillary complete denture insertion significantly decreased as compared to before insertion of complete denture [Graph 1b,1e]. A significant increase in pH value and flow rate was also present [Graph 1c]. A negative correlation was found between retention and difference in salivary flow rate, viscosity, and total protein, and the *P* value was found to be nonsignificant (*P* > 0.05). A positive correlation was found between retention and difference in salivary pH and density, and the *P* value was found to be nonsignificant (*P* > 0.05). A positive correlation was found between retention and total maxillary basal surface area [Graph 2 a,b,c]. The value of correlation coefficient (R) and coefficient of determination (*R*<sup>2</sup>) was found to be 0.7101 and 0.5042, respectively, which was closer to 1. This means that the two variables are closely correlated. The *P* value was found to be <0.0001 which shows that result is significant. Mean basal surface area and retention value in different arch forms were also calculated. The mean (mean ± standard deviation) value of total surface area in tapered, square, and ovoid were found to be 24.7240 ± 2.1596, 31.1090 ± 3.8803, and 26.0700 ± 2.7362, respectively. The difference of mean retention between ovoid, square, and tapered arch was statistically significant [Table 2].

**Table 1: Means of various salivary factors before and after maxillary complete denture insertion**

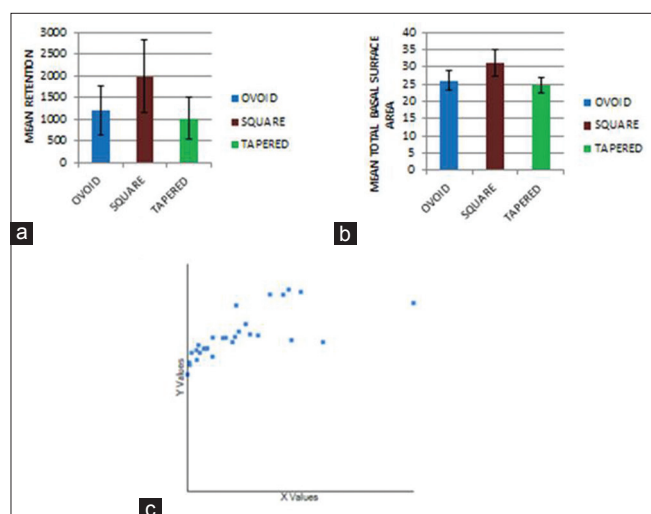
Group	Number	Mean	SD	Minimum	Maximum	Median	<i>P</i>
<b>Means of salivary flow rate (ml/min) before and after maxillary complete denture insertion</b>							
Before	30	0.4098	0.1011	0.2750	0.7070	0.3610	<0.0001
After	30	0.7328	0.1017	0.5250	0.8800	0.7610	
<b>Means of salivary viscosity (Poise) before and after maxillary complete denture insertion</b>							
Before	30	0.0157	0.0024	0.0119	0.0214	0.0157	<0.0001
After	30	0.0134	0.0016	0.0118	0.0171	0.0124	
<b>Means of salivary pH before and after maxillary complete denture insertion</b>							
Before	30	6.9270	0.2125	6.6200	7.4500	6.9000	0.0141
After	30	7.0650	0.2099	6.7300	7.6200	7.1000	
<b>Means of salivary total protein (gm%) before and after maxillary complete denture insertion</b>							
Before	30	0.8526	0.1503	0.6150	1.2850	0.8350	0.0157
After	30	0.7659	0.1174	0.5720	1.0000	0.7690	
<b>Means of salivary density (gm/cm<sup>3</sup>) before and after maxillary complete denture insertion</b>							
Before	30	1.0288	0.0255	1.0020	1.0980	1.0210	0.0005
After	30	1.0092	0.0135	1.0000	1.0500	1.0020	

**Table 2: Distribution of mean retention and total basal surface area in three groups**

<b>Distribution of mean retention (gram) in three groups</b>							
Group	Number	Mean	SD	Minimum	Maximum	Median	<i>P</i>
Ovoid	10	1206.30	568.0155	681.00	2700.00	1034.50	0.0059
Square	10	1985.10	838.7278	953.00	4066.00	1810.00	
Tapered	10	1019.90	485.0841	654.00	2226.00	808.00	
<b>Distribution of means total basal surface area (square cm) in three groups</b>							
Ovoid	10	26.0700	2.7362	22.7200	32.7300	25.7550	0.0001
Square	10	31.1090	3.8803	25.2500	35.5300	31.3200	
Tapered	10	24.7240	2.1596	20.6000	27.2000	25.0100	



**Graph 1:** Means of saliva (a) flow rate (b) viscosity (c) pH (d) total protein (e) density before and after maxillary complete denture insertion



**Graph 2:** Mean of (a) retention (gram) (b) mean total basal surface area (cm<sup>2</sup>) in three groups (c) scattered diagram showing correlation between maxillary denture retention (X-axis) and total maxillary basal surface area (Y-axis)

## DISCUSSION

Saliva is critical for the maintenance and function of all the tissues in the mouth. It fosters and protects the integrity of soft and hard oral tissues and supports important oral functions. Situations that disturb salivary production or its composition have broad negative sequelae in the mouth and may result in systemic complications.<sup>[8]</sup>

A wealth of evidence suggests that saliva plays a profound role in the maintenance of oral health in the denture-wearing patient. Indeed, the presence of a thin salivary film layer is essential to the comfort of the mucosa beneath a denture base and to denture retention.<sup>[6]</sup>

Resting whole saliva was collected and obtained in basal conditions between 9:00 and 11:00 am, to minimize changes due to circadian variations. Dawes (1972) found that salivary flow rate was more consistent during the timing which was included in this present study.<sup>[12]</sup> Maheshwari *et al.* also supports this timing of saliva collection.<sup>[13]</sup>

Navazesh and Christensen supported spitting method [Figure 1a] of salivary collection and concluded that it appeared to be the most reproducible method to collect saliva.<sup>[14]</sup>

Complete denture acts as a mechanical stimulant thus increasing the salivary flow rate immediately after complete denture insertion [Graph 1a]. Yurdukuru and Terzioglu in their study concluded that initial insertion of the complete denture significantly stimulated the salivary flow rate and it was also found that there was a significant difference in resting whole salivary flow rates obtained before ( $0.336 \pm 0.015$ ) and after ( $0.848 \pm 0.034$ ) denture insertion.<sup>[2]</sup> Maheshwari

*et al.* also found that there is a significant difference in the resting and stimulated salivary flow rate before and after denture placement. They also mentioned that complete denture acts as a mechanical stimulant and continues to be so, even after 2–3 months thus increasing the salivary flow rate.<sup>[13]</sup>

Schroeder showed by statistical analysis that the difference in viscosity between first and second measurements of the same salivary sample was due to chance only and that the viscosity of mixed unstimulated saliva under experimental conditions was relatively stable for the first 5–8 min after collection.<sup>[15]</sup> In the present investigation, it was decided to measure viscosity of saliva immediately after collection so that value of viscosity remains nearly constant for individuals.

The decrease in salivary viscosity after denture insertion may be due to decrease in total salivary protein content and increase in salivary flow rate. Östlund (1960) using “Ostwald’s viscometer” determined the viscosity of filtered saliva of 9 individuals. The more viscous of these saliva indicated no increased prosthesis retention in a model experiment, rather the opposite tendency was suggested.<sup>[16]</sup> Rathje and Fröhlich (1951) studied the connection between caries incidence and the saliva’s viscosity and rate of secretion.<sup>[17]</sup> The viscosity was evidently determined with a viscometer of the “Ostwald type.” The increased viscoelasticity of whole saliva in the elderly may result from a reduction in salivary watery content, which results in increased salivary protein concentration, as previously shown in similar conditions (Nagler, 1997).<sup>[18]</sup>

Yurdukuru and Terzioğlu also observed a significant difference in resting whole salivary pH obtained before ( $7.45 \pm 0.54$ ) and after ( $7.62 \pm 0.48$ ) complete denture insertion ( $P < 0.01$ ).<sup>[2]</sup> Maheshwari *et al.* also observed a significant difference ( $P < 0.001$ ) in the pH determined in resting the whole saliva before ( $7.377 \pm 0.063$ ) and after ( $7.498 \pm 0.054$ ) complete denture insertion, but no significant age group-related variations were observed. This increase in pH value may be due to decrease in salivary total protein content and increase in water content of saliva.<sup>[13]</sup> The results obtained in the present study are consistent with studies done by Mandel, 1974.<sup>[20]</sup>

Difference between means of salivary total protein before and after maxillary complete denture insertion was found to be significantly decreased [Graph 1d]. In general, the major factors affecting the protein concentration and composition of whole saliva are the salivary flow rate, protein contributions of the glandular saliva, and crevicular

fluid proteins. The results obtained are consistent with studies by Vibhakar *et al.*, 2013.<sup>[21]</sup>

Yurdukuru and Terzioğlu found no significant difference in the density of saliva related to the insertion of complete denture for both resting and stimulated salivary secretion.<sup>[2]</sup> The results obtained are consistent with studies conducted by others.

Many efforts have been made to explain how a complete denture can be retained in the mouth. Ambler states that Fuller first mentioned the word adhesion and described it as a means of holding upper dentures in place.<sup>[22]</sup> Wilson added the factors of cohesion and atmospheric force to adhesion, calling these three the primary retaining factors.<sup>[23]</sup> Boucher agreed but said that close adaptation of the denture to the mucosa is essential to the effectiveness of the forces.<sup>[24]</sup> Other authors believe that a thin fluid film between the denture and mucosa is necessary for the best retention.

Campbell presented some evidence that apparently contradicted this finding when he compared clinical retention in the presence of a fluid film and in the absence of one. He found that retention was increased when the mucosa and denture were wiped dry and saliva was inhibited with atropine sulfate.<sup>[25]</sup> Östlund reported findings which were opposite to Campbell’s findings. He found more retention when the salivary flow was stimulated with drugs than when it was inhibited.<sup>[16]</sup> These contradictory results were difficult to explain in these studies. One basic point of difference was of dislodgment force which was directed cranially in Östlund’s study whereas directed caudally in Campbell’s study.<sup>[16,25]</sup>

Retention was measured with the approach followed by Skinner and Chung.<sup>[6]</sup> They compared the effect of surface contact on retention of dentures in the laboratory. They found that the addition of a posterior palatal seal and a border seal increased retention. However, the addition of relief areas decreased retention regardless of other factors. Skinner *et al.*<sup>[11]</sup> later did a study of the same type from a clinical approach and found similar results. Here also, the dislodgment force was applied in a caudal direction.

Retention value was found to be greatest in square type and least in tapered type. The ratio of the basal seat area of the ridge to the basal seat area of the palate in maxillae had been measured by Luthra.<sup>[5]</sup> However, the maxillary and mandibular basal seat areas (ridge and the palate) have not been measured according to arch shapes. According to Watt, the mean denture-bearing area was found to be 22.96 cm<sup>2</sup> in the edentulous maxillae and 12.25 cm<sup>2</sup> in the edentulous

mandible.<sup>[26]</sup> It was suggested that the mean denture bearing area in the edentulous maxilla was approximately 2 times greater than the area of the edentulous mandible. However, this is not an evaluation according to the vault forms. Ihsan and Nuran (2005) found that the mean denture-bearing area in the edentulous maxilla was approximately 1.7 times greater than the area of the edentulous mandible.<sup>[10]</sup> Here, a positive correlation was found between retention and total maxillary basal surface area. The results obtained in this study are consistent with studies done by others.

### Limitations of this study include

- Both mechanical and enzymatic destruction rapidly reduce the viscosity of saliva almost to that of water; therefore, very less time for measurement of viscosity was present
- Saliva considered was of mixed type. Saliva can be serous, mucous, or mixed type; therefore, salivary factors might vary according to the type of saliva
- Relation of retention and basal surface area has been described, but retention of denture also depends on the amount and type of undercut present. The variable of undercut has not been considered for maxillary denture
- Retention of maxillary complete denture has been measured by applying force in caudal direction, i.e., away from denture base area. However, during physiological functions, the forces applied to the dentures are mostly in the direction toward the basal surface area.

### CONCLUSIONS

Within the limitations of the study, the following conclusions can be drawn:

- Complete denture acts as a mechanical stimulant thus increasing the salivary flow rate immediately after complete denture insertion
- pH of saliva increased significantly immediately after complete denture insertion
- Density of whole saliva, total protein content, and viscosity of saliva decreased after complete denture insertion due to increase in water content of saliva
- In between the individuals, the rate of change of the salivary factors before and after complete denture insertion does not influence the value of retention. This means individuals with lesser rate of change in factors might have more value of retention and vice versa
- Total basal surface area and maxillary denture retention value are highest in square arch form and least in tapered arch form

- Retention of maxillary complete denture depends directly on the basal surface area.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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