DOI: 10.7860/JCDR/2025/74149.21876

Original Article

Dentistry Section

Combinations of Arch Forms, Palatal Vaults and Posterior Palatal Seal in Completely Edentulous Patients: A Cross-sectional Study

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ABSTRACT

Introduction: Complete dentures have been, and remain, a cornerstone for the treatment of edentulous patients. To achieve success with complete dentures, it is essential to evaluate the anatomic landmarks that support and restrict them in the maxilla. A denture that is properly adapted to the denture area, with the correct width, shape, and extension of denture borders, as well as an adequate Posterior Palatal Seal (PPS) and polished and occlusal surfaces located in the neutral zone, may prevent loss of retention. In a denture, the border seal in the posterior region is created by making the impression of the PPS.

Aim: To assess the various combinations of Arch Forms (AF), Palatal Vault (PV) forms, and PPS in the population of West Bengal.

Materials and Methods: An cross-sectional study was conducted on a total of 32 patients who fulfilled the inclusion criteria from the Outpatient Department (OPD) of the Department of Prosthodontics and Crown and Bridge at Guru Nanak Institute of Dental Sciences and Research in Panihati, Kolkata, India, from October 2017 to March 2018, using elastomeric impression material, to assess the combinations of AFs, PVs, and PPS in completely edentulous patients. A body sensor scanner was employed to scan the maxillary casts with a rotating device to compare the combinations. The Netfabb 4.9 software was used for digital sectioning of the casts. A Contouroscope was utilised to mark the deepest concavity of the palate, and an Iwanson gauge was used for measuring the PPS.

Results: The most prevalent AF found was the ovoid AF (46.9%). The most prevalent PV form was the medium U-shaped vault form (65.6%). After evaluating the different combinations, it was found that the most prevalent combination was combination 14 (tapered AF, medium U-shaped PV form, and class III PPS form).

Conclusion: This study establishes the various existing combinations of arch shape, PV, and PPS. These findings could serve as a guide for future diagnosis and treatment planning, helping to anticipate the combinations of AF, PV form, and PPS form.

Keywords: Denture base, Complete denture, Occlusal surface

INTRODUCTION

Oral diseases are progressive and can contribute to functional difficulties, such as chewing, swallowing, and social interaction. Some consequences of oral disease, such as tooth loss, denture wearing, caries, periodontal conditions, xerostomia, and cancer, are very common in the elderly [1]. Several other factors influence adult oral health, including socioeconomic status, literacy level, tobacco use, and alcohol consumption [2]. Complete dentures are not a replacement for natural teeth, but they have been and continue to be the primary treatment for patients missing all of their teeth. There have been significant advancements in the field of complete denture prosthodontics over the past century [3].

The success of complete dentures depends greatly on the interaction between the denture and the supporting anatomical structures. If the denture bases are not accurately adapted, or if the thickness, shape, and extension of denture flanges are incorrect, it can result in loss of retention. Similarly, failure to establish a proper PPS and to ensure that the polished and occlusal surfaces are located correctly may also lead to problems. In a maxillary denture, the posterior border seal is created by developing a PPS. It's important to note that many dentures have failed due to improper establishment of the distal palatal length and the lack of a PPS [3].

A satisfactory complete denture must fulfill the four basic requirements of aesthetics, efficiency, comfort, and retention. Retention is the factor that is most often neglected, but most complete denture patients adjust and return to normal function after a post insertion practice period lasting several days to several weeks [4].

Previous research has indicated that the authors have mainly concentrated on the anatomy and its relationship to the retention of complete dentures [5]. However, no study has attempted to establish the most prevalent combinations of AF, PV forms and PPS forms using digital measuring devices. The success rate of complete dentures is primarily established by their retention, which largely depends on the anatomical features of the arches. Therefore, this research aims to identify the most common combinations of AFs, PV forms, and PPS forms in the population of West Bengal, leading to the improved success rate of maxillary dentures delivered to the community.

MATERIALS AND METHODS

The cross-sectional study was conducted on a total of 32 patients who fulfilled the inclusion criteria from the Outpatient Department (OPD) of the Department of Prosthodontics and Crown and Bridge at Guru Nanak Institute of Dental Sciences and Research, Panihati, Kolkata, India, during October 2017 to March 2018. The study was carried out after obtaining clearance from the ethical committee (GNIDSR/IEC/2016-11). The sample size of 32 was selected based on convenience sampling.

Inclusion and Exclusion criteria: The subjects includes who were completely edentulous individuals aged between 40 and 70 years,

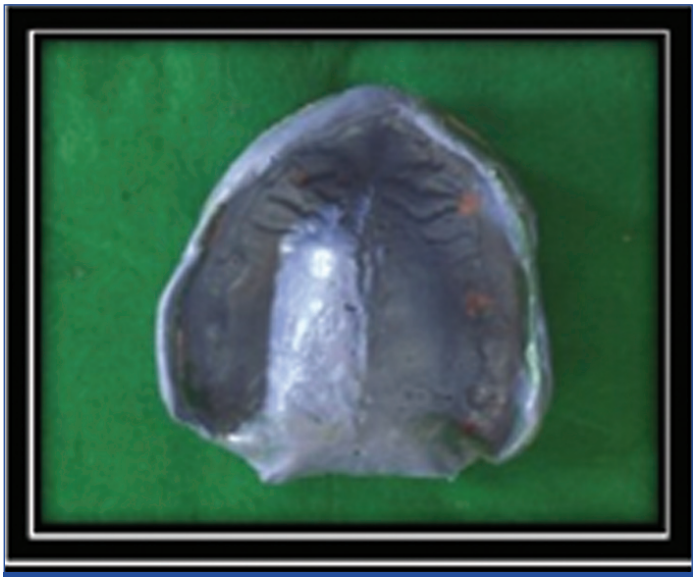
with square, tapering, or ovoid AFs. They were recruited for the study from the Department of Prosthodontics and Crown and Bridge, GNIDSR. The exclusion criteria included patients with a period of edentulism of less than one year, severely resorbed ridges, loss of neuromuscular control (e.g., patients suffering from CNS disorders, Parkinsonism, etc.), presence of tori, presence of flabby tissue, severe undercut, subjects on any medication that alters salivary factors, subjects undergoing radiotherapy, and diabetic patients.

Study Procedure

After the sample selection, each individual was seated upright in the dental chair. Maxillary primary impressions of each subject were made with impression compound (Pyrex, Uttarakhand, India) using a stock edentulous non perforated impression tray (Khatri & Co., West Bengal, India). The primary impressions were poured with Type II gypsum product (BN Chemicals, West Bengal, India), and the primary casts were obtained. A special tray was fabricated using the conventional method with cold cure acrylic (DPI, Maharashtra, India) and modeling wax (Pyrex, Uttarakhand, India).

Relief was provided in the wax spacer design in the PPS area, combining Boucher and Sharry's wax spacer designs for the maxillary arch. Four tissue stops, measuring 4 mm × 4 mm, based on Boucher and Sharry's design, were marked in the canine and first molar regions [6]. The sectional method was employed for border molding using a low fusing compound (DPI Pinnacle tracing stick, Bangalore, India). Border molding commenced at the labial borders and moved towards the buccal vestibules bilaterally to capture the buccal frenum and labial frenum. Following this, the border seal was obtained by recording the PPS using the Valsalva Maneuver method [6].

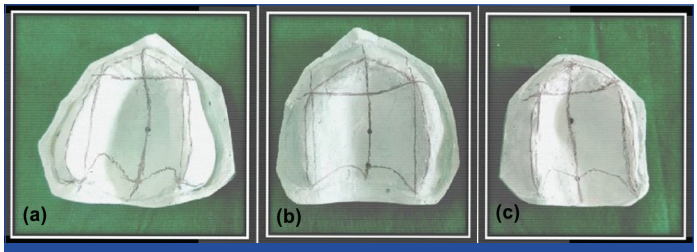
After border molding, the wax was removed from the intaglio surface using a Lecron carver. A tray adhesive (3M Espe, Bangalore, India) was then lightly applied with an applicator brush, and the impression was taken using polyether impression material (3M Espe, Bangalore, India) [Table/Fig-1]. Beading and boxing (using beading and boxing wax from MAARC, Thane, Maharashtra, India) of the impressions were completed before pouring them with Type III gypsum product (dental stone) (BN Chemicals, West Bengal, India) to avoid distortion and dimensional changes.



[Table/Fig-1]: Final impression.

Determination of the Arch Forms (AF): After the casts were obtained, the different AFs were determined by the classification given by Kawabe S [7]. Lines were drawn with a HB lead pencil on the cast from the canine area to the posterior region along the crest of the ridge. Another line was drawn from one side of the canine region to the other side along the anterior crest. The AF was classified as:

- **Tapered Arch Form (AF):** The distance between the canines is narrowest, and the curvature is more severe than in other AFs [Table/Fig-2a].
- **Square Arch Form (AF):** The distance between the canines is wider, the posterior ridges are more parallel than in other types of AFs, and the curvature of the anterior ridge is mild [Table/Fig-2b].
- **Ovoid Arch Form (AF):** The distance between the canines is narrower, and the curvature of the anterior ridge is greater than that of a square AF [Table/Fig-2c].

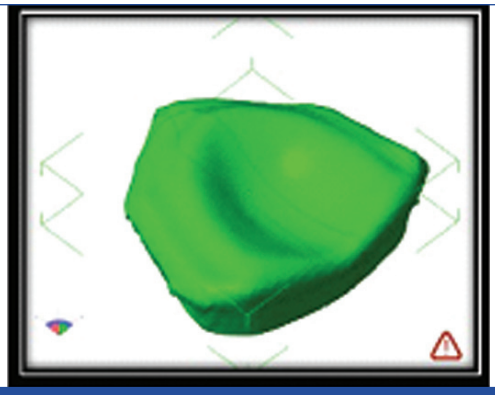


[Table/Fig-2]: a) Tapering Arch Form (AF); b) Square Arch Form (AF); c) Ovoid Arch Form (AF).

Measurement of the Palatal Vault (PV) forms: The measurement was obtained from the maxillary cast using the Sensor 3D Scanner from 3D Systems, manufactured by Handheld Laser 3D Scanner (USA). After stabilising the maxillary cast on a rotating device, the Sense 3D Systems software was opened. The scanner was positioned on a tripod stand, a starting point was marked, and the scanning was conducted [Table/Fig-3]. The recorded file was saved in STL format with the respective patients' names [Table/Fig-4,5] and was then opened in Netfabb Basic 4.9 software for digital sectioning of the cast. The distance was confirmed using a Contour scope and Microtrac software [Table/Fig-6,7].

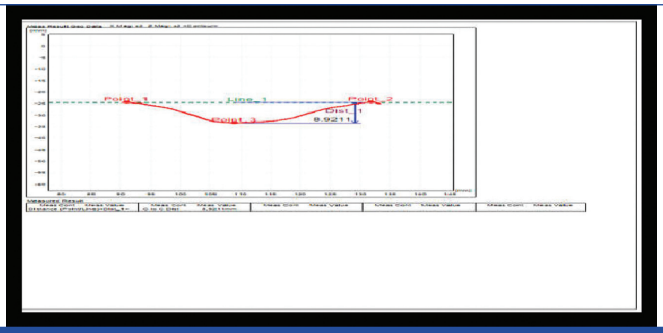
[Table/Fig-3]: Sense 3D Scanner with tripod stand.

[Table/Fig-4]: Scanned maxillary cast on 3D sense system.



[Table/Fig-5]: Sectioned STL file in nettfabb basic 4.9 Software.

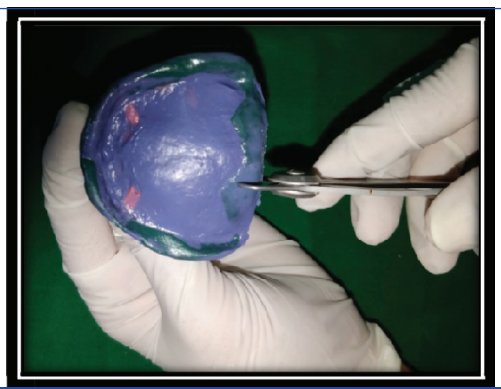
[Table/Fig-6]: CV mitutovo contourscope.



[Table/Fig-7]: Sectioned graph in microtrac software.

The data was recorded, and the PV forms were classified according to the classification of Dr. Johnson DL et al., (1986) [8]. A PV of less than 0.25 inches was considered flat. A PV between 0.25-0.5 inches was classified as U-shaped or medium, while a PV greater than 0.5 inches was classified as V-shaped or high.

The width was measured as the difference between the thinnest point between the anterior vibrating line and the posterior vibrating line and the thickest point using an Iwanson gauge (USA) in the impression taken with Impregum (3M, Espe, India) from a custom tray fabricated from the primary cast [Table/Fig-8]. The data was then classified according to Winland RD and Young JM [9]:



[Table/Fig-8]: Measurement of depth of Posterior Palatal Seal (PPS) with iwanson gauge.

Class I: A butterfly-shaped PPS with a width of 3-4 mm.

Class II: A narrow PPS with a width of 2-3 mm.

Class III: A single beading made on the posterior vibrating line.

STATISTICAL ANALYSIS

The study analysed three prevalent forms: AF, PV, and PPS. Data were collected from a sample size of 32 individuals and analysed using Statistical Package for the Social Sciences (SPSS) 24.0 and GRAPH PAD PRISM 5.0. Descriptive statistics were used to summarise the data, with means and standard deviations for numerical variables, and counts and percentages for categorical variables. The results observed have been summarised accordingly.

RESULTS

The following tables represent the statistical results of the study. The most prevalent AF found was the ovoid AF (46.9%) [Table/Fig-9]. The most prevalent PV form was the medium U-shaped vault form (65.6%) [Table/Fig-10].

Arch Form (AF) (total-32)	Frequency	Percent
Ovoid	15	46.9%
Square	5	15.6%
Tapered	12	37.5%
Total	32	100.0%

[Table/Fig-9]: Distribution of Arch Form (AF).

Classification of the Palatal Vault (PV) (total-32)	Frequency	Percent
Flat	4	12.5%
High V-shaped	7	21.9%
Medium U-shaped	21	65.6%
Total	32	100.0%

[Table/Fig-10]: Distribution of Classification of the Palatal Vault (PV).

The various posterior palatal seal types found in the study indicated that the most frequent PPS forms were of Class III (53.1%) [Table/Fig-11]. The combinations obtained in the present study were categorised into 14 different combinations [Table/Fig-12].

Classification of the PPS (total-32)	Frequency	Percent
Class I	6	18.8%
Class II	9	28.1%
Class III	17	53.1%
Total	32	100.0%

[Table/Fig-11]: Distribution of Classification of the Posterior Palatal Seal (PPS).

Combination	Combination types	Frequency	Percent
Ovoid AF, Flat PV, Class I PPS	Combination 1	1	3.1%
Ovoid AF, Flat PV, Class III PPS	Combination 2	1	3.1%
Ovoid AF, high V-shaped PV, Class I PPS	Combination 3	1	3.1%
Ovoid AF, high V-shaped PV, Class II PPS	Combination 4	2	6.3%
Ovoid AF, medium U-shaped PV, Class I PPS	Combination 5	2	6.3%
Ovoid AF, medium U-shaped PV, Class II PPS	Combination 6	6	18.8%
Ovoid AF, medium U-shaped PV, Class III PPS	Combination 7	2	6.3%
Square AF, high V-shaped PV, Class I PPS	Combination 8	2	6.3%
Square AF, high V-shaped PV, Class III PPS	Combination 9	1	3.1%
Square AF, medium U-shaped PV, Class III PPS	Combination 10	2	6.3%

Tapered AF, flat PV, Class III PPS	Combination 11	2	6.3%
Tapered AF, high V-shaped PV, Class III PPS	Combination 12	1	3.1%
Tapered AF, medium U-shaped PV, Class II PPS	Combination 13	2	6.3%
Tapered AF, medium U-shaped PV, Class III PPS	Combination 14	7	21.9%
Total		32	100.0%

[Table/Fig-12]: Distribution of combination of Arch Form (AF), Palatal Vault (PV) form and Posterior Palatal Seal (PPS) form.

DISCUSSION

It is essential to recognise that the success of a traditional complete denture relies on the retention, stability, and support provided by the local anatomy of the edentulous mouth. Understanding oral anatomy can help clinicians identify landmarks that guide and predict treatment outcomes. "The key anatomical features affecting retention, stability, and support include the AF, PV form, and the form of the posterior palatal seal of the edentulous mouth" [6]. Retention and stability are influenced by the maxillary AF, which results in increased surface area and resistance to forces. It has generally been noted that square AFs provide greater retention than any other AFs. Palatal shapes have been reported to influence the retention, stability, and support of a maxillary complete denture. Retention is directly proportional to the surface area. The mean denture-bearing area was found to be 22.962 cm^2 in the dentulous maxilla. Increased surface area enhances the forces acting between the denture bases and the tissue surfaces, contributing to adhesive and cohesive forces. "Medium vault palates have demonstrated better denture retention as well as favorable stability potential compared to deeper vaults" [5].

The posterior palatal seal enhances denture retention by over 10 times, boosts patient confidence, and reduces the gag reflex. "The percentage linear shrinkage during polymerisation of a complete denture is compensated by the post-dam" [10,11]. One of the anatomical factors that influence retention is the AF of the maxilla. Skinner E et al., found the retention value to be greatest in square-type AFs and lowest in tapered-type AFs [12]. "The same result was found in the study conducted by Shekhar A et al., in 2018" [5]. AFs are generally classified as square, tapering, or ovoid. The method followed in this study for the classification of AF was provided by Kawabe S [7]. In the current study, the most prevalent AF was found to be ovoid, followed by tapered AF and square AF. These findings were not in accordance with another study done in 2018 by Omar H et al., which indicated that the most common AF in their sample was the narrow tapered form, followed by the narrow ovoid form. "This discrepancy might be attributed to the fact that males generally have significantly larger dental arch measurements than females; there were more male subjects than female subjects in our study" [13].

In our study, we discovered that the most common AF was the ovoid AF. The results of this study were consistent with a 2011 study by Shafique A et al., [14], which found that most subjects had ovoid AFs, followed by tapering and square AFs, respectively. In another study conducted in 1998 by Sellen PN et al., it was found that males predominantly had tapering AFs, whereas females had ovoid and square AFs, which aligns with the present study [15]. In our study, we assessed the shape of the PV using 3D scanning. We confirmed the measurements using a contour scope. The 3D Sense Systems device analyses real world objects or environments to gather data on their shape and potentially their appearance, including color. The collected data can then be used to construct digital three dimensional models. In the present study, the Sense 3D Scanner was used, and the collected data was analysed using software known as Netfabb Basic 4.9. As the world becomes increasingly digital, we have established a new method for determining the PV form with a 3D scanner that has a resolution of 1920×1080 pixels for color mapping of objects from seven inches to 72 inches [16].

A contour scope (CV-2100) was used to confirm the depth of the PV. The contour scope is a fast and precise contour measuring instrument. The Mitutoyo software, Microtrac, supplied as standard, provides 0.8 nm accuracy and, combined with a compact dynamic light scattering analyser, contributes significantly to the efficiency and versatility of the CV-2100 (Contour Scope). The program provides automatic evaluation of the measurements, contour analysis, and computer-aided design comparison. It also eliminates the effects of varying workpiece positions when running fully automatic part programs [17]. In this study, we found that the most prevalent PV form was the medium U-shaped vault. The classification of the various PVs was performed according to the classification established by Johnson DL et al., (1986). The most prevalent type of PV form found was the medium U-shaped, which aligns with the findings of Johnson DL et al., (1986). They categorised all cross-arch palatal forms, noting that 93% showed some variation of a U-shaped palatal form, whether angular or mildly curved [8].

A 2014 study by Goyal S et al., found significant variations in the posterior palatal seal area. They observed low compressibility in the midpalatal raphe and hamular notch region, and high compressibility in the lateral aspects of the posterior palatal seal. The depth of the posterior palatal seal area varies depending on the PV form: shallow in Class I palates and deep in Class III palates [18]. Jacobson TE and Krol AJ described the MM House classification of the posterior palatal seal area in their study, noting that in Class III posterior palatal seal areas, there is less than 1 mm of movable tissue available for post-damming. This was associated with poor retention and a high V-shaped PV [19]. We observed that the most prevalent posterior palatal seal form was Class III. The posterior palatal seal, considered an important anatomical factor for the retention of complete dentures, was measured using an Iwanson gauge in our study, similar to the survey conducted by Winland RD and Young JM (1973) [9]. The results were consistent with their survey. The combination of tapered AF, medium U-shaped PV form, and Class III posterior palatal seal was the most prevalent combination found in the population of West Bengal.

It is generally understood that the tapered AF, observed in the majority of combinations, reduces the stability of the denture, while the U-shaped PV provides the most stable denture. In contrast, the Class III posterior palatal seal contributes to less stability due to a small posterior palatal seal and a V-shaped PV [6,8,9].

Limitation(s)

The main limitation of the study was the small sample size, which means the results cannot be generalised. Convenience sampling was used; therefore, the sample may not be representative of the general population. Future studies with larger sample sizes are recommended.

CONCLUSION(S)

This study established the combination of the shapes of the arch, PV, and posterior palatal seal with their respective types. These findings could serve as a guide for future diagnosis and treatment planning, helping to anticipate the combination of AF, PV form, and posterior palatal seal form in creating maxillary complete denture prostheses. The most prevalent combination found was Combination 14 (tapered AF, medium U-shaped PV form, and Class III posterior palatal seal form). Therefore, prosthodontists should determine the specific combination of the AF, PV form, and posterior palatal seal form for treatment planning to increase the stability of the maxillary denture.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 12, 2024
- Manual Googling: May 13, 2025
- iThenticate Software: May 15, 2025 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 9

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jul 11, 2024**
Date of Peer Review: **Aug 28, 2024**
Date of Acceptance: **May 17, 2025**
Date of Publishing: **Oct 01, 2025**