

Evaluation of the prosthetic space in completely edentulous Moroccan patients: a cross-sectional study

Evaluation de l'espace prothétique chez les patients édentés complets Marocains : étude transversale

Asmae Hani¹, Fatine Daoudi², Abdelaziz Bouklouze³, Nadia Merzouk¹, Leila Fajri¹

1. Mohammed V University in Rabat, Faculty of Dental Medicine, Removable Prosthodontics Department, Allal El Fassi Avenue, Mohammed Jazouli Street, Madinat Al Irfane, BP 6212, Rabat, Morocco.

2. Mohammed V University in Rabat, Faculty of Dental Medicine, Allal El Fassi Avenue, Mohammed Jazouli Street, Madinat Al Irfane, BP 6212, Rabat, Morocco.

3. Mohammed V University in Rabat, Faculty of Medicine and Pharmacy, Laboratory of Pharmacology and Toxicology, Bio-Pharmaceutical and Toxicological Analysis Research Team, Rabat, Morocco.

ABSTRACT

Introduction: In completely edentulous patients, the prosthetic space corresponds to the area available for denture integration. Its evaluation relies on inter-ridge height, ridge dimensions, and the degree of alveolar resorption, which condition the functional and esthetic outcome of prosthetic rehabilitation.

Objective: To assess prosthetic space parameters in completely edentulous Moroccan patients and identify associated factors.

Methods: A cross-sectional study was conducted on 50 completely edentulous patients consulting for bimaxillary rehabilitation at Ibn Sina Hospital, Rabat. After recording the maxillomandibular relationship, secondary casts were mounted on an articulator to measure inter-ridge height, ridge dimensions, and arch perimeters. Maxillary and mandibular resorption were classified using Cawood and Howell's classification. Data were analyzed with Jamovi 2.6.13.

Results: Inter-ridge height was greater at the median level [2 cm (1.7–2.2 cm) right; 1.95 cm (1.7–2.3 cm) left] and lower at the tuberosity-trigone level [0.95 cm (0.7–1.48 cm) right; 1.05 cm (0.8–1.48 cm) left] ($p < 0.001$). Maxillary resorption was predominantly classified as type III, whereas mandibular resorption mainly corresponded to classes IV and V, both anteriorly and posteriorly ($p < 0.001$). Age was significantly associated with anterior mandibular resorption ($p < 0.05$), and the duration of edentulism correlated with resorption in both arches ($p < 0.05$).

Conclusion: The joint evaluation of inter-ridge height, ridge perimeters and dimensions, as well as resorption profiles allows, for an objective and comprehensive analysis of prosthetic space in edentulous patients.

keywords : prosthetic space, inter-ridge height, alveolar resorption, gender, age, duration of edentulism.

RÉSUMÉ

Introduction : Chez les patients complètement édentés, l'espace prothétique correspond à la zone disponible pour l'intégration de la prothèse. Son évaluation repose sur la hauteur inter-crête, les dimensions des crêtes, et le degré de résorption alvéolaire, qui conditionnent le résultat fonctionnel et esthétique de la réhabilitation prothétique.

Objectif : Évaluer les paramètres de l'espace prothétique chez des patients marocains complètement édentés et identifier les facteurs associés.

Méthodes : Une étude transversale a été menée sur 50 patients complètement édentés consultant pour une réhabilitation bimaxillaire à l'Hôpital Ibn Sina, Rabat. Après avoir enregistré le rapport maxillo-mandibulaire, les modèles secondaires ont été montés sur articulateur pour mesurer la hauteur inter-crête, les dimensions des crêtes, et les périmètres des arcades. La résorption maxillaire et mandibulaire a été classifiée selon la classification de Cawood et Howell. Les données ont été analysées avec Jamovi 2.6.13.

Résultats : La hauteur inter-crête était plus grande au niveau médian [2 cm (1,7–2,2 cm) à droite ; 1,95 cm (1,7–2,3 cm) à gauche] et plus basse au niveau de la tubérosité-trigone [0,95 cm (0,7–1,48 cm) à droite ; 1,05 cm (0,8–1,48 cm) à gauche] ($p < 0,001$). La résorption maxillaire était surtout de classe III, tandis que la mandibule présentait principalement des classes IV et V, aussi bien en antérieur qu'en postérieur ($p < 0,001$). L'âge était significativement associé à la résorption mandibulaire antérieure ($p < 0,05$), et la durée de l'édentement était corrélée à la résorption dans les deux arcades ($p < 0,05$).

Conclusion : L'évaluation conjointe de la hauteur inter-crête, des périmètres et dimensions des crêtes, ainsi que des profils de résorption, permet une analyse objective et complète de l'espace prothétique chez les patients édentés.

Mots-clés : espace prothétique, hauteur inter-crête, résorption alvéolaire, sexe, âge, durée de l'édentement.

Correspondance

Asmae Hani

Mohammed V University in Rabat, Faculty of Dental Medicine, Removable Prosthodontics Department, Allal El Fassi Avenue, Mohammed Jazouli Street, Madinat Al Irfane, BP 6212, Rabat, Morocco.

Email: asmae_hani@um5.ac.ma

INTRODUCTION

The complete loss of teeth leads to anatomical and physiological changes in the edentulous oral cavity, creating a three-dimensional space called the prosthetic space, distinct from the one previously occupied by natural teeth (1).

In completely edentulous patients, the mandibular prosthetic space should be regarded as a dynamic volume influenced by periprosthetic muscular forces rather than as static anatomical landmark (2-4). These studies underscore that the stability and retention of prosthetics are contingent upon the appropriate accommodation of this functional space. Heath demonstrated that this space varies between rest and function, particularly during swallowing, as lingual forces shift the prosthetic material (2). Klein's "neutral zone" is where the tongue and mouth muscles are balanced. He also discussed phonation as a way to model without inter-occlusal contact (3). Nabid improved this method by creating a three-dimensional piezographic model that allows prosthetics to be made to fit the patient's specific muscle tone (4).

The prosthetic space has three main areas: horizontal, vertical, and the bearing surface. The bearing surface is crucial for keeping the prosthetic stable. The horizontal zone connects the prosthesis to the muscles around it, the vertical zone is affected by the distance between the ridges and the orientation of the occlusal plane, and the bearing surface is affected by the arch perimeter, ridge dimensions, and palatal depth. Space reduction or excess, due to bone changes, requires adjustments to ensure optimal functional and esthetic integration (4).

The vertical component of the prosthetic space is directly related to ridge resorption, which affects the stability and retention of removable prostheses (5,6). Factors such as anatomical, metabolic, prosthetic, and functional factors influence this resorption (7). Mandibular resorption is three to four times greater than maxillary resorption (8). Gender has a significant impact on residual ridge resorption, with women experiencing more bone loss than men (9-12). Some possible reasons for this higher resorption in women are metabolic disorders, high levels of parathyroid hormone (13), and osteoporosis after menopause (11).

Age is another important factor because bone resorption increases with age (14, 15).

Prolonged edentulism has been associated with increased mandibular bone resorption (10,16,17). The evaluation of prosthetic space during the pre-prosthetic phase is essential for treatment planning (18).

This cross-sectional study aimed to evaluate the vertical prosthetic space in a population of completely edentulous Moroccan patients by determining the mean values for inter-ridge height, arch perimeters, ridge height and width, and by assessing the degree of alveolar ridge resorption. It also sought to identify associated factors, such as gender, age, and duration of edentulism.

METHODS

Study design and sample description

This descriptive and analytical cross-sectional study was conducted on a sample of 50 completely edentulous bimaxillary Moroccan patients followed for rehabilitation with total removable prostheses at the Removable Prosthodontics Department of the Dental Consultation and Treatment Center at Ibn Sina Hospital in Rabat. All patients presenting with complete bimaxillary edentulism were included, while cases of partial or single-arch edentulism were excluded.

A sample of 50 was considered sufficient to provide reliable estimates of the vertical prosthetic dimension and to assess different prosthetic space parameters, ensuring a 95% confidence level, methodological rigor, and feasibility of recruitment.

Informed consent was obtained from all participating patients.

Study procedures

We proceeded with the following steps:

1. Clinical Examination

The study began with a clinical examination (intraoral and extraoral) using a questionnaire designed to collect all parameters related to the prosthetic space.

2. Standardization of the vertical dimension of occlusion (VDO) and maxillomandibular relationship determination
This clinical phase was crucial for the study. The upper occlusal model was positioned to be visible 2 mm below the upper lip and validated using the "Fe" and "Ve" tests, ensuring proper labial support. The occlusal plane was oriented parallel to both the bipupillary line and Camper's plane (extending from the center of the tragus to the subnasale point) using a Fox's ruler.

The position of the maxilla was first transferred to the articulator using a facebow. The VDO was then determined using the indirect technique based on the vertical dimension of rest (VDR). The patient was asked to swallow a small amount of water, and the mandibular position immediately after swallowing was recorded in centric relation, and the VDR was measured between the tip of the nose and the tip of the chin. The VDO was then calculated using the formula: $VDO = VDR - IRS$, where the interocclusal rest space (IRS) was considered to be 2-4 mm. This measurement was then validated through both aesthetic assessment and the phonetic test (pronunciation of the "S" sound). Finally, the maxillomandibular relationship was recorded, and the mandibular cast was mounted accordingly.

3. Conducting measurements on the casts according to the reference points

The reference points included the anterior midpoints, the right and left canine points (canine cusps), the right and left posterior median positions (first molar sites), and the most prominent points on the right and left trigons and tuberosities.

All measurements were performed on the mounted casts

on the articulator, including the inter-ridge height, the perimeter of the maxillary and mandibular arches, and the height and width of both ridges.

Variables

- Inter-ridge height was measured using a compass between the following landmarks: the upper and lower anterior midpoints, the upper and lower canine points (see Figure 1), the upper and lower posterior median positions, and the most prominent points on the tuberosities and trignons.

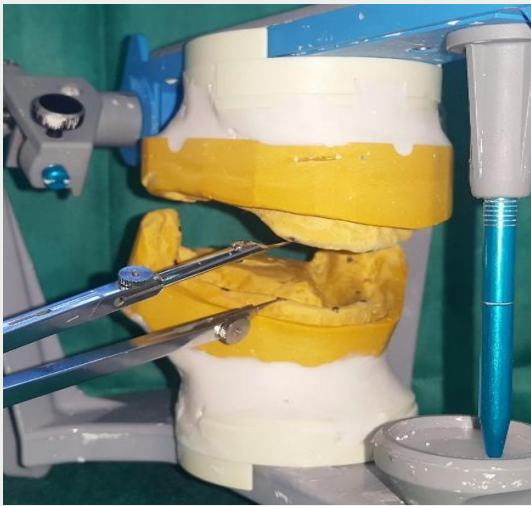


Figure 1. Measurement of the inter-ridge height at the canine level

- The arch perimeter was determined using a wire positioned between the regions behind the maxillary tuberosities and the mandibular trignons.
- Ridge height was determined from the vestibular base to the crest of the ridge at the reference points, while ridge width was measured with a caliper at the same points for both the maxilla and mandible.
- The degree of resorption was assessed using Cawood and Howell's six-class classification: Class I: dentate, Class II: immediately post-extraction, Class III: well-rounded ridge form, adequate in height and width, Class IV: knife-edge ridge form, adequate in height, and inadequate in width, Class V: flat ridge form, inadequate in height and width, Class VI: depressed ridge form (with some basalar loss evident) (19). In this study, the maxillary and mandibular ridges were evaluated qualitatively through direct observation by a single operator, highlighting the subjective nature of this assessment.
- The explanatory variables included gender, age (categorized into two groups: 40 to 69 years old and 70 years or older), and the duration of edentulism (divided into two groups: 1 to 5 years and more than 5 years).

Statistical Analysis

Data analysis was conducted using Jamovi software version 2.6.13. Descriptive statistics, including mean, standard deviation (SD), median, and interquartile range (IQR), were calculated for inter-ridge height, ridge height and width, and arch perimeter. Categorical variables

were presented as frequencies and percentages.

The Friedman test was employed to compare inter-ridge height at different levels (anterior, median, and tuberosity-trignon) and to evaluate ridge dimensions at various reference points. Pearson's correlation coefficient (r) assessed the relationship between inter-ridge height at the right and left median positions. The Wilcoxon test was used to compare arch perimeter between the maxilla and mandible.

For inter-ridge height comparison by age group (40–69 vs. ≥ 70 years), Student's t -test and the Mann-Whitney U test were applied, depending on data distribution. Chi-square and Fisher's exact tests examined associations between alveolar resorption and factors such as gender, age, and duration of edentulism.

The McNemar test compared mandibular resorption between anterior and posterior regions. Finally, simple and multiple logistic regression analyses were performed to explore associations between alveolar resorption and risk factors. The significance level was set at 0.05.

Ethical Approval

The Rabat Ethics Committee for Biomedical Research provided a favorable opinion for the conduct of this study.

RESULTS

The study sample consisted of 50 participants, including 27 males (54%) and 23 females (46%). In terms of age distribution, 11 patients (22%) were 40 to 59 years old, 22 patients (44%) were 60 to 69 years old, and 17 patients (34%) were 70 years old or older. Regarding general health, 33 patients (66%) were in satisfactory health, 8 patients (16%) reported diabetes, 8 patients (16%) had other health problems such as hypertension and heart disease, and 2% reported osteoporosis.

Description of Prosthetic Space Parameters

Comparison of inter-ridge height at the anterior, median, and tuberosity-trigone levels on both the right and left sides revealed a statistically significant difference ($p < 0.001$) (see Table 1).

Table 1. Descriptive Statistics for Inter-Ridge Height in the Anterior, Posterior Right, and Posterior Left Regions

	Inter-ridge height Mean $\pm$ SD (cm)	Inter-ridge height Median (IQR) (cm)
Anterior midpoints	1.77 $\pm$ 0.36	1.7 (1.53–2)
Right canine points	1.93 $\pm$ 0.36	1.9 (1.7–2.08)
Right median positions	2.02 $\pm$ 0.42	2 (1.7–2.2)
Right tuberosity-trigone level	1.10 $\pm$ 0.52	0.95 (0.7–1.48)
Left canine points	1.85 $\pm$ 0.38	1.75 (1.6–2)
Left median positions	2.00 $\pm$ 0.41	1.95 (1.7–2.3)
Left tuberosity-trigone level	1.16 $\pm$ 0.47	1.05 (0.8–1.48)

A statistically significant difference was observed between the perimeters of the maxillary and mandibular

arches ($p < 0.001$). The mean arch perimeter was [12.3 cm (11.7–12.8 cm)] in the maxilla and [14 cm (13.3–14.5 cm)] in the mandible.

Comparison of maxillary and mandibular ridge height at the anterior level, right and left canine points, and right

and left median positions revealed statistically significant differences ($p < 0.05$). Similarly, ridge width in both the maxilla and mandible showed statistically significant differences at the corresponding points ($p < 0.05$ and $p < 0.001$, respectively) (see Table 2).

Table 2. Descriptive Statistics for Ridge Heights and Widths in the Maxilla and Mandible

	Ridge height		Ridge width	
	Mean $\pm$ SD (cm)	Median (IQR) (cm)	Mean $\pm$ SD (cm)	Median (IQR) (cm)
MAXILLA				
Anterior midpoint	1.08 $\pm$ 0.28	1 (0.9–1.28)	0.88 $\pm$ 0.19	0.9 (0.71–1.08)
Right canine point	1.29 $\pm$ 0.30	1.3 (1.1–1.48)	0.84 $\pm$ 0.20	0.9 (0.7–0.95)
Right median position	1.15 $\pm$ 0.25	1.1 (1–1.3)	0.93 $\pm$ 0.25	0.95 (0.7–1.1)
Left canine point	1.34 $\pm$ 0.30	1.3 (1.13–1.5)	0.85 $\pm$ 0.20	0.85 (0.7–1)
Left median position	1.12 $\pm$ 0.28	1.15 (1–1.2)	0.89 $\pm$ 0.21	0.9 (0.7–1.1)
MANDIBLE				
Anterior midpoint	0.89 $\pm$ 0.27	0.9 (0.8–1)	0.50 $\pm$ 0.17	0.5 (0.4–0.54)
Right canine point	0.89 $\pm$ 0.27	0.9 (0.8–1)	0.58 $\pm$ 0.15	0.58 (0.5–0.65)
Right median position	0.75 $\pm$ 0.29	0.7 (0.5–0.9)	0.55 $\pm$ 0.23	0.5 (0.4–0.7)
Left canine point	1.07 $\pm$ 1.46	0.9 (0.7–1.08)	0.58 $\pm$ 0.20	0.53 (0.45–0.65)
Left median position	0.79 $\pm$ 0.3	0.8 (0.63–1)	0.54 $\pm$ 0.19	0.5 (0.45–0.6)

Comparison of the degree of resorption between the anterior and posterior regions of the maxilla and mandible showed a statistically significant difference ($p < 0.001$). Figure 2 illustrates these differences in resorption patterns between the regions of both arches.

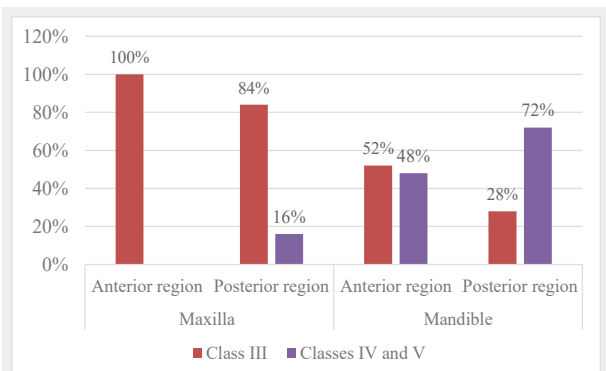


Figure 2. Distribution of Alveolar Resorption in the Maxilla and the Mandible

Analysis of Associated Factors

Regarding the inter-ridge height, the Pearson's correlation test between the right and left heights at median positions showed a statistically significant correlation ($r = 0.862$; $p < 0.001$).

The results showed no statistically significant difference in inter-ridge height at the anterior, right median, and left median regions between patients aged 40–69 years and those aged 70 years or older ($p = 0.177$, $p = 0.366$, and $p = 0.481$, respectively).

In the anterior maxilla, resorption was exclusively Class III in both males and females. In the posterior maxilla, 59% of the males had Class III resorption compared to 41% of females, while Classes IV and V were observed in 75% of females and 25% of males.

In the anterior mandible, Class III resorption was observed

in 50% of both males and females, while Classes IV and V were found in 42% of females and 58% of males. In the posterior mandible, Class III affected 57% of males and 43% of females, whereas Classes IV and V were observed in 47% of females and 53% of males.

The differences were not statistically significant ($p = 0.121$ in the posterior maxilla, $p = 0.555$ in the anterior mandible, and $p = 0.781$ in the posterior mandible).

Resorption in the anterior maxilla was exclusively classified as Class III, affecting 66% of patients aged 40 to 69 years and 34% of those aged 70 years or older. In the posterior region, there was no statistically significant difference in resorption according to age ($p = 0.237$).

Table 3 shows that the variation in resorption in the anterior region of the mandible according to age is statistically significant ($p = 0.022$).

Table 3. Comparison of Anterior Mandibular Ridge Resorption According to Age

Age	Anterior mandibular ridge resorption		p
	Class III	Classes IV and V	
40 to 69 years	21 (81%)	12 (50%)	0.022
70 years and above	5 (19%)	12 (50%)	

In contrast, the variation in resorption in the posterior region of the mandible according to age was not statistically significant ($p = 0.746$).

Table 4 shows that the degree of resorption in the posterior maxilla, anterior mandible, and posterior mandible varied significantly according to the duration of edentulism ($p < 0.05$).

As illustrated in Table 5, simple logistic regression revealed that anterior mandibular ridge resorption was significantly associated with age and duration of edentulism ($p < 0.05$).

In multiple logistic regression, after adjusting for gender and age, mandibular ridge resorption remained significantly associated with the duration of edentulism.

Specifically, among patients with more than 5 years of edentulism, the risk of developing Classes IV and V resorption in the mandible was multiplied by 4.26 (CI [1.19;15.16]) in the anterior region and by 8.75 (CI [2.01;38.18]) in the posterior region, compared to those with less than 5 years of edentulism.

Table 4. Comparison of Alveolar Ridge Resorption Based on the Duration of Edentulism

Duration of edentulism	Alveolar ridge resorption		p
	Class III	Classes IV and V	
Anterior maxilla			
1 to 5 years	38 (76%)		0.041
Over 5 years	12 (24%)		
Posterior maxilla			
1 to 5 years	29 (69%)	2 (25%)	0.041
Over 5 years	13 (31%)	6 (75%)	
Anterior mandible			
1 to 5 years	16 (62%)	6 (25%)	0.009
Over 5 years	10 (38%)	18 (75%)	
Posterior mandible			
1 to 5 years	8 (57%)	5 (14%)	0.004
Over 5 years	6 (43%)	31 (86%)	

Table 5. Factors Associated with Anterior Mandibular Ridge Resorption: Univariate and Multivariate Analysis

Variable	Univariate analysis			Multivariate analysis		
	OR	[95% CI]	p	OR	[95% CI]	p
Gender	1.4	[0.46; 4.28]	0.555	1.58	[0.45; 5.55]	0.475
Male-female						
Age	4.2	[1.19; 14.83]	0.026	3.64	[0.95; 13.98]	0.06
70 years and above--40 to 69 years						
Duration of edentulism	4.8	[1.42; 16.19]	0.011	4.26	[1.19; 15.16]	0.025
Over 5 years--1 to 5 years						

CI: confidence interval, OR: odds ratio

Our study demonstrated that the inter-ridge height, measured at the canine position, the median position, and the distance between the tuberosity and the trigone, was substantially similar between the right and left sides. The results revealed that inter-ridge height was greater at the median positions and lower at the tuberosities and trigones. These areas showed less marked alveolar resorption, probably due to reduced mechanical stress compared to other regions, particularly the medial portion of the posterior ridges, which experienced greater stress prior to tooth extraction.

These findings align with the study by Alidema et al. which reported that the lowest residual mandibular bone height was observed in the right molar region (20). Furthermore, our study found that age had no direct effect on inter-ridge height, regardless of the region (anterior or posterior) or side (right or left).

Alveolar resorption was centripetal in the maxilla and centrifugal in the mandible, as reflected by a wider mandibular arch perimeter compared to the maxillary arch. This discrepancy resulted in an inversion of the arch relationship, with the mandible circumscribing the maxilla.

These findings are consistent with those of Pietrokovski et al. who also reported this difference in post-resorption

DISCUSSION

This study was conducted to provide a detailed description of the vertical prosthetic space and alveolar ridge characteristics in completely edentulous Moroccan patients and to assess the factors associated with alveolar ridge resorption. We included 50 patients. Inter-ridge height was highest at the median positions (2.0 cm on the right and 1.95 cm on the left) and lowest at the tuberosity-trigone level (0.95 cm on the right and 1.05 cm on the left). The mean arch perimeter was 12.3 cm in the maxilla and 14 cm in the mandible, showing significant differences ($p < 0.001$). Maxillary resorption was predominantly classified as type III, whereas mandibular resorption mainly corresponded to classes IV and V, both anteriorly and posteriorly. Ridge resorption was significantly associated with age and duration of edentulism, with longer edentulism markedly increasing the risk of severe resorption, while no significant association was observed with gender.

between the two arches (21).

No statistically significant association was observed between resorption and gender in either the maxilla or mandible.

Our study revealed exclusively Class III resorption in the anterior maxilla for both males and females. In the posterior region, Class III resorption was the most predominant in both sexes, although Classes IV and V were more frequent in females.

In the mandible, resorption patterns were comparable between sexes, consistent with the findings of Pramstraller et al. who reported that gender had a limited impact on posterior mandibular ridge resorption after tooth loss (22), and Imirzalioglu et al. who found that residual ridge resorption was not influenced by gender (14).

In contrast, several earlier studies, including those by Soikkonen et al., de Baat et al., Nishimura et al., Xie et al., and Huuonen et al. observed higher resorption in females, particularly in the mandible (9–12,23). Kordatzis et al. also identified female gender as a major factor in mandibular ridge resorption (5).

No statistically significant association was observed between age and resorption in the maxilla. In the mandible, however, resorption in the anterior region was significantly associated with age.

Classes IV and V resorption were more frequent in the age group of 70 years or older, whereas Class III was more common in the 40-69 age group.

These findings are consistent with those of several authors, such as Imirzalioglu et al. who observed that residual ridge resorption was significantly influenced by age (14).

Bairam et al. also showed that resorption increases with age (15). Similarly, Tayachi et al. reported a decrease in bone height with increasing age (24).

In contrast, Koç et al. found that age had no effect on edentulous ridge dimensions (25).

A statistically significant association was found between resorption and the duration of edentulism, both in the maxilla and mandible. The longer the duration of edentulism, the greater the degree of resorption. These findings concur with those of the studies conducted by Parr et al., AlSheikh et al., and de Baat et al. (10, 16, 17). Parr et al. found that most of the mandibular resorption observed was related to early tooth loss rather than age. AlSheikh et al.'s study demonstrated that with increasing duration of edentulism, mandibular bone height decreased. However, this association was not statistically significant. Similarly, de Baat et al. concluded that the longer the duration of edentulism, the greater the degree of mandibular alveolar bone resorption.

The main strength of the study was the precise and reproducible measurement of inter-ridge space on models mounted on an articulator, essential for complete denture planning. The study's main limitations were the small sample size and the single-center design. The small sample size may have reduced the study's statistical power, possibly hindering the identification of significant associations, especially concerning gender. Additionally, the single-center design may limit the generalizability of the results to other populations.

Abbreviations List

CI: Confidence Interval

IQR: Interquartile Range

IRS: Interocclusal Rest Space

OR: Odds ratio

SD: Standard Deviation

VDO: Vertical Dimension of Occlusion

VDR: Vertical Dimension of Rest

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