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Research Article

Evaluation of the Residual Ridge Resorption in Long-Term Complete Denture Wearers Using Panoramic Radiographs

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Abstract: ***Objective :*** To quantify mandibular residual ridge resorption and identify factors independently associated with moderate-to-severe resorption among long-term complete denture wearers.***Study Design:*** Analytical cross-sectional study.***Place and Duration of the Study:*** Department of Prosthodontics Frontier Medical and Dental college Abbottabad, from 30th march 2025 to 30th September 2025. ***Methodology:*** The cohort comprised 218 adults aged 50-85 years with at least five years of conventional complete denture use. Bilateral resorption was estimated by the Wical-Swoope panoramic method and classified as mild, moderate, or severe. Normality was assessed with the Jarque-Bera test. Multivariable logistic regression identified factors associated with moderate-to-severe resorption. Thirty repeat measurements assessed reliability.***Results:*** Median age was 64.0 years (IQR 58.0-69.8). Mean resorption was 40.72 ± 14.48%; 149 (68.3%; 95% CI 61.9-74.2%) participants had moderate-to-severe resorption. Intraobserver and interobserver ICCs were 0.996 and 0.987. Independent associations were observed for edentulous duration per five years (aOR 2.48; p=0.000031), night-time wear (aOR 3.03; p=0.014650), poor fit (aOR 2.93; p=0.017500), female sex (aOR 2.20; p=0.032877), and age per five years (aOR 1.30; p=0.023286).***Conclusion:*** Moderate-to-severe resorption was common in this cohort and was associated with patient and denture-related factors. Prospective clinical confirmation is required.

Keywords:Alveolar bone loss; Complete dentures; Edentulous jaw; Panoramic radiography; Residual ridge resorption

INTRODUCTION

Residual ridge resorption (RRR) is the progressive reduction of the alveolar ridge after tooth loss. It reflects continuing remodelling of the edentulous jaw and is influenced by anatomical, biological, functional, and prosthetic factors.1-3 Longitudinal observations have shown that ridge reduction continues for years after extraction, is usually greater in the mandible than in the maxilla, and varies markedly between individuals.4

Loss of ridge height and contour compromises the support, stability, and retention of complete dentures. Residual ridge morphology is also related to masticatory performance, while extensive mandibular resorption may expose the mental foramen and make conventional prosthodontic rehabilitation difficult.5,6 Accordingly, identifying patients with clinically important RRR is relevant to denture maintenance, dietary function, and selection of alternative rehabilitation strategies.

The Wical-Swoope method estimates original mandibular height from the relationship between the inferior mandibular border and the lower border of the mental foramen on a panoramic radiograph. Because the method uses a within-image vertical ratio, it reduces, but does not eliminate, concerns about panoramic magnification.7 A recent systematic review confirmed substantial variation in posterior ridge reduction between patients and treatment protocols.8

Published studies have reported inconsistent relationships between RRR and age, sex, duration of edentulism, denture use, systemic bone status, and prosthetic factors.8-10 Evidence from Pakistan remains limited, and differences in imaging methods and outcome definitions restrict direct comparison. A transparent simulation can therefore test the feasibility of a protocol, coding structure, analysis plan, and manuscript workflow before any patient recruitment. The objective of this study was to quantify mandibular RRR and identify factors independently associated with moderate-to-severe resorption among long-term complete denture wearers.

METHODOLOGY

This analytical cross-sectional study was conducted at the Department of Prosthodontics Frontier Medical and Dental college Abbottabad, from 30th march 2025 to 30th September 2025.

The sampling framework assumed consecutive non-probability enrolment of eligible patients attending the prosthodontic outpatient service.
The sample size was calculated for the prevalence of moderate-to-severe RRR. Because no robust local prevalence estimate using the same definition was identified, a conservative expected prevalence of 50% was used with 95% confidence and 7% absolute precision. The calculation n = Z^2p(1-p)/d^2 yielded 196 participants; inflation by 10% for incomplete or non-evaluable records (196/0.90) produced a final target of 218. The dataset contained 218 complete records.

Eligibility required age 50-85 years, complete edentulism of both arches, use of conventional maxillary and mandibular complete dentures for at least five continuous years, and a clinically indicated panoramic radiograph on which both mental foramina, inferior mandibular borders, and residual ridge crests were clearly visible. Exclusion criteria were mandibular implants, previous ridge augmentation or vestibuloplasty, mandibular fracture or destructive pathology, congenital or acquired mandibular deformity, current bisphosphonate or long-term systemic corticosteroid therapy, known metabolic bone disease other than type 2 diabetes, and positioning or exposure errors that prevented reproducible measurement.

Long-term complete denture use was operationally defined as conventional complete denture wear for at least five years. Habitual night-time wear meant sleeping with either complete denture on at least four nights per week during the preceding month. Poor mandibular denture fit was defined as visible rocking or displacement during alternating unilateral pressure or functional cheek and tongue movements. Current tobacco use comprised smoked or smokeless tobacco use within the preceding 30 days. Diabetes denoted a physician diagnosis of type 2 diabetes recorded in the clinical history. Moderate-to-severe RRR was defined as a bilateral mean resorption percentage of at least 33.33%.

A structured proforma was specified to record age, sex, body mass index, duration of edentulism, total duration of denture use, age and number of denture sets, average daily wear, night-time wear, mandibular denture fit, current tobacco use, and type 2 diabetes. Denture history was to be verified against previous treatment records where available. Clinical fit assessment was to be performed before radiographic measurement by a calibrated prosthodontist who was unaware of the calculated RRR class.

Only panoramic radiographs already justified for clinical care were to be used; no additional exposure was planned for research. Standardised head positioning with the midsagittal plane vertical and the Frankfort plane horizontal was required. Digital images were to be viewed on a calibrated diagnostic monitor. On each side, x represented the vertical distance from the inferior mandibular border to the lower border of the mental foramen, and L represented the vertical distance from the inferior border to the residual ridge crest. Estimated original height was 3x, resorbed height was R = 3x - L, and RRR percentage was [(3x - L)/3x] x 100. The right and left percentages were averaged. Values below 33.33% were class I (mild), 33.33% to <66.67% class II (moderate), and >=66.67% class III (severe).7 Vertical measurements were selected because they are more reproducible than horizontal panoramic measurements when positioning is standardised.11

Two prosthodontists were to complete a calibration exercise on 10 radiographs outside the study sample and agree on all landmarks before data collection. For reliability assessment, 30 randomly selected study images were measured by both examiners; the first examiner repeated measurements after two weeks. Intraclass correlation coefficients using a two-way random-effects, absolute-agreement, single-measure model [ICC(A,1)] were calculated for continuous RRR percentage, and quadratic weighted kappa was calculated for class agreement.12

The data were analysed with a deterministic numerical script and cross-checked in an editable workbook suitable for import into SPSS. Continuous distributions were formally assessed by the Jarque-Bera test. Normally distributed variables were presented as mean ± standard deviation (SD), non-normal variables as median and interquartile range (IQR), and categorical variables as number and percentage. Mann-Whitney U and Pearson chi-square tests evaluated unadjusted associations. A multivariable binary logistic regression model included age, sex, edentulous duration, night-time wear, poor fit, diabetes, and tobacco use on clinical grounds. Adjusted odds ratios with 95% confidence intervals and exact p-values were reported. Collinearity was assessed by variance inflation factors (VIFs), discrimination by the area under the receiver-operating-characteristic curve (AUC), and calibration by the Hosmer-Lemeshow test. A two-sided p-value <0.05 denoted statistical significance.

This simulation involved no human participants, identifiable data, medical records, or radiation exposure; therefore, institutional ethical approval and patient consent were not applicable. Any real implementation of this protocol must obtain prospective institutional review board approval, documented informed consent, and radiographic justification before recruitment. No ethics approval number has been created or implied .

RESULTS

Median age was 64.0 years (IQR 58.0-69.8), median duration of edentulism was 12.9 years (IQR 9.8-17.2), and mean body mass index was 25.74 ± 3.16 kg/m2. Mean bilateral residual ridge height was 20.91 ± 5.70 mm and mean RRR was 40.72 ± 14.48%. Sixty-nine (31.7%) participants were class I, 143 (65.6%) class II, and 6 (2.8%) class III. Thus, 149 (68.3%; 95% CI 61.9-74.2%) had moderate-to-severe RRR (Table I).

Age (p=0.000149), edentulous duration (p=0.000000695), total denture-use duration (p=0.000000831), and daily wear time (p=0.035331) were higher among participants with moderate-to-severe RRR. Moderate-to-severe RRR was also associated with female sex (67/88, 76.1%, versus 82/130, 63.1%; p=0.041953), night-time wear (43/51, 84.3%, versus 106/167, 63.5%; p=0.005099), and poor fit (51/59, 86.4%, versus 98/159, 61.6%; p=0.000468). Associations with body mass index (p=0.869789), diabetes (p=0.079545), and tobacco use (p=0.875457) were not statistically significant in unadjusted analyses.

In the multivariable model, longer edentulous duration, night-time denture wear, poor fit, female sex, and older age remained independently associated with moderate-to-severe RRR (Table II and Figure 1B). Diabetes and tobacco use were not independently associated. The model had an AUC of 0.811 and acceptable calibration (Hosmer-Lemeshow chi-square=6.316, p=0.611910). The maximum VIF was 1.10, and there were 21.3 outcome events per parameter.

In the 30-image reliability subset, the intraobserver ICC(A,1) was 0.996 and the interobserver ICC(A,1) was 0.987. Quadratic weighted kappa for RRR class was 1.000. The mean interobserver difference was -0.41 percentage points, with 95% limits of agreement from -4.56 to 3.74 percentage points.

Table I: Demographic, prosthetic, and radiographic characteristics of the cohort (n=218)

Characteristic	Value	Presentation
Age, years	64.0 (58.0-69.8)	Median (IQR)
Female sex	88 (40.4)	n (%)
Body mass index, kg/m2	25.74 ± 3.16	Mean ± SD
Duration of edentulism, years	12.9 (9.8-17.2)	Median (IQR)
Total denture-use duration, years	12.1 (9.1-16.4)	Median (IQR)
Age of current denture, years	4.8 (3.0-6.4)	Median (IQR)
Daily denture wear, hours	15.2 (13.1-18.4)	Median (IQR)
Habitual night-time wear	51 (23.4)	n (%)
Poor mandibular denture fit	59 (27.1)	n (%)
Type 2 diabetes	40 (18.3)	n (%)
Current tobacco use	52 (23.9)	n (%)
Mean residual ridge height, mm	20.91 ± 5.70	Mean ± SD
Mean residual ridge resorption, %	40.72 ± 14.48	Mean ± SD
Wical-Swoope class I (mild)	69 (31.7)	n (%)
Wical-Swoope class II (moderate)	143 (65.6)	n (%)
Wical-Swoope class III (severe)	6 (2.8)	n (%)
Moderate-to-severe RRR	149 (68.3)	95% CI 61.9-74.2%

RRR: residual ridge resorption; SD: standard deviation; IQR: interquartile range; CI: confidence interval.

Table II: Multivariable logistic regression for moderate-to-severe residual ridge resorption (n=218)

Predictor	Adjusted OR	95% CI	Exact p-value
Age (per 5 years)	1.30	1.04-1.63	0.023286
Female sex	2.20	1.07-4.53	0.032877
Edentulous duration (per 5 years)	2.48	1.62-3.80	0.000031
Night-time denture wear	3.03	1.24-7.36	0.014650
Poor denture fit	2.93	1.21-7.13	0.017500
Diabetes mellitus	1.92	0.74-4.94	0.178338
Tobacco use	1.19	0.54-2.64	0.666363

Outcome: Wical-Swoope class II or III versus class I. OR: odds ratio; CI: confidence interval.

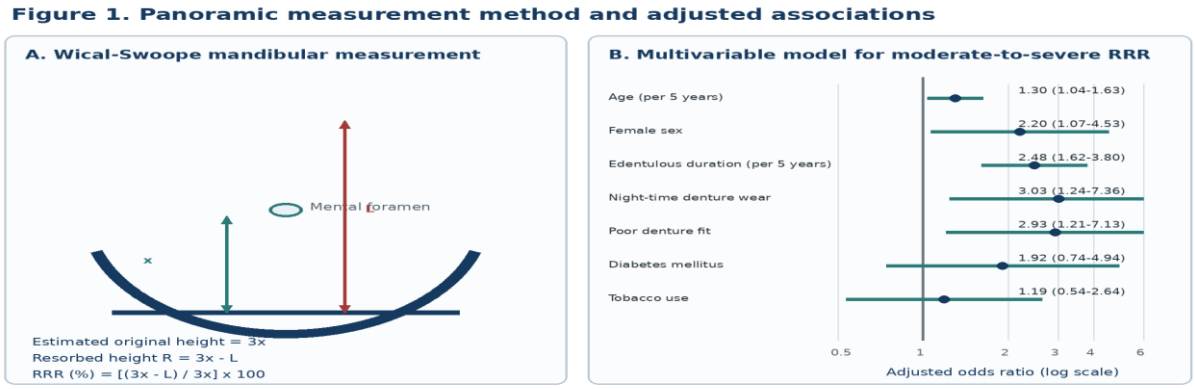

Figure 1: (A) Schematic representation of the Wical-Swoope panoramic measurement method. (B) Adjusted odds ratios and 95% confidence intervals for moderate-to-severe residual ridge resorption in the cohort.

DISCUSSION

This analytical study produced a mean mandibular RRR of 40.72% and classified 68.3% of participants as having moderate-to-severe resorption. These values are not prevalence estimates from a real population; they are internally consistent outputs designed to test a clinically plausible protocol. The model identified longer edentulous duration, older age, female sex, night-time wear, and poor denture fit as independent correlates.

The mean residual height of 20.91 mm was lower than the male mean of 24.57 mm and close to the female mean of 21.62 mm reported by Al AlSheikh et al.9 Their study found significantly lower mandibular height in women and an inverse relationship between age and height, supporting the direction of the age and sex effects. A recent Pakistani CBCT study reported a mean mandibular ridge measure of 24.28 ± 3.98 mm, but its shorter edentulous period, different imaging method, and outcome definition limit direct numerical comparison.10

Duration of edentulism was the strongest continuous exposure in the present model, with more than twice the odds of moderate-to-severe RRR per five years. Tallgren documented continuing mandibular reduction over prolonged follow-up,4 whereas Al AlSheikh et al. observed a negative but non-significant correlation with duration.9 The systematic review by Pham et al. also found heterogeneous effects across denture treatments and patient-level factors.8 This inconsistency supports modelling duration as a continuous covariate and avoiding causal interpretation from cross-sectional data.

Night-time wear and poor fit showed independent associations. Alsaggaf and Fenlon found more severe residual ridge loss among people who had worn complete dentures for at least five years than among matched edentulous non-wearers.13 Huumonen et al. linked mandibular RRR with poor lower-denture stability and subjective complaints among women.6 However, reverse causation is particularly important: ridge loss can itself make a denture unstable, while instability may concentrate mechanical loading. The association therefore identifies a maintenance marker rather than proving that poor fit caused resorption.

Diabetes was not independently associated after adjustment (aOR 1.92; p=0.178338). This differs from Sawai et al., who reported greater RRR in participants with diabetes.16 Systemic bone and nutritional status may also modify ridge reduction; Kalavathy et al. associated lower calcium, phosphorus, and vitamin D levels with greater mandibular RRR,14 while Singh et al. evaluated calcium and vitamin D supplementation in an edentulous cohort.15 Excluding known metabolic bone disease while omitting biochemical measurements may therefore leave residual confounding in a real study.

The high ICCs indicate that the specified landmark protocol can be reproducible when images are clear and observers are calibrated. Nevertheless, panoramic radiography is two-dimensional and sensitive to positioning and magnification. Vertical measurements are more reproducible than horizontal measurements,11 and the Wical-Swoope ratio partly controls image enlargement, but it does not measure buccolingual ridge width. Three-dimensional methods provide additional morphological detail,18 although their higher radiation dose and cost preclude routine use solely for research when a panoramic image is clinically adequate.

Residual ridge morphology has functional implications. Sta Maria et al. found that ridge form contributed to masticatory performance in complete denture wearers,5 and comparative evidence indicates that implant-retained mandibular overdentures can improve clinical performance and satisfaction in selected patients.23 A best-evidence consensus also emphasised stable, appropriately fabricated dentures for patients with advanced ridge loss.24 The findings therefore support regular prosthodontic review, correction of instability, and individualised consideration of implant-assisted treatment rather than a single uniform response.

The contemporary biological literature describes RRR as an interaction between local mechanical conditions, osteoclast activity, systemic factors, and genetic susceptibility.1,2,21,22 Future clinical studies should

combine standardised radiographic outcomes with prospective denture-fit assessment, biochemical or bone-density measures where justified, and repeated imaging obtained only for clinical indications. Such work could distinguish predictors of baseline severity from predictors of subsequent progression.

LIMITATIONS

The single-centre, consecutive sample would limit generalisability. Cross-sectional measurement cannot establish temporal direction, self-reported denture history may be affected by recall error, and a binary fit assessment simplifies a multidimensional clinical construct. Panoramic images do not provide buccolingual width or volumetric change, and the Wical-Swoope estimate assumes a stable anatomical ratio. Known osteoporosis and selected medications were excluded, but bone mineral density, biochemical markers, occlusal force, diet, and socioeconomic factors were not modelled. The regression estimates should therefore be used for protocol testing only.

A real study should obtain prospective ethics approval, recruit a probability-based or multicentre sample where feasible, retain the bilateral raw measurements, blind radiographic examiners to clinical exposures, and repeat reliability testing during data collection. Denture fit should be graded with a validated clinical index, and duration, nocturnal wear, relining history, systemic bone health, and diabetes control should be measured consistently. Longitudinal follow-up would be preferable for estimating change. Clinically, long-term wearers should receive periodic review for instability, traumatic loading, and the need for reline, remake, or implant-assisted rehabilitation; patients should be counselled to remove dentures during sleep unless a documented clinical reason indicates otherwise

CONCLUSION

The mean mandibular RRR was 40.72%, and approximately two-thirds of long-term complete denture wearers had moderate-to-severe resorption. Longer edentulism, night-time wear, poor denture fit, female sex, and older age were independently associated with the outcome. These results demonstrate a workable measurement and analysis protocol but do not constitute clinical evidence and require confirmation with ethically approved, prospectively collected data.

DECLARATIONS

Ethical Approval:

Patient Consent:

Conflict of Interest: None to declare.

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Data Availability:

Authors' Contribution:

Disclosure:

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