

Prosthetic Occlusal Stability, Masticatory Function, and Auditory Phenotyping In Removable Denture Users

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ABSTRACT

Background: Somatosensory tinnitus may coexist with temporomandibular disorders and altered jaw function, while removable prostheses can change occlusal contacts and masticatory loading. Direct evidence linking artificial-tooth wear or denture-related occlusal instability to tinnitus remains limited.

Objective: To examine longitudinal prosthodontic outcomes and evaluate an age-stratified audiometry analysis framework relevant to somatosensory tinnitus research.

Methods: Summary-level data from a 12-month prospective prosthodontic cohort of 90 removable denture users were evaluated together with a separate simulated audiometry dataset of 90 age-stratified records used for methodological validation. Clinical outcomes included two-colour chewing-gum mixing efficiency at 15 and 30 seconds, three-dimensional occlusal surface change, Vickers microhardness, and compressive strength. The audiometry dataset contained bilateral thresholds at 1000, 2000, 4000, and 8000 Hz. Boxplots and age-stratified inferential tests were used to evaluate the proposed auditory analysis pipeline; no patient-level linkage between the two datasets was assumed.

Results: In the prosthodontic cohort summary, 15-second masticatory efficiency declined from 69.77 $\pm$ 5.34% at baseline to 66.22 $\pm$ 5.04% at 12 months, while the 30-second value declined from 87.73 $\pm$ 6.41% to 85.01 $\pm$ 5.17%. Mean occlusal surface change increased from 0% to 1.39 $\pm$ 0.32%. Wear was inversely associated with masticatory efficiency ($r=-0.72$ for 15 seconds and $r=-0.68$ for 30 seconds). In the audiometry pipeline analysis, thresholds increased with age and frequency. Tinnitus-specific associations were not estimated because tinnitus endpoints were not included in that dataset.

Conclusion: Longitudinal prosthodontic phenotyping can quantify clinically relevant changes in occlusal stability and mastication, but these data alone cannot establish a somatosensory tinnitus mechanism. A valid clinical study must link patient-level denture, DC/TMD, audiometric, tympanometric, and THI/TFI measurements at common time points and control strongly for age and hearing loss.

Keywords: Removable denture; occlusal wear; masticatory performance; somatosensory tinnitus; temporomandibular disorders; pure-tone audiometry.

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INTRODUCTION

Tinnitus is the perception of sound without a corresponding external acoustic source and is heterogeneous in mechanism, clinical burden, and response to treatment. Population estimates vary because case definitions and time frames differ, but contemporary syntheses confirm that tinnitus is common and that a smaller clinically important subgroup experiences persistent or disabling symptoms^{1,2}. The auditory system remains central to most tinnitus models; however, somatosensory input from the cervical and trigeminal systems can alter activity within auditory pathways and modulate tinnitus loudness or pitch in selected patients¹.

Temporomandibular disorders (TMDs), masticatory muscle pain, oral parafunctions, and tinnitus frequently coexist³. An updated 2026 meta-analysis reported a pooled tinnitus prevalence of 31.8% among patients with TMDs and an odds ratio of 3.924 for tinnitus in individuals with versus without TMD, while emphasizing extreme heterogeneity, observational designs, self-reported outcomes, and the inability to infer causality⁴. Earlier systematic reviews reached the same cautious conclusion: the association is clinically meaningful enough to investigate but is vulnerable to referral bias, diagnostic inconsistency, age-related confounding, and reverse causation^{5,6}.

The potential relevance of removable prosthodontics is plausible but under-tested. Artificial teeth undergo material-dependent wear; changes in cusp-fossa anatomy and occlusal contacts may alter masticatory muscle recruitment, mandibular position, prosthesis stability, and symptom-provoking jaw movements. Clinical studies have linked poor prosthesis occlusion or vertical dimension to worse masticatory performance⁷, and optical three-dimensional methods can quantify denture-tooth wear over time⁸. These observations do not prove a tinnitus mechanism, but they identify measurable prosthodontic exposures that could be incorporated into a rigorous somatosensory tinnitus study.

The analysis included longitudinal summary outcomes from a cohort of 90 removable denture users followed for 12 months, with repeated masticatory-performance and three-dimensional occlusal-surface measurements. A separate simulated audiometry dataset of 90 age-stratified records was used solely to evaluate the statistical and visualization workflow. Because the datasets were not linked at participant level, the auditory analysis is presented as methodological validation and not as evidence of an association between denture-related outcomes, hearing thresholds, or tinnitus⁹.

METHODS

Study design and data structure

This methodological integration study used aggregate outcomes from a prospective 12-month clinical cohort of 90 adults with partial secondary edentulism treated with removable acrylic plate dentures. A separate simulated

audiometry dataset contained 90 records divided equally among three age strata and was used only to evaluate the analysis workflow. The datasets had no common participant identifier and were not statistically linked¹⁰.

Clinical prosthodontic cohort

The prosthodontic cohort comprised 90 patients aged 18-74 years, with 30 participants in each of the 18-44, 45-59, and 60-74 year groups. All underwent removable plate-denture rehabilitation and were evaluated at baseline, 6 months, and 12 months. Only aggregate cohort outcomes were available for the present analysis; participant-level demographic data, recruitment dates, and detailed eligibility criteria were not available for independent reanalysis^{9,10}.

Masticatory performance

Masticatory performance was assessed using a two-colour chewing-gum mixing test at 15 and 30 seconds. After chewing, samples were photographed and processed by an automated hue-saturation-value colour-segmentation method that quantified the proportion and uniformity of mixed colour zones. The method is described as automated colour segmentation rather than a machine-learning algorithm. Two-colour mixing tests are established tools for quantifying masticatory function, including in complete-denture wearers, when image acquisition and analysis are standardized¹¹.

Occlusal surface change and material properties

Artificial-tooth occlusal surfaces were scanned at baseline, 6 months, and 12 months using a Medit T710 laboratory scanner. Digital models were compared in exocad, and surface change was expressed as a percentage. The laboratory component measured Vickers microhardness under an HV 0.5 protocol and compressive strength. These measurements characterize material behavior and occlusal stability; they do not by themselves diagnose TMD or somatosensory tinnitus¹².

Audiometry analysis framework

The audiometry pipeline dataset included right- and left-ear air-conduction thresholds at 1000, 2000, 4000, and 8000 Hz. Binaural frequency-specific values were calculated as the arithmetic mean of the two ears. Right-ear and left-ear four-frequency averages and the lower (better-ear) average were also available. The term 'PTA4' was not used because 500 Hz was unavailable; the metric was therefore labelled as an average from 1-8 kHz. Tinnitus presence and THI/TFI scores were not included in the pipeline dataset.

Statistical analysis

Clinical prosthodontic outcomes were summarized using means, standard deviations, and reported correlations. Because individual clinical observations were unavailable for reanalysis, repeated-measures models, distribution checks, attrition analyses, and adjusted associations could not be independently reproduced. For the

simulated audiometry pipeline dataset, frequency-specific distributions were summarized by mean, standard deviation, median, interquartile range, minimum, and maximum. One-way ANOVA and Kruskal-Wallis tests compared the three age strata; these tests evaluated the behavior of the analytical pipeline and are not interpreted as clinical evidence. Boxplots show medians, interquartile ranges, whiskers, and outliers. Analyses were performed using pandas, SciPy, NumPy, and Matplotlib¹³.

RESULTS

Clinical prosthodontic outcomes

Masticatory efficiency decreased modestly across 12 months. At 15 seconds, the mean declined from 69.77 $\pm$ 5.34% at baseline to 67.89 $\pm$ 5.30% at 6 months and 66.22 $\pm$ 5.04% at 12 months. At 30 seconds, the corresponding means were 87.73 $\pm$ 6.41%, 86.35 $\pm$ 5.66%, and 85.01 $\pm$ 5.17%. The longer chewing interval consistently produced higher mixing values, but both series showed the same direction of change.

Mean occlusal surface change increased from 0% at baseline to 0.68 $\pm$ 0.20% at 6 months and 1.39 $\pm$ 0.32% at 12 months. The dissertation summary reported inverse correlations between surface change and masticatory efficiency ($r=-0.72$ for the 15-second test and $r=-0.68$ for the 30-second test; both $p<0.001$). These estimates support internal coherence between progressive wear and reduced mixing performance, but confidence intervals and adjusted models could not be recalculated without participant-level data.

Table 1

Figure 1

Material-specific findings

Microhardness varied widely across the evaluated materials. Eray had the highest reported value (176.1 HV) and the lowest 12-month surface change (1.05 $\pm$ 0.25%). Yamahachi showed the highest compressive strength (135 $\pm$ 4.5 MPa) but greater 12-month surface change (1.55 $\pm$ 0.30%). The source summary reported correlations of $r=0.74$ between microhardness and preservation of the occlusal surface and $r=0.61$ between compressive strength and surface preservation. These results reinforce the need to evaluate hardness, strength, wear, occlusal behavior, and function jointly rather than treating a single material property as a surrogate for clinical benefit.

Table 2

Audiometry analysis pipeline

The simulated pipeline dataset contained 90 records, with 30 records per age stratum; 56 were labelled female and 34 male. The hearing-category field classified 40 records as normal, 42 as mild, and 8 as moderate. These methodological categories do not estimate hearing-loss prevalence among removable denture users.

The pipeline dataset showed an age-frequency gradient. Mean binaural thresholds in the 18-44, 45-59, and 60-74 year groups were 13.1, 18.5, and 26.2 dB HL at 1000 Hz;

Table 1: Twelve-month prosthodontic outcomes.

Outcome	Baseline	6 months	12 months
Masticatory efficiency, 15 seconds (%)	69.77 $\pm$ 5.34	67.89 $\pm$ 5.30	66.22 $\pm$ 5.04
Masticatory efficiency, 30 seconds (%)	87.73 $\pm$ 6.41	86.35 $\pm$ 5.66	85.01 $\pm$ 5.17
Occlusal surface change (%)	0	0.68 $\pm$ 0.20	1.39 $\pm$ 0.32

Twelve-month prosthodontic outcomes (summary-level clinical data)

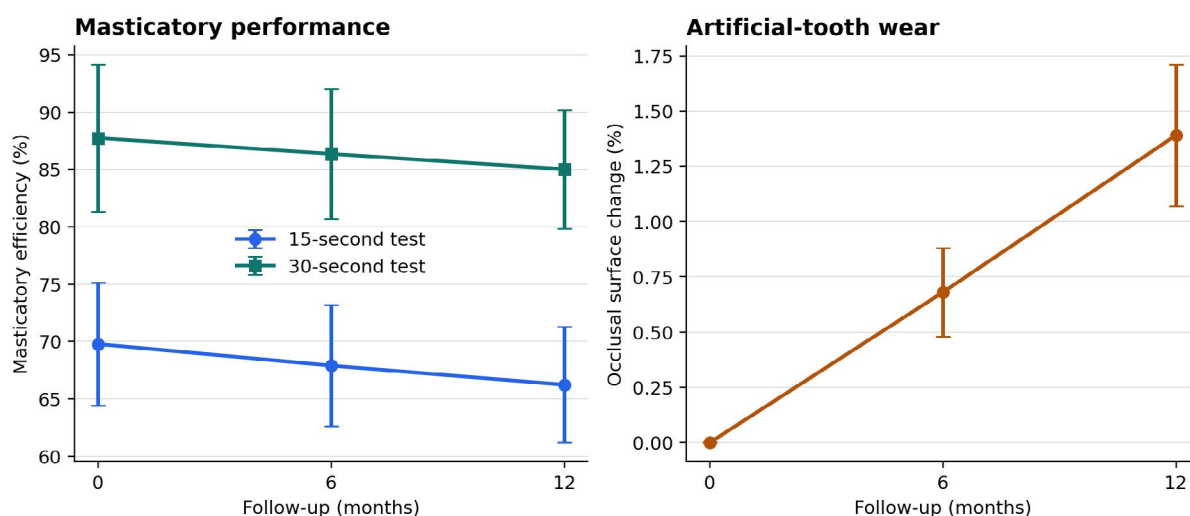


Figure 1: Twelve-month prosthodontic outcomes. Error bars show the reported standard deviations. The figure presents summary-level clinical data and does not imply an auditory or tinnitus treatment effect.

Table 2: Artificial-tooth material properties and 12-month surface change.

Material	Vickers microhardness (HV)	Compressive strength (MPa)	12-month surface change (%)
Tiziano	40.1	130 +/- 4.2	1.42 +/- 0.29
Yamahachi	27.0	135 +/- 4.5	1.55 +/- 0.30
Super S	23.9	132 +/- 4.3	1.60 +/- 0.31
Eray	176.1	120 +/- 3.8	1.05 +/- 0.25
Kali	67.9	115 +/- 4.0	1.45 +/- 0.28
Press Ceramic	56.3	128 +/- 4.1	Not reported
Spofad	22.6	Not reported	1.48 +/- 0.27

14.4, 23.2, and 33.0 dB HL at 2000 Hz; 18.1, 31.1, and 45.4 dB HL at 4000 Hz; and 23.1, 42.7, and 59.7 dB HL at 8000 Hz. ANOVA and Kruskal-Wallis tests were significant at every frequency. These results evaluate table generation, distribution displays, and age-stratified code; they do not demonstrate a biological effect of dentures or occlusal wear.

Table 3**Tinnitus endpoint availability**

Tinnitus presence and THI/TFI scores were not included in the audiometry pipeline dataset. Consequently, tinnitus prevalence, severity, laterality, pitch, jaw-movement modulation, change after occlusal correction, mediation by TMD pain, and associations with auditory thresholds were not estimated. No tinnitus-specific odds ratio, regression coefficient, or treatment effect was calculated.

DISCUSSION**Principal findings**

This study preserves the principal prosthodontic findings while evaluating an analysis framework relevant to future tinnitus research¹⁴. The clinical summary documents progressive artificial-tooth surface change over 12 months and a parallel decline in two-colour mixing performance. These outcomes are directly relevant to prosthetic material selection, occlusal monitoring, and functional follow-up. They are not, on their own, evidence that denture wear causes tinnitus or hearing loss¹⁵.

The audiometry pipeline produced age-stratified tables

and distribution-sensitive graphics, including boxplots. It also illustrates why age must be controlled: the simulated separation between strata increased markedly at 4000 and 8000 Hz. In a real clinical study, failure to adjust for age, sex, noise exposure, ototoxic medication, vascular risk, and baseline hearing would create substantial confounding. Hearing impairment could influence tinnitus independently of any stomatognathic mechanism, while age could influence both prosthodontic status and hearing.

Relationship to somatosensory tinnitus evidence

The literature supports coexistence rather than a simple causal chain. Tinnitus is more common in TMD populations in many observational studies¹⁶⁻¹⁹, and neuroanatomical work supports convergence of somatosensory and auditory inputs²⁰. Yet the 2026 meta-analysis reported major diagnostic heterogeneity, reliance on self-report, and evidence of publication bias⁵. The strongest clinical approach is therefore to phenotype a subgroup with reproducible somatic modulation and standardized TMD assessment rather than to attribute tinnitus to any occlusal finding.

Interventional evidence is encouraging but specific. A randomized trial found that multidisciplinary non-invasive orofacial treatment reduced tinnitus severity in selected patients with temporomandibular-related somatosensory tinnitus²¹, and mediation analysis suggested that improvement in TMD pain contributed to tinnitus reduction²²⁻²⁴. These findings do not establish that prosthetic occlusal correction alone is effective. They

Table 3: Age-stratified binaural thresholds in the synthetic audiometry dataset.

Frequency	Age stratum	n	Mean +/- SD (dB HL)	Median (IQR), dB HL
1000 Hz	18-44 years	30	13.1 +/- 5.5	12.5 (8.1-17.5)
1000 Hz	45-59 years	30	18.5 +/- 4.7	18.8 (15.0-22.5)
1000 Hz	60-74 years	30	26.2 +/- 5.2	25.0 (22.5-30.0)
2000 Hz	18-44 years	30	14.4 +/- 5.6	15.0 (10.0-17.5)
2000 Hz	45-59 years	30	23.2 +/- 4.9	23.8 (18.1-27.5)
2000 Hz	60-74 years	30	33.0 +/- 5.0	32.5 (30.0-37.5)
4000 Hz	18-44 years	30	18.1 +/- 5.6	17.5 (15.0-21.9)
4000 Hz	45-59 years	30	31.1 +/- 5.9	30.0 (27.5-35.0)
4000 Hz	60-74 years	30	45.4 +/- 6.6	45.0 (42.5-50.0)
8000 Hz	18-44 years	30	23.1 +/- 7.1	22.5 (17.5-27.5)
8000 Hz	45-59 years	30	42.7 +/- 7.9	43.8 (40.0-45.0)
8000 Hz	60-74 years	30	59.7 +/- 6.3	60.0 (55.0-65.0)

indicate that patient selection, standardized diagnosis, and repeated outcome measurement are critical²⁵.

For removable denture users, occlusal wear could be studied as one component of a broader exposure construct that includes prosthesis stability, retention, vertical dimension, functional tooth units, occlusal contact symmetry, masticatory muscle tenderness, joint pain, joint sounds, bruxism, and jaw-dependent tinnitus modulation. The available prosthodontic outcomes provide several longitudinal variables, especially wear and masticatory performance, but the dataset did not include DC/TMD or tinnitus endpoints. A future primary analysis could use change in THI or TFI as the dependent variable among participants with baseline tinnitus, with time, occlusal wear, DC/TMD status, and their interactions modelled using a linear mixed-effects approach. Baseline tinnitus severity, age, baseline hearing, noise exposure, and relevant vascular and metabolic covariates should be prespecified. Secondary analyses could test whether change in TMD pain or masticatory performance mediates tinnitus improvement. Audiometric thresholds should remain secondary unless a biologically plausible and time-aligned hearing hypothesis is specified. Multiplicity control and sensitivity analyses excluding conductive pathology should be included.

Strengths and limitations

The principal strength is methodological transparency. Clinical prosthodontic summaries and simulated audiometry records were not combined at participant level, and the auditory analysis is explicitly limited to pipeline evaluation. The framework keeps prosthodontic material behaviour, occlusal surface change, and masticatory function at the centre of the research question²⁶.

The limitations are decisive. Individual-level prosthodontic data were unavailable for independent reanalysis, preventing verification of distributional assumptions, missingness, attrition, repeated-measures effects, confidence intervals, and adjusted correlations²⁷. Recruitment dates, detailed eligibility criteria, and sex distribution were not available in the analytical dataset²⁸. The audiometry records were simulated and were not linked to dental outcomes, and tinnitus or THI/TFI endpoints were not included. Therefore, the auditory component is methodological and hypothesis-generating and does not provide evidence of a clinical association or treatment effect²⁹.

CONCLUSION

The prosthodontic outcomes support a coherent longitudinal finding: artificial-tooth occlusal surface change accumulates during 12 months of removable denture use and accompanies a modest decline in two-colour masticatory performance. These observations justify careful prosthetic monitoring and provide measurable exposures for future somatosensory tinnitus research. The separate simulated audiometry dataset demonstrates an age-stratified analysis and

boxplot workflow but contains no tinnitus endpoints. Clinical inference will require participant-level linkage of prosthodontic outcomes with standardized DC/TMD assessment, comprehensive audiology, and validated THI or TFI measures

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Tashkent State Dental Institute (Protocol No. 8, dated 1 May 2024). Written informed consent was obtained from all participants.

DATA AVAILABILITY

The audiometry pipeline dataset and analysis code used to create the tables and boxplots are available from the corresponding author on reasonable request. Participant-level prosthodontic data were not available for the present secondary analysis.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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