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ORIGINAL ARTICLE

Periodontal Mechanoreceptor Contribution to Minimal Holding Force Between Incisor Teeth

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ABSTRACT

Background: The functional importance of periodontal mechanoreceptors (PMRs) is highlighted by impaired force control when periodontal input is reduced or absent. Previous studies used handheld transducers to measure the minimum holding force between the incisors. In the present study, a high-resolution force transducer was held passively between the incisors against gravity.

Objective: To quantify the contribution of anterior PMRs to minimum holding force and examine the effects of body position and periodontal health.

Methods: Twenty healthy adults (12 females, 8 males; 23.2 ± 1.9 years) participated in this repeated-measures study. A lightweight FlexiForce transducer was positioned passively between the incisors and held against gravity. Minimum holding force was measured in sitting and prone positions before and after local anaesthesia (LA) of the incisors. Data were analysed using linear mixed models and correlation analyses.

Results: Mean minimum holding force in the sitting position increased from 0.63 N to 1.87 N following LA. In comparison, prone values increased from 1.23 N to 2.63 N. Significant main effects were observed for position ($p = 0.027$) and LA ($p = 0.036$), with no interaction effect ($p = 0.848$). Periodontal health was significantly associated with holding force only when LA was present ($R^2 = 0.234$, $p = 0.031$).

Conclusion: Reduced periodontal sensory input from the anterior dentition may impair early detection of food properties, potentially compromising feedforward control during mastication. These findings highlight the functional importance of periodontal integrity and the need to retain healthy teeth in restorative and orthodontic treatment planning.

1 | Introduction

Teeth are suspended within the alveolar bone by the periodontal ligament (PDL), a specialised connective tissue that permits small, controlled tooth displacements during function [1, 2]. Embedded within the PDL are highly sensitive periodontal mechanoreceptors (PMRs) that respond to forces applied to the teeth in multiple directions [3, 4]. Even minimal tooth displacement can generate stress and strain within the ligament, activating low-threshold afferents [3–5].

PMRs transmit sensory input to the trigeminal brainstem nuclei, where they critically regulate jaw muscle activity and coordinate jaw movements [6–9]. Their discharge properties are characterised by high sensitivity to low force levels, particularly in anterior teeth, where receptor firing increases steeply below approximately 1 N [1, 3, 4]. This encoding enables precise modulation of bite force during object manipulation and the early phases of mastication. Sensory feedback from PMRs enables rapid feedforward adjustment of motor output, ensuring efficient food breakdown while preventing excessive loading [3, 10–12].

The functional importance of PMRs is underscored by studies demonstrating impaired force control when periodontal input is reduced or absent [3, 13, 14]. Individuals with dental implants or complete dentures, who lack functional periodontal afferents, exhibit increased and more variable bite forces during food handling and object holding [15, 16]. Similarly, transient elimination of anterior periodontal input by local anaesthesia (LA) results in elevated incisal holding forces [17–20]. Periodontal disease, characterised by loss of attachment and increased tooth mobility, may alter mechanoreceptive function and sensory-motor integration [21]. Previous work reported that the minimum force required to hold an object between the incisors is approximately 0.6 N in dentate individuals, increasing nearly fourfold following LA [19].

Despite these observations, experimental data on incisal holding force remain limited. Prior studies required subjects to manually hold the force transducer during a hold-then-bite paradigm, which may have influenced their force control strategies. The minimum holding force requires that, when the holding force is reduced further, the transducer should fall. Thinking along these lines, we have attempted to measure the minimum holding force against gravity both while sitting with the head bent and in the prone position. Two different positions against gravity are used to suggest a more convenient position for studying the holding force in the future.

The present study replicates and extends earlier investigations of incisal holding force using a lightweight, high-resolution force transducer capable of detecting forces as low as 4 mN. Unlike previous designs, the device was held passively between the incisors, against gravity, without manual assistance. Minimum holding force was recorded in both sitting and prone positions, before and after LA of the anterior teeth and correlated with indices of periodontal and gingival health.

We hypothesised that (1) minimum incisal holding force is lower and more variable than previously reported when measured without manual stabilisation and (2) holding force increases with reduced periodontal sensory integrity, as reflected by LA and worsening periodontal health. By refining the measurement paradigm, this study aims to delineate further the functional role of anterior periodontal mechanoreceptors in the fine control of oral forces.

2 | Materials and Methods

2.1 | Participants

Twenty healthy adults (12 females, 8 males; mean age ± SD: 23.2 ± 1.9 years) with natural, non-crowded dentition and who exhibited a skeletal pattern Class I relationship with normal overjet (mean ± SD: 1.70 ± 0.78 mm) and overbite values (2.02 ± 0.90 mm; details in Table 1). They had no history of orthodontic or periodontal therapy within the previous 6 months, and no temporomandibular disorders. Exclusion criteria included systemic disease affecting neuromuscular function, medications that influence sensory or motor performance and current orofacial pain.

TABLE 1 | Skeletal pattern and overjet and overbite values of the subjects.

Subjects	Overbite	Overjet	Skeletal pattern
1	1.00	1.00	Class 1
2	3.00	3.00	Class 1
3	2.00	1.00	Class 1
4	2.00	3.00	Class 1
5	2.00	2.00	Class 1
6	1.00	1.00	Class 1
7	1.00	1.00	Class 1
8	1.50	2.00	Class 1
9	2.00	2.00	Class 1
10	2.00	2.00	Class 1
11	3.00	1.00	Class 1
12	2.00	2.00	Class 1
13	2.00	1.50	Class 1
14	4.00	3.00	Class 1
15	2.00	2.00	Class 1
16	3.00	2.00	Class 1
17	3.00	1.00	Class 1
18	2.00	1.50	Class 1
19	0.00	0.00	Class 1
20	2.00	2.00	Class 1

The study protocol was approved by the Koç University Human Research Ethics Committee (2017.124.IRB2.038) and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to participation.

2.2 | Experimental Design

A within-subject repeated-measures design was used. Minimum holding force was assessed under four conditions:

1. Sitting—without anaesthesia
2. Prone—without anaesthesia
3. Sitting—with LA
4. Prone—with LA

The order of sitting and prone positions was randomised. All non-anaesthetised trials were completed before LA was administered.

2.3 | Body Positions

2.3.1 | Sitting Position

Participants were seated comfortably in a quiet room. The head was tilted forward so that the occlusal plane was perpendicular to the ground. A pillow was placed on the lap to protect the sensor if dropped.

2.3.2 | Prone Position

Participants lie comfortably on an examination table. The occlusal plane was again aligned perpendicular to the ground to maintain consistent gravitational loading across positions. (Figure 1).

2.4 | Local Anaesthesia

LA was administered by an experienced dentist using articaine hydrochloride with epinephrine (80 mg/2 mL articaine +0.02 mg/2 mL epinephrine; Maxicaine Fort, Vem Pharmaceuticals). Infiltration was performed bilaterally from canine to canine in both jaws (approximately 0.5 mL buccally and 0.1 mL palatally per tooth). Successful anaesthesia was confirmed by subjective numbness and absence of response to light tactile stimulation and pressure testing. Experimental procedures were repeated under anaesthetised conditions.

2.5 | Outcome Measures

The primary outcome variable in this study was the holding force, and the secondary variables were the clinical attachment level, bleeding on probing, plaque and gingival inflammation.

2.6 | Holding Force Assessment

Participants were familiarised with the apparatus prior to testing and were blindfolded during data collection to eliminate visual feedback. The transducer was positioned between the upper and lower central incisors and held passively against gravity without manual assistance. Participants were instructed to maintain the minimal force necessary to prevent the transducer from falling and to avoid contact with their lips or tongue. After 30 s, participants were instructed to 'let go', allowing the transducer to fall onto a pillow (placed on the lap in the sitting position; on a stool in the prone position). For each trial, the holding force was determined at the steady state reached towards the end of the 30-s holding interval, and values within this stable window were used for analysis (Figure 2).

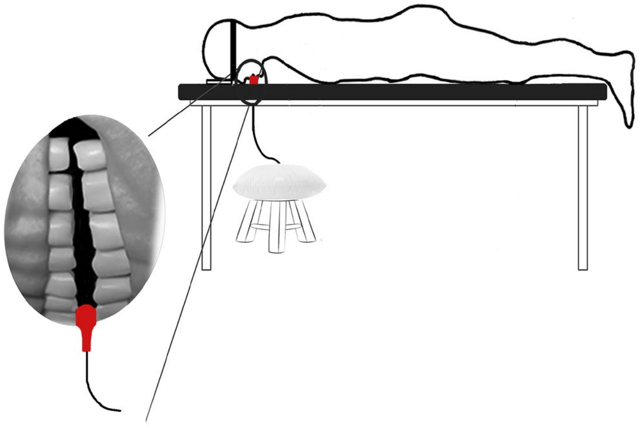

FIGURE 1 | Transducer was placed between the participant's upper and lower incisors. Subjects were instructed to hold the transducer between their incisors with minimal force and to prevent it from falling. It was also emphasised that subjects should not touch the transducer with their lips or tongues. There was a large hole in the head of the examination bed, and a pillow on a stool protected the transducer if it fell.

Each condition consisted of five 30-s trials. The first trial served as a familiarisation trial and was excluded from the analysis. The remaining four trials were averaged. A 30-s rest interval was provided between trials. A 1-min rest interval was provided between positions.

2.7 | Force Transducer

Incisal holding force was measured using a FlexiForce piezoresistive sensor (Tekscan Inc., Boston, MA, USA). The sensor consisted of two polyester substrates coated with conductive silver and pressure-sensitive ink (0.203 mm thick). To make the device, we glued two 2 mm-thick hard-rubber squares to both sides of the sensor so it could be comfortably held between the teeth. This addition increased the device's thickness to about 5 mm (1 cm length and 1 cm width). Applied force reduced electrical resistance in proportion to load. The device was calibrated before and after each experiment.

The transducer had a response time of 50 µs, a force resolution of 4 mN. The total weight of the measurement apparatus, including the sensor, was 4 g. The active sensing area of the transducer was positioned between the maxillary and mandibular incisors. For hygiene, the sensor assembly was covered with a sterile transparent film and replaced between participants.

2.8 | Clinical Periodontal Assessment

Periodontal status was classified according to the 2017 World Workshop Classification of Periodontal and Peri-Implant Diseases and Conditions [22, 23]. All measurements were performed by a single examiner using a UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA) before the administration of local anaesthesia. The following parameters were recorded at six sites per tooth:

- Clinical attachment level (CAL, mm)
- Bleeding on probing (BOP, %)
- Plaque index (PI)
- Gingival index (GI)

PI and GI were scored on established 0–3 scales [24]. Full-mouth BOP was expressed as a percentage of bleeding sites. CAL was measured as the distance from the cemento-enamel junction to the base of the sulcus/pocket [23, 25].

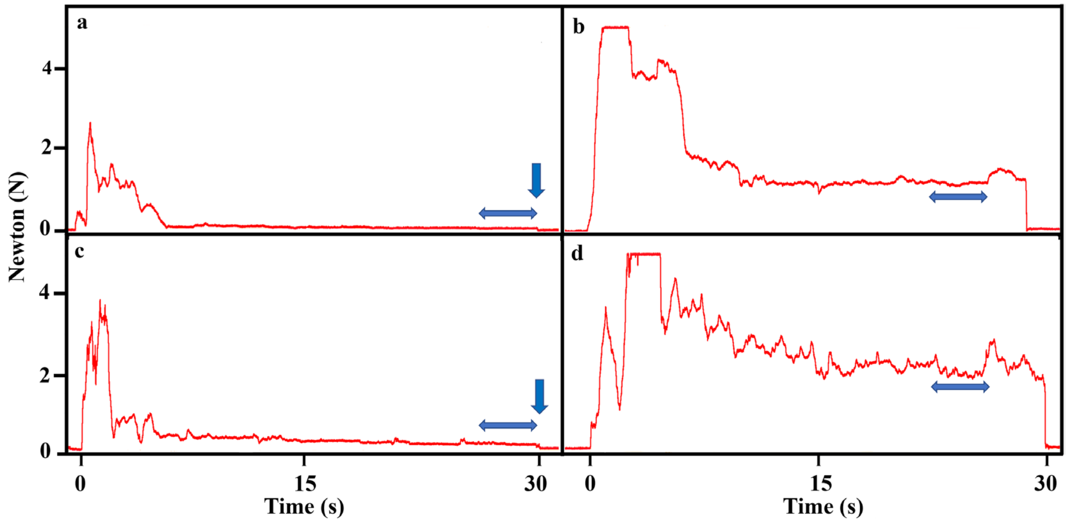

FIGURE 2 | Example of the holding force before and after local anaesthetic application. (a) Holding force while sitting before local anaesthetic application, (b) Holding force while sitting after local anaesthetic application, (c) Holding force during prone before local anaesthetic application, (d) Holding force during prone after local anaesthetic application. Note that when the subject first bites the transducer, the force trace increases dramatically and then settles to a steady level. Holding force for each trial was determined from a steady-state period defined as at least 5 consecutive seconds of stable minimal holding force without abrupt fluctuations in the force trace. This steady-state period generally occurred towards the end of the 30-s holding period, although in some participants it appeared earlier once stable control of the transducer was achieved, as shown by the horizontal double-headed arrows. This single recording was obtained from Subject 11.

2.9 | Data Processing and Statistical Analysis

First, all individual trial values obtained across experimental conditions were examined to identify the highest minimum holding force recorded for each participant. The condition in which this value occurred was then identified, and the mean of the four analysed trials from that condition was defined as the 100% reference value. Subsequently, all individual trial values were normalised relative to this reference and expressed as percentages to enable inter-individual comparisons.

Data normality was assessed using the Shapiro–Wilk test. To further examine the effects of experimental conditions, a linear mixed model (LMM) was applied. Body position (sitting vs. prone), LA (with vs. without) and gender were included as fixed effects, along with their interaction terms, while subject was included as a random effect to account for within-subject variability. Variability across experimental conditions was additionally evaluated using the coefficient of variation (CV), calculated as (standard deviation/mean)×100. Intra-rater reliability of repeated holding-force measurements was assessed using intraclass correlation coefficients (ICCs). A two-way random-effects model with absolute agreement (ICC [2,1]) was applied for each experimental condition. ICC values were interpreted as follows: <0.50 indicates poor reliability; 0.50–0.75, moderate reliability; 0.75–0.90, good reliability; and >0.90, excellent reliability. Additionally, associations between holding force and periodontal parameters (CAL, BOP, PI and GI) were evaluated using linear regression models. All analyses were performed using IBM SPSS Statistics, and statistical significance was set at $\alpha = 0.05$.

A priori power analysis was performed using G*Power 3.1.9.7. Based on a repeated-measures ANOVA design with four within-subject conditions, an effect size of $f = 0.2526$, $\alpha = 0.05$, power $(1-\beta) = 0.80$, and an assumed correlation of $r = 0.60$ among repeated measures, the required sample size was estimated to be 19 participants. Therefore, 20 participants were included in the study.

3 | Results

3.1 | Reliability

Intra-rater reliability analysis demonstrated overall good-to-excellent reliability across the four experimental conditions, based on average measurements. Reliability was lowest in the sitting-without-LA condition and highest in the prone-with-LA condition. In all conditions, average-measure ICC values were higher than single-measure ICC values. All ICC values were statistically significant ($p < 0.001$) (Table 2).

3.2 | Minimum Holding Force Across Experimental Conditions

The mean holding force values for the four test conditions are presented for each participant and as overall means in Table 3.

LMM analysis revealed a significant main effect of position on normalised holding force (F = 5.773, $p = 0.027$), indicating that holding force differed between sitting and prone conditions. A significant main effect of LA was also observed ($F = 5.101$, $p = 0.036$), suggesting that anaesthesia significantly influenced holding force values. However, the interaction between position and LA was not significant ($F = 0.038$, $p = 0.848$), indicating that the effect of anaesthesia on holding force did not differ across body positions. Additionally, when gender was included as a covariate in the model to evaluate its potential confounding effect, no significant main effect of gender ($F = 0.091$, $p = 0.767$)

TABLE 2 | Intra-rater reliability of holding force measurements.

Condition	ICC (Single)	ICC (Average)	95% CI	Interpretation[a]
Sitting without LA	0.484	0.789	0.583–0.908	Moderate–Good
Sitting with LA	0.705	0.905	0.814–0.958	Good–Excellent
Prone without LA	0.723	0.913	0.829–0.961	Good–Excellent
Prone with LA	0.892	0.971	0.942–0.987	Excellent

Abbreviations: CI, Confidence Interval; ICC, Intraclass Correlation Coefficient; LA, Local Anaesthesia.
[a]Interpretation was based on average-measure ICC values. ICC was calculated using a two-way random-effects model with absolute agreement.

or gender-related interaction effects were observed (Position × Gender: $p=0.530$; LA × Gender: $p=0.523$) (Table 4). These findings are illustrated in Figure 3.

3.3 | Associations With Periodontal Parameters

Mean full-mouth clinical parameters were as follows: CAL, 1.87 ± 0.17 mm; BOP, 23.19% ± 18.00%; PI, 0.83 ± 0.44; and GI, 0.71 ± 0.43.

Linear regression analyses revealed that most periodontal parameters were not significantly associated with holding force across conditions ($p>0.05$) (Table 5). A significant association was found only between PI and holding force in the prone position with LA ($R^2=0.234$, $p=0.031$), indicating that higher plaque index values were associated with changes in holding force under this condition. No significant relationships were observed between GI, CAL, or BOP and holding force in any of the tested conditions (all $p>0.05$). Although not statistically significant, GI in the prone position with LA showed a moderate relationship with holding force ($R^2=0.164$, $p=0.076$). These relationships are illustrated in Figure 4.

3.4 | Adverse Events

No participant reported discomfort during testing, and no adverse events occurred following LA.

4 | Discussion

The present study demonstrates that anterior periodontal sensory input plays a critical role in regulating low-level incisal holding force. Under physiological conditions, participants maintained stable object holding with remarkably low forces in both sitting (0.63 N) and prone (1.23 N) positions. Following LA, minimum holding forces increased significantly in both positions (1.87 N and 2.63 N, respectively), indicating that the loss of anterior periodontal afferent input results in a systematic overestimation of force.

These findings provide direct experimental support for the role of periodontal mechanoreceptors in fine-tuning oral motor output. Periodontal afferents are characterised by exceptionally high sensitivity to low-magnitude strain, particularly below 1 N in anterior teeth [1, 3, 4]. Their activity provides high-resolution feedback regarding tooth load direction, magnitude and stability. When this feedback is pharmacologically blocked, the motor system appears to compensate by increasing force output to maintain object security, likely reflecting a safety-oriented control strategy in the absence of precise peripheral feedback. Our interpretation aligns with previous work demonstrating increased force levels and variability during experimental periodontal deafferentation and in clinical conditions with reduced periodontal input [3, 13, 14].

Importantly, the present results extend prior findings by demonstrating that the modulatory contribution of anterior periodontal mechanoreceptors persists across different gravitational orientations. The minimum holding force was significantly higher in the prone position than in the sitting position under non-anaesthetised conditions. This positional effect may reflect biomechanical influences of head–neck alignment and gravitational loading on the dentoalveolar complex, potentially altering strain distribution or muscle recruitment patterns. While in the sitting position, neck proprioceptors may have contributed to the holding force; in the prone position, these muscles are relaxed and may have lost their proprioceptive capacity. However, the consistent increase in holding force following anaesthesia in both positions indicates that anterior periodontal afferent input remains essential for low-force regulation irrespective of body orientation. Thus, periodontal feedback appears to provide a position-independent stabilising signal within the trigeminal sensorimotor system [1, 13–20].

The high coefficients of variation observed in the present study indicate substantial variability in minimum incisal holding force when measured without manual stabilisation. This finding is consistent with Svensson and Trulsson [18], who showed that force variability during food holding increased as periodontal sensory input was reduced, particularly in implant-supported prostheses. Although their paradigm differed from the present study, both findings suggest that periodontal mechanoreceptors contribute not only to force magnitude regulation but also to the stability of fine oral force control.

Inter-individual variability in holding force was substantial, whereas intra-individual variability remained relatively stable under intact sensory conditions. After anaesthesia, variability increased, suggesting reduced precision of motor output in the absence of anterior periodontal feedback. Similar patterns of increased force variability have been reported in both experimental deafferentation paradigms and in individuals with implant-supported prostheses lacking periodontal receptors [3, 4, 15, 16]. Collectively, these observations support the concept that periodontal mechanoreceptors contribute not only to force magnitude control but also to force stability and consistency.

TABLE 3 | Mean holding force values (N) obtained from individual participants are presented.

Subject	Sitting without LA	Sitting with LA	Prone without LA	Prone with LA	PI	GI	CAL	BOP
1	0.28	0.93	0.87	1.54	0.21	0.10	1.59	1.39
2	1.51	1.05	3.20	3.37	0.50	0.51	1.92	16.67
3	0.22	0.38	0.18	0.06	1.53	1.29	2.08	47.44
4	0.07	0.43	0.08	4.50	0.75	0.80	2.15	36.77
5	0.05	0.29	0.22	0.26	0.60	0.85	1.81	39.70
6	0.53	0.57	0.73	1.38	0.32	0.54	1.77	17.86
7	1.47	2.89	1.27	0.88	0.56	0.53	1.75	11.91
8	1.41	0.69	0.69	1.35	0.66	0.42	2.09	17.16
9	1.86	3.51	2.42	7.39	1.78	1.37	2.13	58.20
10	0.19	2.11	0.44	2.56	0.91	0.42	1.98	9.43
11	0.05	5.11	0.41	2.41	0.94	1.10	2.00	35.12
12	0.45	0.33	0.46	0.43	0.25	0.32	1.89	10.72
13	0.11	0.90	0.26	1.52	1.02	0.68	1.75	17.27
14	1.30	9.40	1.75	8.94	0.94	0.75	1.65	19.64
15	0.31	2.80	0.96	3.21	0.96	0.73	1.64	19.05
16	0.45	3.63	0.82	3.73	1.47	1.27	1.96	28.58
17	1.64	0.69	1.69	0.28	0.24	0.03	1.77	0.60
18	0.11	0.50	1.51	1.54	0.70	0.47	1.81	8.34
19	0.07	1.23	6.50	3.00	1.21	0.37	1.76	5.36
20	0.57	0.03	0.24	4.14	1.10	1.62	1.96	62.50
Median (IQR)	0.38 (0.09–1.38)	0.81 (0.41–2.72)	0.77 (0.25–1.63)	2.03 (0.73–3.64)	0.81 (0.53–1.00)	0.52 (0.40–0.89)	1.89 (1.76–1.99)	18.46 (9.16–37.50)
Mean ± SD	0.63 ± 0.63	1.87 ± 2.26	1.23 ± 1.49	2.63 ± 2.33	0.83 ± 0.44	0.71 ± 0.43	1.87 ± 0.17	23.19 ± 18.00
Coefficient of Variation (%)	100.00	120.86	121.14	88.59	53.01	60.56	9.09	77.62

4.1 | Relationship Between Holding Force and Anterior Periodontal Status

An exploratory objective of this study was to examine associations between holding force and clinical periodontal indices. Under intact sensory conditions, no significant relationships were observed between minimum holding force and CAL, BOP, PI, or GI, suggesting that mild variations in periodontal or gingival status within a healthy population do not substantially alter the functional performance of periodontal afferents.

Interestingly, significant correlations between holding force and PI, which indicate the health of the subjects' periodontal tissue, emerged only after LA. This finding, although highly speculative, may indicate that when periodontal mechanoreceptor input is compromised, secondary sensorimotor mechanisms—such as muscle spindle afferents from the jaw and cervical musculature, or temporomandibular joint receptors—are insufficient to fully compensate for the loss of periodontal feedback. In other words, periodontal mechanoreceptors appear to provide a unique and non-redundant contribution to fine oral motor control. Although these findings should be interpreted with caution, given the limited sample size, they suggest that periodontal proprioception may represent a distinct functional domain that is not readily replaced by other sensory systems.

TABLE 4 | Linear mixed model results for normalised holding force.

Fixed effect	*F*	df	*p*
Position	5.773	1, 18.856	0.027
LA	5.101	1, 18.147	0.036
Gender	0.091	1, 17.997	0.767
Position × LA	0.038	1, 19	0.848
Position × Gender	0.411	1, 18	0.530
LA × Gender	0.425	1, 18	0.523

Note: Values are based on a linear mixed model with participant as a random effect and an unstructured covariance matrix.
Abbreviation: LA, local anaesthesia.

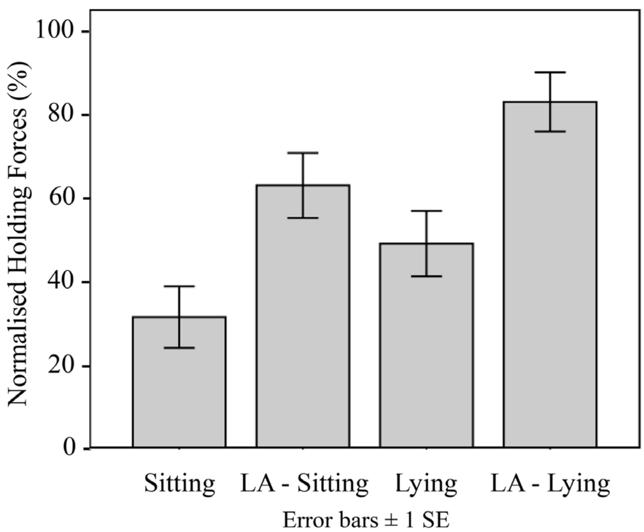

FIGURE 3 | Normalised holding forces data are presented as mean ± 1 standard error (SE). The LA application increased the holding force values in both positions.

4.2 | Methodological Considerations

Several methodological features strengthen the present study. First, the lightweight, gravity-dependent transducer design minimised the need for external stabilisation and reduced mechanical interference. Unlike handheld or manually stabilised sensor systems [17–19], the current setup ensured that insufficient holding force resulted in immediate sensor displacement, thereby providing a functionally relevant measure of the minimum force required to counteract gravity. This approach likely enhanced validity and measurement sensitivity. Second, the force sensor operated within the physiologically relevant low-force range of periodontal mechanoreceptor sensitivity. Because periodontal afferents exhibit maximal responsiveness at low force levels, particularly in anterior teeth [1, 3, 4], the high-resolution measurement system enabled detection of subtle changes in force regulation before and during anaesthesia.

Third, a systematic comparison of the sitting and prone positions, controlled for potential gravitational and head–neck orientation effects that have not been consistently addressed in previous holding-force paradigms. By maintaining the occlusal plane perpendicular to the ground in both conditions, the design allowed a controlled assessment of orientation-dependent modulation.

TABLE 5 | Results of linear regression analyses between clinical periodontal parameters and holding force under different conditions. Values represent the coefficient of determination (R^2) and *p*-values obtained from linear regression analyses.

	Sitting				Prone			
	Without LA		With LA		Without LA		With LA	
	R^2	*p*	R^2	*p*	R^2	*p*	R^2	*p*
PI	0.002	0.838	0.091	0.196	0.024	0.516	**0.234**	**0.031**
GI	0.006	0.746	0.042	0.386	0.064	0.284	0.164	0.076
CAL	0.007	0.731	0.033	0.446	0.041	0.390	0.011	0.657
BOP	0.000	0.989	0.001	0.874	0.087	0.207	0.123	0.129

Note: A linear regression model was used to obtain R^2 and *p*-values ($p < 0/05$) indicated in bold.
Abbreviations: BOP, bleeding on probing; CAL, clinical attachment level; GI, Gingival Index; LA, local anaesthesia; PI, plaque index.

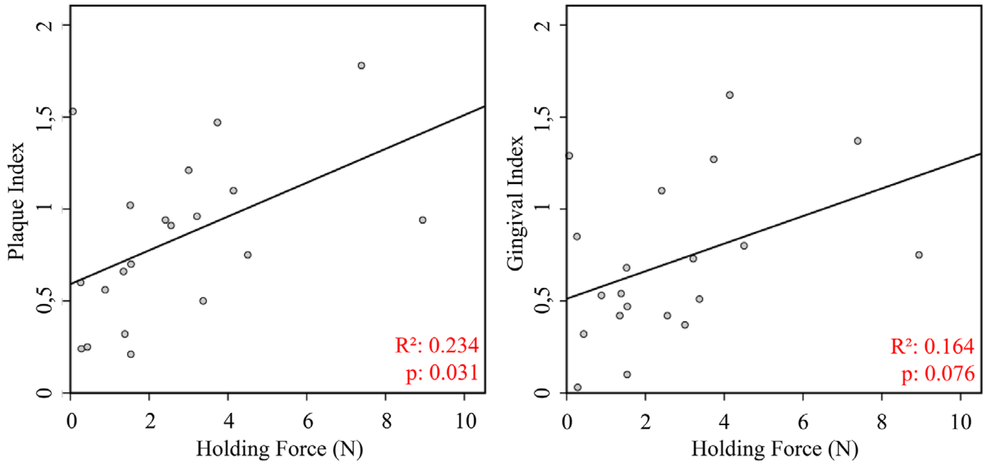

FIGURE 4 | Scatter plots illustrating the relationship between holding force (N) and periodontal indices (PI and GI) in the LA-prone condition. Each point represents one participant, and the solid line indicates the fitted linear regression model.

Finally, normalising force values to each participant's maximal condition reduced inter-individual scaling differences and enabled clearer identification of within-subject sensory effects. Notably, analyses using normalised values yielded different statistical patterns than raw force comparisons, underscoring the importance of accounting for individual motor scaling strategies.

4.3 | Limitations

The study has several limitations. The sample size was modest and consisted exclusively of systemically and periodontally healthy adults, limiting generalizability to clinical populations. In addition, because the study population was intentionally restricted to periodontally healthy individuals, the clinical periodontal variables (CAL, BOP, PI and GI) showed a relatively narrow range. This restricted variability likely reduced the statistical power to detect associations between periodontal status and holding force; therefore, these findings should be interpreted as exploratory. Furthermore, the relatively narrow age range of the participants limits the extrapolation of the findings across different age groups. Age-related alterations in periodontal mechanoreceptor sensitivity, neuromuscular control, proprioceptive acuity and oral sensorimotor integration may influence how holding force is regulated in older adults. The experimental instruction to maintain 'minimum force' inherently involves subjective interpretation, although the blindfolded design and gravity-dependent paradigm likely constrained behavioural variability. Additionally, only acute sensory blockade was examined; chronic sensory adaptation, as occurs in periodontal disease or implant rehabilitation, may produce different compensatory mechanisms. Also, we have only examined the holding force of the anterior teeth. Posterior teeth should also be studied to get the full picture. Furthermore, due to restrictions on bringing subjects to the lab, we have always used non-LA measurements before the LA measurements, which may have introduced learning and fatigue effects. Ideally, the LA conditions should have been counterbalanced.

Future studies should investigate larger and clinically diverse populations, including individuals with periodontitis, tooth loss, implant-supported prostheses, or temporomandibular disorders. Further studies including patients with gingivitis and periodontitis are also needed to determine whether inflammatory periodontal changes and loss of attachment modify holding force regulation and periodontal sensory contribution under more clinically relevant conditions. Integration with electromyographic recordings and neurophysiological techniques would further elucidate the central mechanisms underlying periodontal-motor integration.

4.4 | Clinical Considerations

Within the limitations of this study, anterior periodontal mechanoreceptors are essential for regulating low-level incisal holding force. Sensory blockade leads to systematic overproduction of holding force and increased variability, consistent with a compensatory motor strategy in the absence of high-resolution periodontal feedback. These findings reinforce the concept that periodontal afferents are a fundamental component of the trigeminal sensorimotor system, uniquely contributing to the precision and stability of oral motor control. Reduced periodontal sensory input from the anterior dentition may impair the early detection of food properties, potentially compromising anticipatory (feedforward) adjustments by the posterior teeth during mastication. During surgical and restorative planning of the anterior dentition, retaining periodontally healthy teeth through endodontic treatment rather than extraction may be advantageous. Such teeth can serve as strategic abutments for restorative rehabilitation while preserving periodontal sensory feedback.

5 | Conclusions

Within the limitations of this study, anterior periodontal mechanoreceptors are essential for regulating low-level incisal holding force. Sensory blockade leads to systematic overproduction of holding force and increased variability, consistent with a compensatory motor strategy in the absence of high-resolution periodontal feedback. These findings reinforce the concept that periodontal afferents are a fundamental component of the trigeminal sensorimotor system, uniquely contributing to the precision and stability of oral motor control.

Author Contributions

Elif Ezgi Oguz: methodology, validation, writing – review and editing, visualization. **Nilgun Yildiz:** methodology, validation, visualization, writing – review and editing, formal analysis, data curation. **Ilhan Karacan:** methodology, validation, visualization, writing – review and editing, data curation. **Kemal Sitki Türker:** conceptualization, investigation, funding acquisition, writing – original draft, writing – review and editing, visualization, validation, methodology, software, formal analysis, project administration, resources, supervision, data curation. **Hans-Werner Weisskircher:** methodology, validation, visualization, writing – review and editing. **Serap Karakis Akcan:** methodology, validation, visualization, writing – review and editing. **Ahmet Mihmanli:** methodology, validation, visualization, writing – review and editing. **Gulfem Ozlu Ucan:** methodology, validation, visualization, writing – review and editing. **Nursuna Busra Cetinkaya:** methodology, validation, visualization, writing – review and editing.

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Ethics Statement

Authors confirm that they have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data will be available upon reasonable request.

Peer Review

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