AFMN BIOMEDICINE

ORIGINAL ARTICLE

MONITORING MICROCIRCULATION IN THE PALATAL MUCOSA BENEATH AN UPPER COMPLETE DENTURE USING A LASER DOPPLER FLOWMETRY: A PRELIMINARY STUDY

Petar Tekić[1] **Stefan Vulović**[2] **Marija S. Milić**[3] **Marko Igić**[4,5] **Milena Kostić**[4,5] **Aleksandra Popovac**[2] **Ivica Stančić**[2] **Aleksandra Milić Lemić**[2]

[1]School of Dental Medicine, University of Belgrade, Belgrade, Serbia [2]Department of Prosthodontics, University of Belgrade, School of Dental Medicine, Belgrade, Serbia [3]Department of General and Oral Physiology, University of Belgrade, School of Dental Medicine, Belgrade, Serbia [4]Department of Prosthodontics, Clinic of Dental Medicine Niš, Niš, Serbia [5]University of Niš, Faculty of Medicine, Niš, Serbia

Older edentulous adults often rely on mucosa-supported complete dentures (CDs) due to limitations that preclude implant therapy. Although an adequate retention of maxillary CD is essential for functional efficiency, compression of the palatal mucosa during impression making may compromise palatal mucosal microcirculation during denture wear. The aim of the study was to evaluate short-term changes in palatal mucosal blood perfusion in elderly individuals during adaptation to newly fabricated maxillary CDs. Ten fully edentulous participants (mean age 67.3 years) received conventionally fabricated maxillary CDs and custom-made thermoplastic splintsreplicating the denture base. Palatal microcirculation was measured using laser Doppler flowmetry (LDF) through perforations in the splints at three regions (frontal, premolar, and molar), and at four time points: before denture insertion (T0), and at 30 min (T1), one week (T2), and six weeks (T3) post-insertion. Significant reductions in blood perfusion units (BPU) were observed over time in the premolar and molar regions ($p < 0.05$), while changes in the frontal region were not significant ($p > 0.05$). At each time point, the molar region exhibited higher BPU values than the other regions. The greatest reductions were noted between the initial (T0/T1) and later (T2/T3) stages. Short-term use of maxillary CDs was associated with reduced palatal mucosal blood perfusion, particularly in posterior regions. These findings underscore the importance of monitoring tissue response during maxillary complete denture adaptation to improve therapy outcomes in elderly patients.

Keywords: complete denture, laser Doppler flowmetry, microcirculation, palatal mucosa

Submitted: June 26, 2025 **Accepted:** August 13, 2025
Published online: March 15, 2026

Correspondence to:
Stefan Vulović
Department of Prosthodontics
School of Dental Medicine
University of Belgrade
Rankeova 4, Belgrade, Serbia
E-mail: stefan.vulovic@stomf.bg.ac.rs

INTRODUCTION

Older adult edentulous patients often face socioeconomic constraints, systemic health challenges, and limited bone support for implant placement, which can preclude implant-based treatment options. As a result, prosthodontic rehabilitation in this population predominantly relies on the fabrication of mucosa-supported complete dentures (CDs) (1), with the maxillary CD often meeting both esthetic and functional demands to a satisfactory extent (2).

To fulfill functional requirements, a maxillary complete denture (CD) must achieve adequate retention and stability. A well-retained, stable prosthesis significantly improves mastication and encourages the consumption of healthier, fiber-rich food, including raw fruits and vegetables. This diet has been shown to enhance both oral and systemic health in older adults (3). The retention and, more critically, the stability of the maxillary CD depend largely on the intimate contact between the denture base and the underlying mucosa. This relationship underscores the importance of precise impression techniques and denture base design to accurately capture the edentulous ridge morphology and border extensions, as well as to properly displace soft tissues to establish an effective mucosal seal (4). Retention is further enhanced by slight compression of the palatal mucosa, especially in the posterior palatal seal area and along the lateral regions adjacent to the midline, where the mucosa houses the greater palatine nerve and blood vessels (5).

During mastication, occlusal forces are predominantly distributed across the peripheral seal and the supporting tissues, which must be resilient enough to withstand functional loading (6). However, intermittent or continuous pressure exerted by the maxillary CD can potentially compromise the microcirculation within the palatal mucosa. Prolonged disturbances in blood perfusion may lead to localized ischemia, the accumulation of metabolic by-products (7), and the alveolar ridge resorption (8). Furthermore, mechanical stress transmitted through the denture base and the resulting vascular alterations have been associated with the accumulation of microorganisms, especially fungal species, and the development of pathological conditions such as denture stomatitis (9).

Considering all the aforementioned, the present study aimed to evaluate changes in palatal mucosal microcirculation microcirculation in older adults during the adaptation period to a newly fabricated maxillary CD. The null hypotheses were that: 1. No significant changes in blood perfusion would be found across different time points within the same anatomical region. 2. No significant changes in blood perfusion would be found among anatomical regions at the same time point.

METHODS

A total of 10 edentulous participants (n = 10; 7 females and 3 males), aged 65–72 years (mean age 67.3 years), were included in the study between October and November 2024. Eligibility was determined according to predefined systemic and local inclusion and exclusion criteria. Systemic inclusion criteria comprised age ≥65 years, stable general health, and non-smoking status. Local inclusion criteria included complete edentulism in both the upper and lower jaws, absence of pathological changes in the oral mucosa, and no prior experience wearing complete dentures.

Systemic exclusion criteria included uncontrolled diabetes or hypertension, a history of head and neck radiation therapy, ongoing chemotherapy, psychiatric disorders, use of bisphosphonates, acute anemia, alcohol abuse, and refusal to provide informed consent. Local exclusion criteria included the presence of active pathology in the upper or lower jaw and the presence of a median palatal torus. Experimental procedures were conducted in full accordance with the ethical principles outlined in the 1964 Declaration of Helsinki, and the study protocol was reviewed and approved by the institutional Ethics Committee of the School of Dental Medicine, University of Belgrade (approval number 36/7, issued on 12.03.2024). Prior to participation, all participants provided written informed consent, and, during the study, no dropouts were recorded.

Denture fabrication

For each participant, maxillary CD was fabricated following standardized clinical and laboratory protocols. A selective pressure impression technique was employed, utilizing border molding with extended custom trays and an impression compound (Impression compound green, Harvard, Hoppegarten, Germany). Final impressions were made using a zinc oxide eugenol paste (Cavex Outline, Cavex Holland BV, Haarlem, The Netherlands) to ensure precise anatomical detail reproduction. Following denture insertion, any clinical issues, such as pressure spots, were identified and promptly adjusted. A balanced occlusal scheme was established to promote functional efficiency and comfort, whereas occlusion was carefully evaluated to

ensure uniform bilateral contacts and to eliminate any deflective interferences.

Splint fabrication

To enable accurate microcirculation assessment, a transparent, custom-made splint was fabricated to match the base of the maxillary CD. The splint was constructed on a duplicated master model before denture flasking, using a 3 mm thermoplastic foil (Erkoloc Pro 3.0 × 120 mm, Erkodent, Pfalzgrafenweiler, Germany) adapted with a vacuum-forming device (Erkoform 3D Motion, Erkodent, Pfalzgrafenweiler, Germany). The splint design ensured that no pressure was applied to the maxillary mucosa during microcirculation measurements. This was achieved by creating a relief space using two layers of baseplate wax during the splint fabrication process. To facilitate probe stabilization and enable reproducible positioning for repeated measurements, the splint was perforated at three specific anatomical landmarks in the frontal, premolar, and molar regions to accommodate the probe holder (Figure 1) along the course of the greater palatine artery (10). During the procedure, the probe was positioned perpendicular to the mucosal surface to ensure consistent and accurate contact throughout the measurements.

Microcirculation measurements were performed at four time points: prior to denture insertion (T0), 30 min after insertion (T1), one week after insertion (T2), and six weeks after insertion (T3) (11). Following initial insertion, participants were instructed on proper denture usage, including evenly distributed mastication and removing the denture overnight. Follow-up appointments for measurements were scheduled accordingly. Microcirculation was assessed using a laser Doppler flowmeter (PeriFlux PF 5001, Perimed, Järfälla, Sweden), operating with red laser light at a wavelength of 632.8 nm. Red light was produced by a 1 mW helium-neon laser diode within the flowmeter and transmitted to the tissue surface along the fiber-optic conductor inside a round probe (407-2, Perimed), with a cross-sectional diameter of 1 mm. The probe of the flowmeter, stabilized using a probe holder (PH 07-6, Perimed), simultaneously received the reflected and scattered light via an afferent optical fiber, which was then registered by a photodetector in the flowmeter. According to the Doppler phenomenon, the light reflecting from moving particles (red blood cells) shifted in frequency, while the frequency of light reflecting from static structures remained unchanged. Frequency shifts were used to calculate the concentration and velocity of moving particles, and the result was proportional to tissue blood flow, expressed in semiquantitative blood perfusion units (BPU). To ensure measurement accuracy, the device was calibrated prior to each measurement session using a latex particle colloidal suspension (Perimed Motility Standard, Perimed), and recordings were obtained for a minimum of 3 min at each designated point to ensure signal stability and reliability. Data acquisition and analysis were performed using the associated software (PeriSoft v.2.50, Perimed). All measurements were performed by the same experienced, trained operator, under consistent ambient conditions (room temperature, at 10:00 AM), with participants seated in a semi-reclined position to minimize body movements.

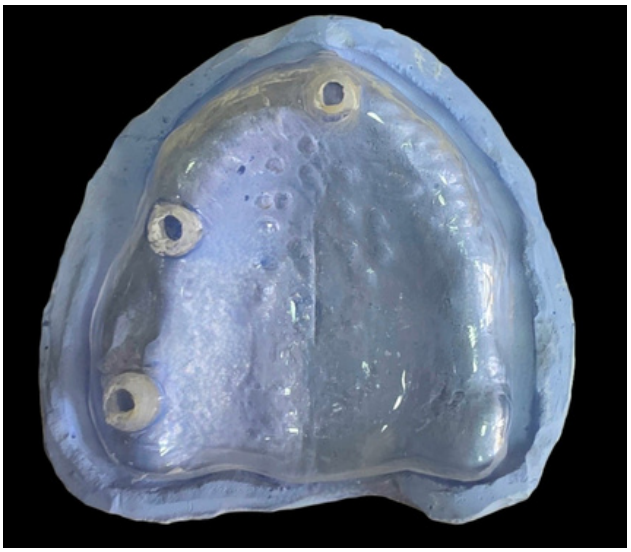

Figure 1. *Transparent, custom-made splint made of thermoplastic foil used for microcirculation measurements.*

Statistical analysis

All statistical analyses were conducted using statistical software (SPSS v.22.0, Chicago, IL, USA), with the threshold for statistical significance set at $\alpha = 0.05$. The normality of the data was verified using the Kolmogorov-Smirnov test, which confirmed that all variables followed a normal distribution. To assess differences in BPU between anatomical regions at a given time point, a one-way analysis of variance (ANOVA) was applied, followed by Tukey's post hoc test for pairwise comparisons. Temporal changes in BPU within the same anatomical region were examined using repeated measures ANOVA, with Bonferroni correction applied to adjust for multiple

comparisons. Results were reported as mean values with their corresponding standard deviations (mean ± SD).

RESULTS

Comparison across time points within the same region

The results of the microcirculation measurements are presented in Tables 1 and 2. When evaluating changes in BPU across different time points within each region, a statistically significant difference was observed in both the premolar and molar regions ($p < 0.05$), whereas no significant variation was found in the frontal region ($p > 0.05$). In the frontal region, although a decreasing trend in BPU was observed over time, the changes were not statistically significant ($p > 0.05$). BPU values were slightly higher at T0 and T1 compared to T2 and T3, though the differences remained non-significant ($p > 0.05$).In the premolar region, a significant decline in BPU was observed across the time points ($p < 0.001$). No significant difference was found between T0 and T1 ($p > 0.05$); however, statistically significant reductions were detected when comparing T0 and T1 with T2 and T3, respectively (T0 vs T2: $p = 0.012$; T0 vs T3: $p = 0.002$; T1 vs T2: $p = 0.004$; T1 vs T3: $p < 0.001$). In the molar region, BPU values also significantly decreased over time ($p < 0.001$). BPU at T0 was significantly higher compared to BPU at T1 ($p = 0.021$), T2 ($p = 0.027$), and T3 ($p = 0.002$). No significant difference was found between BPUs at T1 and T2 ($p > 0.05$), whereas both were significantly higher than BPU at T3 (T1 vs T3: $p = 0.002$; T2 vs T3: $p = 0.001$).

Comparison among regions at the same time point

Significant differences in BPU were found among regions at each time point ($p < 0.05$). At baseline (T0), interregional differences were significant ($p = 0.001$). The molar region exhibited the highest BPU value (47.81 ± 18.25), which was significantly higher compared to the frontal (20.22 ± 9.63; $p = 0.001$) and premolar regions (30.29 ± 14.32; $p = 0.031$). Although BPU in the premolar region was higher than in the frontal region, the difference was not statistically significant ($p > 0.05$). A similar trend was observed 30 min post-insertion (T1), with statistically significant differences among the regions ($p = 0.004$). The molar region again demonstrated the highest BPU value (40.47 ± 17.50), significantly higher than the BPUs in frontal (20.02 ± 9.28; $p = 0.004$) and premolar regions (25.80 ± 9.61; $p = 0.040$). The difference between the frontal and premolar regions remained non-significant ($p > 0.05$), with the premolar

Table 1. *Blood perfusion units (BPU) were measured for each participant and expressed as mean ± SD*

Participant	Frontal region				Premolar region				Molar region			
	T0	T1	T2	T3	T0	T1	T2	T3	T0	T1	T2	T3
1	7.64	7.86	6.74	6.27	11.11	9.34	8.21	3.94	30.05	15.21	14.09	6.73
2	14.24	14.27	14.03	13.79	20.92	20.56	9.10	4.70	44.13	31.86	22.51	13.60
3	29.53	28.25	22.96	22.82	55.57	37.64	18.09	14.26	54.42	44.31	22.88	16.75
4	16.85	16.80	12.29	11.77	25.45	26.95	8.83	9.30	49.47	41.81	32.38	22.13
5	18.39	18.36	16.09	15.72	31.77	28.27	11.64	6.56	77.71	60.64	32.10	27.16
6	14.81	14.78	14.22	13.81	21.48	15.22	8.91	7.45	30.11	28.10	25.05	20.01
7	12.31	12.09	10.64	9.45	18.92	19.09	16.24	10.55	24.45	23.31	20.08	18.62
8	35.32	34.85	38.72	36.12	52.11	38.56	23.24	14.15	61.11	59.52	53.24	39.91
9	34.91	34.24	28.78	26.43	36.74	33.22	29.15	21.01	71.11	67.72	60.34	55.54
10	18.22	18.75	16.54	15.71	28.83	29.11	18.43	10.23	35.56	32.22	33.11	21.11

T0 - baseline measurements; T1 - measurements 30 min after denture insertion; T2 - measurements 1 week after denture insertion; T3 - measurements 6 weeks after denture insertion.

Table 2. *Blood perfusion units (BPU) were measured for each anatomic region and time point and expressed as mean ± SD*

Region	Time point			
	T0	T1	T2	T3
Frontal	20.22 ± 9.63 $^{B, a}$	20.02 ± 9.28 $^{B, a}$	18.10 ± 9.54 $^{B, a}$	17.19 ± 8.89 $^{AB, a}$
Premolar	30.29 ± 14.32 $^{B, a}$	25.80 ± 9.61 $^{B, a}$	15.18 ± 7.13 $^{B, b}$	10.21 ± 5.16 $^{B, b}$
Molar	47.81 ± 18.25 $^{A, a}$	40.47 ± 17.50 $^{A, b}$	31.58 ± 14.67 $^{A, b}$	24.16 ± 14.04 $^{A, c}$

T0 - baseline measurements; T1 - measurements 30 min after denture insertion; T2 - measurements one week after denture insertion; T3 - measurements six weeks after denture insertion. Different uppercase letters indicate significant difference inside the columns ($p < 0.05$; Tukey's post hoc test), whereas different lowercase letters indicate significant difference inside the rows ($p < 0.05$; Bonferroni post hoc test).

region showing slightly higher values. After one week (T2), significant interregional differences in BPU persisted ($p = 0.005$). The molar region showed the highest BPU value (31.58 ± 14.67), significantly greater than both the frontal (18.10 ± 9.54; $p = 0.027$) and premolar regions (15.18 ± 7.13; $p = 0.006$). Although the frontal region exhibited a higher BPU value than the premolar region, the difference was not statistically significant ($p > 0.05$). After six weeks (T3), the trend continued with statistically significant differences across regions ($p = 0.016$). The molar region remained dominant (24.16 ± 14.04), showing significantly higher BPU value than the premolar region (10.21 ± 5.16; $p = 0.012$), and a higher, but not statistically significant BPU value compared to the frontal region (17.19 ± 8.89; $p > 0.05$). As observed at T2, the frontal region demonstrated a slightly higher BPU value than the premolar region, though without statistical significance ($p > 0.05$).

DISCUSSION

The present study was designed to observe changes in palatal mucosal blood perfusion over a six-week period of adaptation to CDs. The procedure was performed using LDF, a non-invasive and efficient method for assessing capillary blood flow, volume, and velocity. This technique detects the Doppler shift caused by moving red blood cells within the tissue illuminated by the laser beam, producing measurements in blood perfusion units (BPU). LDF has been safely used in several studies since the 1980s for evaluating blood perfusion in various oral tissues, including the tongue, gingiva, periodontium, masseter muscle, and denture-supporting mucosa (12-16).

The results of the present study revealed a consistent decline in blood perfusion from baseline to subsequent measurement stages across all three anatomical regions, which supports the opinion that maxillary CDs impose mechanical stress, thereby contributing to reduced blood perfusion beneath the denture-bearing palatal mucosa. This reduction aligns with what occurs during impression-making and reflects the functional dynamics of the denture during mastication, as also reported in the previous study (17). Furthermore, it was also observed that individuals with reduced reactive hyperemia exhibited lower mucosal blood perfusion under their dentures, suggesting that denture use can influence microvascular behavior (16). Biomechanically, the oral mucosa acts as a cushion, distributing occlusal forces from the denture to the underlying bone, and its vascular network plays a critical role in supplying nutrients to the supporting bone. Therefore, excessive mechanical loading can impair this function, compromising tissue health (18). Moreover, a poorly designed or ill-fitting denture may exacerbate these effects and diminish the success of prosthetic treatment. However, the results of this study suggest that a properly fabricated maxillary CD can gradually conform to the supporting tissues and allow redistribution of occlusal forces in line with the mucosa's physiological capacity to adapt. Although the duration of this study was limited, the findings align with previous research, in which a reduction in mucosal perfusion following denture insertion was reported, with improvement observed by the end of a six-month period, suggesting tissue adaptation over time (19). Contrarily, other studies report minimal effects of loading forces on palatal blood perfusion (17) or no differences in palatal blood perfusion between long-term denture wearers and edentulous individuals who had never worn dentures, indicating that age-related vascular changes may play a more dominant role than prosthesis use alone (20, 21). Considering all the aforementioned, the first null

hypothesis that no significant changes in blood perfusion would be found across different time points within the same anatomical region was rejected.

When analyzing regional differences in blood perfusion at the same time point, the molar region consistently exhibited significantly higher perfusion compared to the frontal and premolar regions throughout the entire observation period. This observation may be explained by the fact that the molar region is primarily supplied by the greater palatine artery and is located closer to the main vascular entry point, thereby receiving a richer, more direct blood supply compared to the anterior region. In addition, the palatal mucosa in the molar area is generally thicker and more vascularized than the mucosa in the anterior palate, which is more firmly attached to the underlying periosteum, particularly in the region of the palatal rugae. However, immediately following denture insertion, a significant decline in blood perfusion was observed in the molar region. One plausible explanation is that the posterior palatal seal area is often intentionally compressed during final impression procedures to enhance denture retention. This compression may contribute to localized disturbances in blood perfusion. Conversely, one study reported that although blood perfusion initially decreased in both the canine and molar regions after denture placement, vascular recovery occurred over a six-month period, particularly in the molar region, suggesting region-specific adaptation (22). Similarly, another group of authors observed greater vascular compromise in the anterior maxilla following denture insertion, potentially due to increased occlusal forces generated by mandibular implant-retained overdentures opposing maxillary CDs (11). These conflicting findings may be attributed to differences in study design, specifically, the inclusion of participants with natural teeth or various dental restorations in the opposing arch, unlike the present study, which included only fully edentulous participants in both the maxilla and mandible. Nevertheless, the second null hypothesis that no significant changes in blood perfusion would be found among regions at the same time point was also rejected.

One of the main limitations of this study is the relatively small sample size. However, as a preliminary investigation, the findings provide indicative value and serve as a foundation for future research. Subsequent studies should aim to include larger cohorts and control groups with varying prosthetic or implant-supported configurations in the opposing arch. Another limitation pertains to the methodology itself, specifically the use of LDF. While LDF is widely accepted and has undergone technological refinement, it remains technique-sensitive. Although the method is highly successful for measuring microcirculatory blood flow, it cannot distinguish between different vessel types (arterioles, capillaries, venules) and measures only superficial perfusion, typically within 1-2 mm of tissue depth (23). Therefore, deeper tissue changes may go undetected. Moreover, several methodological factors may also influence LDF measurements, including probe type, use of a stabilization splint, measurement duration, and operator skill (21). In addition, various local and systemic factors, such as temperature variation (24), smoking (25), local anesthesia (26), mechanical compression (27), blood pressure, heart rate, and auto-nomic nervous system activity (28), may affect measurement reliability. Thus, strict control of these parameters is essential to ensure valid and reproducible results when using LDF in oral soft tissue evaluation.

Nevertheless, the findings of the present study underscore the importance of monitoring microvascular responses in the supporting tissues of denture wearers. Further research is warranted to explore the relationship between microcirculatory changes and conditions such as denture stomatitis, and to investigate how clinical variables, including impression techniques, radiotherapy, bisphosphonate therapy, and systemic diseases like diabetes, may influence tissue responses beneath dentures. Understanding the interplay between aging and palatal mucosal blood flow remains essential for optimizing denture design and ensuring long-term oral health in the edentulous population.

Within the limitations of this preliminary study, it can be concluded that the short-term use of maxillary complete dentures is associated with a measurable decrease in palatal mucosal blood perfusion. The alterations were evident one week after denture insertion, more prominent in the molar region, compared with both the frontal and premolar regions.

Acknowledgements

This study was not supported by any sponsor or funder.

Authors' Contribution

Conceptualization, P.T., M.S.M, A.P., and A.M.L.; Data curation, P.T., S.V., M.I., and A.P.; Formal analysis, S.V., M.S.M., and M.I.; Funding acquisition, M.K., I.S., and A.M.L.; Investigation, P.T., S.V., M.S.M., and M.I.; Methodology, P.T., M.I., A.P., and A.M.L.; Project administration, M.S.M., I.S., and A.M.L. Resources, M.K., I.S., and A.M.L. Software, P.T., S.V. Supervision, M.K., A.P., I.S., and A.M.L. Validation, I.S., and A.M.L. Visualization, P.T., M.I., and I.S. Writing – original draft, P.T, S.V., M.S.M., and

M.I.; Writing – review & editing, M.K., A.P., I.S., and A.M.L. All authors have read and approved the published version of the manuscript.

Statement of Ethics

This study protocol was reviewed and approved by the Ethics Committee of School of Dental Medicine, University of Belgrade (approval number 36/7, issued on 12.03.2024). Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

Statement of Competing Interest

The authors declare no relevant conflicts of interest.

Statement of Data Availibility

Not applicable.

Statement of Generative AI Use

No generative AI was used.

REFERENCES

1. Jovanović G, Đorđević M, Đerlek E, Jovanović R, Kostić M. Hybrid Implant-Prosthetic Rehabilitation of Edentulism: A Case Report. Acta Fac Medicae Nai 2024;41(4):575-83. [CrossRef]

2. Milić Lemić A, Vulović S, Jakovljević A, Jaćimović J, Müller F, Maniewicz S, et al. Analysis of Clinical and Patient-Reported Outcomes Between Single- and Two-Implant Mandibular Overdenture-An Umbrella Review. J Oral Rehabil 2025;52(5):733-47. [CrossRef]

3. Popovac A, Jaćimović J, Trichopoulou A, Peppa E, Kotrokois K, Stančić I, et al. Mediterranean diet and oral health: is there an association? A scoping review. Nutr Res Rev 2024:1-15. [CrossRef]

4. Darvell BW, Clark RK. The physical mechanisms of complete denture retention. Br Dent J 2000;189(5):248-52. [CrossRef]

5. Devlin H. Complete dentures. 2nd ed. Cham: Springer; 2021.

6. The Glossary of Prosthodontic Terms: Ninth Edition. J Prosthet Dent 2017;117(5S):e1-e105. [CrossRef]

7. Mori S, Sato T, Hara T, Nakashima K, Minagi S. Effect of continuous pressure on histopathological changes in denture-supporting tissues. J Oral Rehabil 1997;24(1):37-46. [CrossRef]

8. Maruo Y, Nishigawa G, Irie M, Oka M, Hara T, Suzuki K, et al. Stress distribution prevents ischaemia and bone resorption in residual ridge. Arch Oral Biol 2010;55(11):873-8. [CrossRef]

9. Kossioni AE. The prevalence of denture stomatitis and its predisposing conditions in an older Greek population. Gerodontology 2011;28(2):85-90. [CrossRef]

10. Akazawa H, Sakurai K. Changes of blood flow in the mucosa underlying a mandibular denture following pressure assumed as a result of light clenching. J Oral Rehabil 2002;29(4):336-40. [CrossRef]

11. Kouadio AA, Fabienne J, Soueidan A, Volteau C, Koffi NJ, Djérédou KB, et al. Effects of wearing removable dentures and aging on palatal mucosa blood flow by laser doppler. J Indian Prosthodont Soc 2022;22(2):161-8. [CrossRef]

12. Le Bars P, Niagha G, Kouadio AA, Demoersman J, Roy E, Armengol V, et al. Pilot Study of Laser Doppler Measurement of Flow Variability in the Microcirculation of the Palatal Mucosa. Biomed Res Int. 2016;2016:5749150. [CrossRef]

13. Alsrouji MS, Ahmad R, Ibrahim N, Kuntjoro W, Al-Harbi FA, Baba NZ. Blood Flow Alterations in the Anterior Maxillary Mucosa as Induced by Implant-Retained Overdenture. J Prosthodont 2019;28(4):373-8. [CrossRef]

14. Singh DB, Stansby G, Harrison DK. Assessment of oxygenation and perfusion in the tongue and oral mucosa by visible spectrophotometry and laser Doppler flowmetry in healthy subjects. Adv Exp Med Biol 2008;614:227-33. [CrossRef]

15. Chen E, Abbott PV. Dental pulp testing: A review. Int J Dent 2009;2009:365785. [CrossRef]

16. Cho KH, Yu SK, Lee MH, Lee DS, Kim HJ. Histological assessment of the palatal mucosa and greater palatine artery with reference to subepithelial connective tissue grafting. Anat Cell Biol 2013;46(3):171-6. [CrossRef]

17. Curtis DA, Gansky SA, Plesh O. Deep and superficial masseter muscle blood flow in women. J Prosthodont 2012;21(6):472-7. [CrossRef]

18. Ogino T, Ueda T, Ogami K, Koike T, Sakurai K. Effects of chewing rate and reactive hyperemia on blood flow in denture-supporting mucosa during simulated chewing. J Prosthodont Res 2017;61(1):54-60. [CrossRef]

19. Chen J, Ahmad R, Li W, Swain M, Li Q. Biomechanics of oral mucosa. J R Soc Interface 2015;12(109):20150325. [CrossRef]

20. Binsu S, Nair KC, Jhon B, Nayar S, Julian J, Shahid M. Ultrasonic evaluation of influence of hard acrylic resin denture on blood flow of mandibular denture supporting mucosa utilizing duplex color Doppler studies: An in vivo study. J Indian Prosthodont Soc 2017;17(3):289-94. [CrossRef]

21. Kouadio AA, Jordana F, Koffi NJ, Le Bars P, Soueidan A. The use of laser Doppler flowmetry to evaluate oral soft tissue blood flow in humans: A review. Arch Oral Biol 2018;86:58-71. [CrossRef]

22. Kocabalkan E, Turgut M. Variation in blood flow of supporting tissue during use of mandibular complete dentures with hard acrylic resin base and soft relining: a preliminary study. Int J Prosthodont 2005;18(3):210-3.

23. Fredriksson I, Larsson M, Strömberg T. Measurement depth and volume in laser Doppler flowmetry. Microvasc Res 2009;78(1):4-13. [CrossRef]

24. Heckmann JG, Hilz MJ, Hummel T, Popp M, Marthol H, Neundörfer B, et al. Oral mucosal blood flow following dry ice stimulation in humans. Clin Auton Res 2000;10(5):317-21. [CrossRef]

25. Molnár E, Lohinai Z, Demeter A, Mikecs B, Tóth Z, Vág J. Assessment of heat provocation tests on the human gingiva: the effect of periodontal disease and smoking. Acta Physiol Hung 2015;102(2):176-88. [CrossRef]

26. Donos N, D'Aiuto F, Retzepi M, Tonetti M. Evaluation of gingival blood flow by the use of laser Doppler flowmetry following periodontal surgery. A pilot study. J Periodontal Res 2005;40(2):129-37. [CrossRef]

27. Patiño-Marín N, Martínez F, Loyola-Rodríguez JP, Tenorio-Govea E, Brito-Orta MD, Rodríguez-Martínez M. A novel procedure for evaluating gingival perfusion status using laser-Doppler flowmetry. J Clin Periodontol 2005;32(3):231-7. [CrossRef]

28. Rajan V, Varghese B, van Leeuwen TG, Steenbergen W. Review of methodological developments in laser Doppler flowmetry. Lasers Med Sci 2009;24(2):269-83. [CrossRef]