Original Article
DOI: 10.22037/jds.v40i3.40565
ISSN 2645-4351

Evaluation of Salivary Matrix Metalloproteinase-9 (MMP-9) Level in Patients With Oral Lichen Planus Before and After Treatment With 0.2% Triamcinolone Mouthwash

Marziye Sehatpour[a], Jamile Beigom Taheri[b], Zahra Yadegari[c], Zahra Namazi[d], Mahshid Namdari[e], Homa Mirzaei[b]

[a]DDS, MS, Oral & Maxillofacial Medicine Specialist, Fellowship in LASER Dentistry, Tehran, Iran
[b]Professor, Dept.of Oral Medicine, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[c]PhD of Biotechnology, Dept. of Dental Material, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[c]Associate Professor, Dept. of Periodontics, School of Dentistry, Zanjan University of Medical Sciences, Zanjan, Iran
[d]PhD of Biotechnology Dept. of Dental Biomaterials, School of Dentistry, Shahid Beheshti University of Medical Siences.
[e]Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Correspondence to Homa Mirzaei (email: homa.mirzaei@sbmu.ac.ir).
(*Submitted: 9 January 2023 – Revised version received: 22 May 2023 – Accepted: 31 May 2023– Published online: Summer 2023*)

Objectives Oral lichen planus (OLP) is a chronic mucocutaneous disease, involving the skin and mucous membranes. Although the pathogenesis of OLP is not fully understood, the immune system, genetic and environmental factors, medications, and infections may play an important role in OLP. The level of matrix metalloproteinases (MMPs) is known to increase in pathological conditions, such as squamous cell carcinoma (SCC), as well as inflammatory conditions, such as OLP. If pain and soreness are present, topical corticosteroids (CSs) are the first-line treatment for these patients. This study aimed to evaluate the level of MMP-9 in individuals with OLP before and after treatment with triamcinolone 0.2% mouthwash.
Method This study was conducted on 18 patients with erosive-atrophic OLP. First, 5 mL of unstimulated saliva was collected, and then, triamcinolone 0.2% mouthwash was prescribed to all the patients. After treatment and healing of the lesions, a sample was collected again from the participants. The MMP-9 concentration was quantified in all the samples using an ELISA kit.
Results The mean age of the participants, including five males and 13 females, was 45.7 years in this study. Before treatment, the mean MMP-9 concentration was 1.599 ng/mL, with a standard deviation (SD) of 1.074, while the mean (±SD) level of MMP-9 was 0.933 ng/mL (0.649) after treatment. The mean reduction was estimated at 0.666, with SD of 1.056 (P=0.016).
Conclusion The MMP-9 level was significantly lower after treatment compared to the pretreatment stage. Based on the results, topical CSs, such as triamcinolone, can decrease the level of MMP-9, as a reliable biomarker of OLP severity; therefore, they can diminish inflammation and prevent the dysplastic progression of the disease.
Keywords Oral Lichen Planus; Saliva; MMP-9; Triamcinolone.

Introduction

Lichen planus is recognized as a recurrent and chronic inflammatory mucocutaneous disorder with an unknown etiology. The prevalence of oral lichen planus (OLP) is estimated at 1-2% in middle age, with a predilection for women. Clinically, OLP can be detected in different forms, such as papular, reticular, plaque-like, bullous, atrophic, and erosive OLP. It mainly occurs in the buccal region (often bilaterally), followed by the tongue, gingiva, and lips. [1-7] The precancerous potential of erosive and erythematous lesions warrants increased attention and follow-up. [8]

Although the pathogenesis of OLP is not fully understood, the immune system, along with genetic and environmental factors, medications, and infections may be involved. [2] It is known that T cell-mediated immune responses lead to epithelial cell disruption and apoptosis and cause clinical manifestations. [8] The basement membrane (BM) destruction in OLP is attributed to proteinases, such as MMPs or matrixes and mast cell chymases. [3] Generally, MMPs, as a broad family of zinc-dependent endopeptidases, contribute to the activation of inflammation and metastasis of malignancy cascades by destroying the BM components and the extracellular matrix; consequently, lymphocytes can migrate and infiltrate into the BM and epithelial layers. [1, 2, 5] Moreover, MMP-9 (gelatinase B) participates in the demolition of tissue matrix proteins through collagen IV destruction, giving rise to OLP, periodontal disease, and other inflammatory conditions. [3, 9, 10]

In addition to the elevation of MMPs in inflammatory conditions, such as OLP, arthritis rheumatoid, osteoarthritis, and atherosclerosis [11-13], the increased level of MMPs can be a prognostic factor for pathological conditions, such as head and neck squamous cell carcinoma (SCC). [1, 10, 14] Previous studies have reported elevated MMP-9 levels in the serum, saliva, and tissues of OLP and other dysplastic lesions. Moreover, in premalignant lesions, MMPs can cause early changes in cancer progression (10). According to previous reports, this biomarker may play an essential role in the OLP pathogenesis. [15]

Treatment is not necessary for asymptomatic OLP, especially its reticular form. If a patient experiences pain and soreness, topical corticosteroids (CSs) are used as the first-line treatment. Triamcinolone is a branch of CSs, used for the treatment of most inflammatory conditions, immunological disorders, and oral cavity lesions. It is eight

times more potent than prednisone and is considered an intermediate-acting glucocorticoid. [16] The triamcinolone mouthwash is commonly used for symptomatic OLP, as it exerts similar effects to triamcinolone in Orabase®. [17-19] The mechanism of action of CSs in OLP treatment involves their anti-inflammatory properties for inflammation control. [20, 21] This mechanism acts on intracellular glucocorticoid receptors and eliminates protein gene coding for inflammation [22]; consequently, it can lead to the suppression of inflammatory substance production. [16]

Generally, the saliva composition reflects the body's health. The analysis of saliva may be a suitable method for the assessment of numerous biomarkers at a reasonable cost. [8] Salivary testing is a useful method for the diagnosis, prognosis, and prediction of numerous lesions and cancers, such as oral SCC (OSCC); however, only few studies have focused on the salivary evaluation of premalignant lesions and conditions, such as OLP. [4] In this regard, Mair et al. (2016) studied the serum and salivary MMP-2 and MMP-9 levels in patients with vesiculoerosive diseases and concluded that MMP-9 in the saliva and MMP-2 in the serum were significantly higher in this group compared to the control group. [15]

In another study, Fathi et al. reported that MMP-9 is a suitable salivary biomarker for the OLP activity. [8] Moreover, some studies have suggested that CSs, such as dexamethasone and methylprednisolone, can decrease MMP-9 and the tissue inhibitor of MMP (TIMP-1) in respiratory diseases. [23-25] To the best of our knowledge, no research has yet evaluated the level of MMP-9 in the oral fluid before and after treatment with topical CS in patients with OLP. Therefore, in this study, we aimed to evaluate the level of MMP-9 in patients with OLP before and after treatment with triamcinolone 0.2% mouthwash.

Methods and Materials

Study population

This study was approved by the Ethics Committee of the School of Dentistry of Shahid Beheshti University of Medical Sciences (IR.SBMU.RIDs.REC.1394.186). It was also registered in the Iranian Registry of Clinical Trials (IRCT) (IRCT2016071728963N1). The informed consent form was signed by all the participants.

Sample collection

This analytical-descriptive clinical trial was performed on 18 patients with erosive-atrophic OLP, who were referred to Shahid Beheshti Oral Medicine Department. After history taking, OLP was diagnosed based on the clinical and histopathological findings. The Burket's Oral Medicine Book was used to specify the clinical diagnostic criteria. [6] The patients were considered eligible if they had clinically and histopathologically proven OLP and required treatment.

Inclusion criteria

Patients with erosive-atrophic OLP, proven clinically and histopathologically, were included in this study.

Exclusion criteria

The exclusion criteria were as follows: cutaneous lichen planus lesions; drug-induced lichenoid reactions; lichenoid contact reactions; use of OLP medications; use of drugs or antibiotics; local or systemic diseases; pregnancy; lactation; smoking; alcohol consumption; use of mouthwash or antiseptic toothpaste; and periodontal diseases.

Stage 1: Sample collection

For sample collection, 5 mL of unstimulated saliva was collected from the participants using a standard technique proposed by Navazesh. [26] The patients were asked not to eat, not to use a mouthwash, and not to brush their teeth for at least two hours before collecting the salivary samples. The samples were collected in the morning between 10 am and 12 pm. They were then immediately centrifuged at 4000 g for 15 minutes at 4°C, and the clarified supernatant was collected and aliquoted in microtubes. The samples were finally frozen at –80°C until the day of assessment.

Stage 2: Treatment intervention

Triamcinolone 0.2% mouthwash (prepared by mixing 1 cc of 40 mg/mL triamcinolone in 19 cc of distilled water in a vial) was prescribed to all the patients. One teaspoon (5 cc) of the mouthwash was used (five minutes of rinsing and spitting out) four times a day after meals and before the nighttime sleep. The patients were asked not to eat or drink for at least 30 minutes after using the mouthwash. [11] The mouthwash was selected as the treatment of choice, because it was easy to apply on all parts of the mouth and was an available option for protection against candidiasis. Moreover, an oral suspension of nystatin (100,000 units) was prescribed from the third week, four times a day; each time, 30 drops of the mouthwash were used (two minutes of rinsing and spitting out). Treatment continued until the lesions healed. After healing, to avoid recurrence, the frequency of mouthwash use decreased to twice a day after meals and then once a day for another week. After this period, there was no need to continue the use of the mouthwash.

Stage 3: Sample collection after treatment

After the lesions healed, the patient's saliva was collected according to the technique described in stage 1.

Stage 4: Laboratory analysis

All the samples were defrosted at room temperature (RT) and gently vortex for 20 seconds. Next, they were assessed in duplicate, according to the manufacturer's instructions for the measurement of MMP-9 level using an ELISA kit (Catalogue No.: DMP900; R&D System Inc., USA & Canada). Next, 100 µL of the assay diluent was added to each well. In the next step, 100 µL of the standards and samples was added. Following the incubation of the plate for two hours at RT on a microplate shaker, four washing

steps were performed using 400 µL of wash buffer. Subsequently, 200 µL of human MMP9-conjugated antibody was added and incubated for one hour. Next, the washing step was repeated, and after adding 200 µL of the substrate solution, the plate was incubated for 30 minutes. To stop the reactions, 50 µL of the stop solution was added (Figure 1). Finally, the optical density was read using an ELISA microplate reader (Anthos 2020, Austria) at two wavelengths of 450 nm and 570 nm as the reading and reference wavelengths, respectively.

Figure1: Added stop solution to each well. The color in the well changed from blue to yellow.

Statistical analysis

The level of MMP-9 was measured in all the samples. Descriptive statistics, including mean and standard deviation (SD), were calculated. Shapiro-Wilk test was also utilized to evaluate the distribution of MMP-9 changes, and paired t-test was carried out to examine changes in the level of MMP-9 before and after treatment.

Results

The mean age of the participants, including five males and 13 females, was 45.7 years. The mean (SD) level of MMP-9 in the salivary samples was 1.599 ng/mL (1.074) before treatment and 0.933 ng/mL (0.649) after treatment. The mean reduction was 0.666, with SD of 1.056 (P=0.016) (Table 1). The results showed that the salivary level of MMP-9 significantly decreased after treatment. However, the salivary MMP-9 level was elevated after treatment in three female participants, one of whom had halitosis in the second salivary sampling, while the rest did not have any problems.

Table 1- Statistical data

Salivary MMP-9 level (ng/ml)	Mean	Standard deviation	P-value
Before	1.5999	1.07425	-
After	0.9339	0.64971	-
Before- after	.066606	1.05647	0.016

Discussion

The findings of the present study demonstrated a significant decrease in the salivary MMP-9 level in patients with OLP following treatment with triamcinolone 0.2% mouthwash. Generally, the salivary level of MMP-9 is significantly related to premalignant and malignant lesions, such as OSCC. To date, more than 100 biomarkers related to SCC have been recognized in the saliva, with MMP-9 being the most important one. Accordingly, constant monitoring and treatment have been performed using such biomarkers. [11-13]

In this regard, Gallab et al. (2016) studied the serum and salivary levels of MMP-9 and chemerin in OSCC and oral premalignant lesions (e.g., atrophic lichen planus). They found that the salivary level of MMP-9 was twice higher in oral premalignant lesions compared to the control group. [27] Moreover, Vajaria et al. assessed the level of MMP-9 in the oral fluid of premalignant and OSCC lesions. According to their results, the elevated salivary levels of MMP-9 and truncated 42-kDa MMP can be used as diagnostic biomarkers for neoplastic changes in individuals with premalignant lesions and OSCC. [10]

Several studies have investigated the effects of CSs and some other medications on the level and function of MMPs in different clinical conditions. In a study by Yuan et al., dexamethasone created a balance between MMP-2 and TIMP-1 and decreased inflammation (23), while Obase et al. reported the balanced function of MMP-8 and TIMPs following the decreased and increased production of these two factors, respectively after inhaled budesonide treatment. [28] Moreover, Tanaka et al. found that methylprednisolone decreased the MMP-9 level in individuals with asthma. [29]

In another study by Mattos et al., no significant change was observed in the MMP-9 or TIMP-1 levels of individuals with mild asthma after treatment with inhaled budesonide. [30] Although some studies have reported lower levels of MMP-9 after the use of inhaled CSs in asthmatic individuals [29, 31], Grzela et al. indicated no significant decline in the concentration or function of MMP-9 in the breath condensate samples of four asthmatic individuals after treatment with inhaled fluticasone propionate [32]; this discrepancy can be attributed to some variables, such as the sample size, type of samples, and type of assay. [32]

Although some studies have demonstrated the decreased concentration of MMP-9 after corticosteroid therapy [29, 31], the assessment of the activity of this enzyme is important due to a lack of significant decline in the high activity of MMP-9 after the long-term use of inhaled CSs by asthmatic children. [33] On the other hand, Barton et al. studied the concentrations of MMPs and TIMPs as treatment-monitoring markers in horses with an asthma-like disease, called recurrent airway obstruction. They reported a significant decrease in three MMPs, as well as TIMP-1 and TIMP-2, following inhaled budesonide

administration and environmental dust reduction (EDR). [34] Additionally, the findings of a study by Park et al. recently indicated the downregulation of MMP-2 and MMP-9 as two contributors of the migration and invasion of endometrial stem cells after treatment with glucocorticoids. [35] According to a previous study, the level and function of MMPs could alter due to a change in the concentration of steroid hormones. Moreover, it has been proposed that MMPs could be utilized as therapeutic targets in endometriosis due to their significant role in the pathogenesis of this disease. [36]

Some studies have suggested the role of various treatments in reducing the concentration of MMPs in OLP. Likewise, Romano et al. indicated a significant reduction in the levels of MMP-1 and MMP-9 following a structured plaque control in individuals with gingival desquamation along with OLP. [37] Moreover, omega-3 polyunsaturated fatty acids (PUFAs) in seafood could be useful for the treatment of OLP, as they suppress the expression of MMP-9 (38). In another study, probiotics were suggested as a supplementary treatment to manage OLP. One of the mechanisms of probiotics could be the reduced expression of MMP-9. [39] Besides, the literature review demonstrated the inhibitory effects of CSs and immunosuppressive medications on MMP-9. [34] Conversely, lack of significant MMP-9 changes after CS therapy was an interesting observation in COVID-19 cases. [40]

Overall, the assessment of biomarkers in the saliva is an important diagnostic technique and a good alternative to serum testing, as it is less invasive and less costly; it is also used at a high rate for the evaluation of oral lesions. [4] In the current study, a high concentration of MMP-9 was detected in the saliva of three female participants after treatment. One of the participants had halitosis in the second salivary sampling, while the others showed no problems. It should be noted that these individuals could be in the early stages of gingivitis or in a phase, such as menstruation; besides, OLP individuals may not respond to steroid treatment. [41, 42] The present study, which is the first evaluation of the effectiveness of triamcinolone 0.2% mouthwash in the management of erosive OLP, indicated its significant effects on replacing MMP-9 elimination with MMP-9 reduction. It is worth mentioning that keratin patterns resolved after treatment with triamcinolone 0.2% mouthwash, and erosion and ulceration healed; these findings are in line with the results reported by Vincent et al. [43].

Limitations

The limitations of this research were the patients' lack of cooperation to participate in the study or attend the follow-up, besides the challenges of finding adequate eligible erosive OLP patients. Gingival examination was not accurately performed in the second sample collection. Finally, gingival inflammation exacerbated the salivary level of MMP-9, and complete exclusion of participants with early gingivitis was not feasible.

Conclusion

The present results revealed that the MMP-9 concentration was significantly lower after treatment compared to the pretreatment stage. Topical CSs, such as triamcinolone, can decrease the level of MMP-9 as a reliable biomarker of OLP severity and consequently diminish inflammation and prevent the dysplastic progression of disease. However, it is suggested to conduct further studies on a larger sample size and to use different topical CSs.

Conflict of Interest

No Conflict of Interest Declared ■

References

1. Agha-Hosseini F, Mirzaii-Dizgah I. Serum and saliva collagenase-3 (MMP-13) in patients with oral lichen planus and oral squamous cell carcinoma. Med J Islam Repub Iran. 2015;29:218.
2. Farzin M, Mardani M, Ghabanchi J, Fattahi MJ, Rezaee M, Heydari ST, et al. Serum level of matrix metalloproteinase-3 in patients with oral lichen planus. Iran Red Crescent Med J. 2012;14(1):10-3.
3. Lavanya N, Jayanthi P, Rao UK, Ranganathan K. Oral lichen planus: An update on pathogenesis and treatment. J Oral Maxillofac Pathol. 2011;15(2):127-32.
4. Vanja V. The Role of salivary cytokines in patients with oral lichen planus. J Autacoids. 2014;3(1):e125.
5. Delavarian Z, Mohtasham N, Javadzadeh Bolouri A, Babakoohi s, Sadr B, Shakeri MT, et al. The expression of tissue matrix metalloproteinase 2 and 9 in erosive and non-erosive oral lichen planus, inflammatory hyperplasia of oral mucosa by immunohistochemistry. J Cosmet Dermatol. 2010;1(1):7-13.
6. Glick M. Burket's oral medicine. 13th edition, PMPH USA; 2021. Chap 4:107.
7. Neville BW, Damm DD, Allen CM, Chi AC. Oral and maxillofacial pathology: 4th edition, Elsevier Health Sciences; 2016. Chap 16:730.
8. Fathi MS, El Dessouky HF, Breni HA. CD4+CD25+ T regulatory cells and MMP-9 as diagnostic salivary biomarkers in oral lichen planus. Egypt J Immunol. 2013;20(2):39-53.
9. Zhou XJ, Sugerman PB, Savage NW, Walsh LJ. Matrix metalloproteinases and their inhibitors in oral lichen planus. J Cutan Pathol. 2001;28(2):72-82.
10. Vajaria BN, Patel KR, Begum R, Shah FD, Patel JB, Joshi GM, et al. Clinical Significance of Salivary Matrix Metalloproteinase-9 in Oral Precancerous Conditions and Oral Cancer. Cancers Review. 2014;1(2):33-44.
11. Ahadian H, AKHAVAN KA, Vahidi A, Owlia F. Comparison of two corticosteroids mouthwashes in treatment of symptomatic oral lichen planus. 2012.
12. Malemud CJ. Matrix metalloproteinases (MMPs) in health and disease: an overview. Front Biosci. 2006;11:1696-701.
13. Rai B, Kharb S, Jain R, Anand SC. Biomarkers of periodontitis in oral fluids. J Oral Sci. 2008;50(1):53-6.

14. Ram M, Sherer Y, Shoenfeld Y. Matrix metalloproteinase-9 and autoimmune diseases. J Clin Immunol. 2006;26(4):299-307.
15. Mair YH, Jhamb T, Visser MB, Aguirre A, Kramer JM. Sera and salivary matrix metalloproteinases are elevated in patients with vesiculoerosive disease: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2016;121(5):520-9.
16. Ashkenazi M, Dennison DK. A new method for isolation of salivary neutrophils and determination of their functional activity. J Dent Res. 1989;68(8):1256-61.
17. Thongprasom K, Dhanuthai K. Steriods in the treatment of lichen planus: a review. J Oral Sci. 2008;50(4):377-85.
18. Roopashree MR, Gondhalekar RV, Shashikanth MC, George J, Thippeswamy SH, Shukla A. Pathogenesis of oral lichen planus--a review. J Oral Pathol Med. 2010;39(10):729-34.
19. Otero-Rey EM, Suarez-Alen F, Peñamaria-Mallon M, Lopez-Lopez J, Blanco-Carrion A. Malignant transformation of oral lichen planus by a chronic inflammatory process. Use of topical corticosteroids to prevent this progression? Acta Odontol Scand. 2014;72(8):570-7.
20. Jayachandran S, Koijam Sashikumar S. Management of oral lichen planus: a clinical study. Jimsa. 2012;25(3):205-8.
21. Boorghani M, Gholizadeh N, Taghavi Zenouz A, Vatankhah M, Mehdipour M. Oral lichen planus: clinical features, etiology, treatment and management; a review of literature. J Dent Res Dent Clin Dent Prospects. 2010;4(1):3-9.
22. Coutinho AE, Chapman KE. The anti-inflammatory and immunosuppressive effects of glucocorticoids, recent developments and mechanistic insights. Mol Cell Endocrinol. 2011;335(1):2-13.
23. Yuan Y, Wang Z, Dong B. [Modulation of matrix metalloproteinase by dexamethasone in airway remodeling in asthmatic rats]. Sichuan Da Xue Xue Bao Yi Xue Ban. 2003;34(4):680-3.
24. Cincik H, Erkul E, Pinar D, Ipcioglu O, Gungor A, Cekin E, et al. Evaluation of MMP-9 and TIMP-1 Levels of the Patients with Nasal Polyposis After Corticosteroid Therapies. Indian J Otolaryngol Head Neck Surg. 2013;65(Suppl 2):445-9.
25. Nagase H, Woessner JF, Jr. Matrix metalloproteinases. J Biol Chem. 1999; 274(31):21491-4.
26. Navazesh M. Methods for collecting saliva. Ann N Y Acad Sci. 1993;694:72-7.
27. Ghallab NA, Shaker OG. Serum and salivary levels of chemerin and MMP-9 in oral squamous cell carcinoma and oral premalignant lesions. Clin Oral Investig. 2017;21(3):937-47.
28. Obase Y, Rytilä P, Metso T, Pelkonen AS, Tervahartiala T, Turpeinen M, et al. Effects of inhaled corticosteroids on metalloproteinase-8 and tissue inhibitor of metalloproteinase-1 in the airways of asthmatic children. International archives of allergy and immunology. 2010;151(3):247-54.
29. Tanaka H, Miyazaki N, Oashi K, Tanaka S, Ohmichi M, Abe S. Sputum matrix metalloproteinase-9: tissue inhibitor of metalloproteinase-1 ratio in acute asthma. J Allergy Clin Immunol. 2000;105(5):900-5.
30. Mattos W, Lim S, Russell R, Jatakanon A, Chung KF, Barnes PJ. Matrix Metalloproteinase-9 Expression in Asthma: Effect of Asthma Severity, Allergen Challenge, and Inhaled Corticosteroids. Chest. 2002;122(5):1543-52.
31. Weitoft M, Andersson C, Andersson-Sjöland A, Tufvesson E, Bjermer L, Erjefält J, et al. Controlled and uncontrolled asthma display distinct alveolar tissue matrix compositions. Respir Res. 2014;15(1):67.
32. Grzela K, Zagórska W, Krejner A, Banaszkiewicz A, Litwiniuk M, Kulus M, et al. Inhaled corticosteroids do not reduce initial high activity of matrix metalloproteinase (MMP)-9 in exhaled breath condensates of children with asthma exacerbation: a proof of concept study. Central-European journal of immunology. 2016;41(2):221-7.
33. Grzela K, Zagorska W, Krejner A, Litwiniuk M, Zawadzka-Krajewska A, Banaszkiewicz A, et al. Prolonged Treatment with Inhaled Corticosteroids does not Normalize High Activity of Matrix Metalloproteinase-9 in Exhaled Breath Condensates of Children with Asthma. Archivum Immunologiae et Therapiae Experimentalis. 2015;63(3):231-7.
34. Barton AK, Shety T, Bondzio A, Einspanier R, Gehlen H. Metalloproteinases and their inhibitors are influenced by inhalative glucocorticoid therapy in combination with environmental dust reduction in equine recurrent airway obstruction. BMC Vet Res. 2016;12(1):282.
35. Park SR, Kim SK, Kim SR, Kim D, Kim KW, Hong IS, et al. Noncanonical functions of glucocorticoids: A novel role for glucocorticoids in performing multiple beneficial functions in endometrial stem cells. Cell Death Dis. 2021;12(6):612.
36. Ke J, Ye J, Li M, Zhu Z. The Role of Matrix Metalloproteinases in Endometriosis: A Potential Target. Biomolecules. 2021;11(11):1739.
37. Romano F, Arduino PG, Maggiora M, Curmei E, Manavella V, Broccoletti R, et al. Effect of a structured plaque control on MMP-1 and MMP-9 crevicular levels in patients with desquamative gingivitis associated with oral lichen planus. Clin Oral Investig. 2019;23(6):2651-8.
38. Xia DN, Tan YQ, Yang JY, Zhou G. Omega-3 polyunsaturated fatty acids: a promising approach for the management of oral lichen planus. Inflamm Res. 2020;69(10):989-99.
39. Han X, Zhang J, Tan Y, Zhou G. Probiotics: A non-conventional therapy for oral lichen planus. Arch Oral Biol. 2017;81:90-6.
40. D`Avila-Mesquita C, Couto AES, Campos LCB, Vasconcelos TF, Michelon-Barbosa J, Corsi CAC, et al. MMP-2 and MMP-9 levels in plasma are altered and associated with mortality in COVID-19 patients. Biomed Pharmacother. 2021;142:112067.
41. Yang H, Wu Y, Ma H, Jiang L, Zeng X, Dan H, et al. Possible alternative therapies for oral lichen planus cases refractory to steroid therapies. Oral Surg Oral Med Oral Pathol Oral Radiol. 2016;121(5):496-509.
42. Didona D, Caposiena Caro RD, Sequeira Santos AM, Solimani F, Hertl M. Therapeutic strategies for oral lichen planus: State of the art and new insights. Front Med (Lausanne). 2022; 9:997190.
43. Vincent SD, Fotos PG, Baker KA, Williams TP. Oral lichen planus: the clinical, historical, and therapeutic features of 100 cases. Oral Surg Oral Med Oral Pathol. 1990;70(2):165-71.
.

How to cite:
Sehatpour M, Taheri JB, Yadegari Z, Namazi Z, Namdari M, Mirzaei H. Evaluation of salivary matrix metalloproteinase-9 (MMP-9) level in patients with oral lichen planus before and after treatment with 0.2% triamcinolone mouthwash. J Dent Sch 2022;40(3):111-115.