DOI: 10.7860/JCDR/2023/64422.18847

Original Article

Dentistry Section

Assessment of Xerostomia or Hyposalivation among Smokers Using the Modified Schirmer Test in the Saudi Population: A Cross-sectional Study

SAEED ABDULLAH AREM

ABSTRACT

Introduction: Saliva is essential for maintaining homeostasis in the oral cavity through its various components. A decrease in Salivary Flow Rate (SFR) has various deleterious effects on the oral tissues. Several factors can alter salivary flow, and one such factor is smoking. Therefore, this study aims to evaluate the effect of smoking on salivary flow.

Aim: To assess xerostomia and hyposalivation using the Modified Schirmer Test (MST) and the spitting method among smokers and compare the results with non-smokers in the Saudi population.

Materials and Methods: A cross-sectional study was conducted at the Institutional Diagnostic Clinic at the College of Dentistry, King Khalid University in the Aseer region of Saudi Arabia from February 2023 to March 2023. A total of 200 subjects were divided into two groups of 100 each. Group-I consisted of individuals with a smoking habit history for 10 years, while Group-II comprised healthy subjects with no smoking history. All subjects underwent screening for xerostomia and hyposalivation using the spitting method and MST. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0, and a p-value of <0.05 was considered statistically significant. Mean SFRs by the spitting method and MST were calculated, and the means were compared using an unpaired t-test. Pearson correlation analysis was used to assess the correlation between the two methods.

Results: A statistically significant decrease in SFR was observed in smokers compared to healthy subjects using both methods ($p<0.001$). There was an excellent correlation between the two estimation methods ($p<0.001$). The prevalence of xerostomia in Group-I was 45 (45%), and in Group-II, it was 14 (14%), while the prevalence of hyposalivation in Group-I was 73 (73%) and in Group-II, it was 10 (10%).

Conclusion: Salivary flow was lower in smokers compared to non-smokers in the Saudi population. There is an excellent correlation between the two assessment methods, and based on the study experience, the MST can be considered a reliable, objective, inexpensive, easy-to-perform, and well-tolerated test for assessing hyposalivation.

Keywords: Dry mouth, Homeostasis, Saliva, Salivary flow rate

INTRODUCTION

Saliva is a complex biological fluid of the oral cavity that is vital for maintaining the integrity of oral health by regulating homeostasis through its various components [1-3]. Saliva plays a crucial role in protecting the oral mucosa, initiating digestion, remineralising teeth, providing taste sensation, facilitating phonation, and balancing pH [4]. Consequently, an altered SFR plays a significant role in the pathogenesis of oral and dental diseases [5]. Xerostomia is characterised as the subjective feeling of oral dryness [6], whereas hyposalivation is an objective evaluation resulting from reduced salivary flow [7]. Previous studies have indicated that dry mouth does not always correspond with hyposalivation [8].

Assessing xerostomia is more challenging compared to measuring hyposalivation, as it is subjective. It typically involves obtaining a patient's history, utilising a dry mouth questionnaire to inquire about symptoms and medications, and possibly employing a visual analogue scale to quantify the patient's perception of the degree and severity of oral dryness [9].

Hyposalivation can be objectively measured through sialometry, which involves assessing glandular function by measuring whole or glandular salivary flow rate. Saliva can be either stimulated or unstimulated, but unstimulated saliva is the predominant type that persists for most of the duration and is responsible for the majority of saliva's functions. Therefore, measuring the unstimulated SFR is considered the ideal method for assessing hyposalivation. Unstimulated SFR is commonly used in salivary research, employing techniques such as draining or spitting methods. However, these methods are rarely used in clinical practice due to their cumbersome nature, time-consuming process, requirement of special equipment and trained personnel, and limited sensitivity [10,11].

In the search for an alternative method that is user-friendly, patient-friendly, and feasible in clinical settings, a newer approach called the MST has been identified as a good and reliable option. This method utilises commercially available Schirmer tear strips, typically used by ophthalmologists to measure tear gland function. In the MST, these strips are placed in the oral cavity to measure the Salivary Flow Rate [11].

Smoking is an addictive habit, and approximately one-third of the adult population are smokers [12]. Cigarette smoke contains 300 carcinogens and 4,000 bioactive chemical compounds that can cause structural and functional changes in saliva [13]. Saliva is the first to come into contact with the smoke, which spreads throughout the entire oral cavity [14]. Previous studies have shown that chronic or long-term smoking may lead to a decrease in sensitivity to taste receptors and a depressed salivary reflex. Therefore, smoking is considered one of the risk factors that can reduce salivary flow and cause xerostomia in patients [15].

To assess xerostomia using the Fox PC et al., questionnaire [9] and hyposalivation using the MST and spitting methods among smokers and non-smokers in the Saudi population, and to determine the

correlation and association between the MST and spitting methods for diagnosing xerostomia and hyposalivation conditions.

MATERIALS AND METHODS

A cross-sectional study was conducted on subjects attending the Institutional Diagnostic Clinic at the College of Dentistry, King Khalid University in the Aseer region of Saudi Arabia from February 2023 to March 2023. Informed consent was obtained from all subjects after explaining the study objectives. The proposed study was reviewed by the Ethical Committee of the College of Dentistry and received clearance under reference no. IRB/KKUCOD/ETH/2022-23/038.

Inclusion criteria: The study included subjects aged between 30-50 years who had a daily smoking habit for a minimum of 10 years and were willing to participate and provide consent.

Exclusion criteria: Subjects wearing dentures, with a history of radiotherapy, systemic or salivary gland diseases, or currently undergoing drug therapy were excluded from the study.

Sample size calculation: The required sample size was calculated using GPower 3.1 software. With a significance level of 5%, a study power of 80%, and an expected effect size of 0.41, it was determined that a minimum of 93 samples per group was necessary to conduct the study.

Procedure

A total of 200 subjects were recruited for the present study and divided into two groups of 100 each. The groups consisted of age and gender-matched smokers and non-smokers (healthy controls) aged between 30-50 years.

Group-I: Subjects with a daily smoking habit for a minimum of 10 years.

Group-II: Healthy subjects who were non-smokers.

All subjects were provided with a detailed explanation of the study protocol and were included in the study after obtaining informed consent. A routine clinical examination was conducted on all subjects by the examiner. Xerostomia was assessed first using a questionnaire developed by Fox PC et al., [9]. The severity of symptoms was classified as mild, moderate, or severe based on the reported symptoms [Table/Fig-1]. Subjects were asked to respond with "yes" or "no" to the questionnaire, and based on their reported symptoms, they were categorised into the respective groups.

S. No.	Questionnaire	Severity	Response
1	Do you feel your mouth is dry?	Mild xerostomia	Yes/no
2	Do you sip liquids to aid in swallowing dry food?		
3	Do you feel thirsty very frequently?	Moderate xerostomia	
4	Do you have difficulties swallowing any food?		
5	Does your mouth feel dry throughout the day?	Severe xerostomia	
6	Do you chew gum/hard candies/minutest daily to relieve oral dryness?		

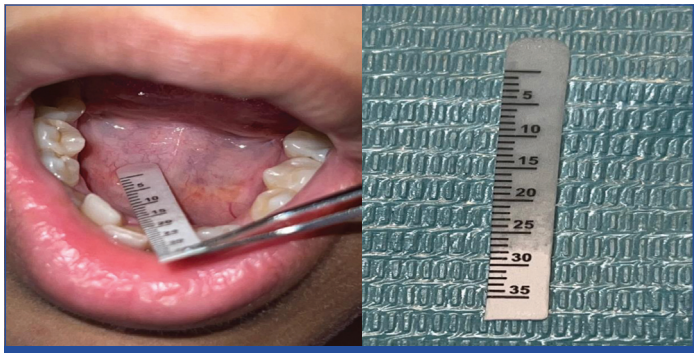
[Table/Fig-1]: Xerostomia questionnaire by Fox PC et al., [9].

Assessment of unstimulated SFR for hyposalivation was performed using both the Spitting method and the MST. Unstimulated saliva collection was conducted between 9 am and 12 noon, and all patients were instructed to refrain from eating, drinking, and smoking for a minimum of 90 minutes prior to the procedure. The two methods were randomly employed to assess unstimulated SFR. By measuring unstimulated SFR, the original results would not be masked by simultaneous stimulation of the salivary glands. A 30-minute time gap was maintained between the two procedures to prevent interference with the test results.

Spitting method: The patient was asked to sit upright with the head tilted downwards, allowing saliva to accumulate in the floor of the mouth while keeping the lips closed. The patient was then instructed to spit into a pre-weighed container approximately every 60 seconds for a duration of 10 minutes. After the designated collection period, the container was weighed again. The difference between the pre-weight and post-weight, divided by the collection time, provided the SFR. The flow rate was calculated in grams per minute (g/min), which is approximately equivalent to milliliters per minute (mL/min). Subjects were classified as having hyposalivation if their SFR was <0.1 mL/min.

MST method: The MST was adapted from the Schirmer tear test, which is commonly used by ophthalmologists to measure tear film wetness [13]. A commercially available Schirmer tear test strip, measuring 5-35 mm, was used for the MST. The strip has a blue colour bar that moves along with the fluid front and a millimetre scale (0-35 mm) to measure the amount of fluid flow.

During the MST, subjects were seated upright in a dental chair and instructed to swallow any saliva in their mouth before the test and avoid swallowing during the test. They were also asked to rest their tongue on the hard palate to prevent contact between the test strip and the tongue. The MST strip, held vertically with a cotton plier, was placed at the floor of the mouth to the right or left of the lingual frenum [Table/Fig-2]. When the rounded end of the strip came into contact with moisture, the wetting area travelled along the strip. The distance travelled by the wet area was measured and recorded at 1, 2, and 3 minutes [Table/Fig-3]. The strip was briefly removed for 2-3 seconds to take the readings. In this study, hyposalivation was defined as a wet area movement of less than 25 mm at three minutes, following the criteria established by Fontana M et al., [11].



[Table/Fig-2]: Clinical image of Schirmer tear strip in the oral cavity.
[Table/Fig-3]: Wetting of the strip. (Images from left to right)

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS version 20.0. Mean SFRs obtained from the spitting method and MST were calculated, and an unpaired t-test was used to compare the means. Pearson's correlation analysis was utilised to assess the correlation between the two methods. Results were presented as mean±SD, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 200 subjects were included in the present study, with 100 subjects in each group. Xerostomia was reported in 45 (45%) subjects in Group-I and 14 (14%) subjects in Group-II. Among the subjects in Group-I, 32 (71%) complained of mild xerostomia and 13 (29%) complained of moderate xerostomia. In Group-II, 12 (86%) subjects complained of mild xerostomia and 2 (14%) complained of moderate xerostomia. None of the subjects in either group reported severe symptoms of xerostomia.

The mean SFR obtained through the spitting method was presented in [Table/Fig-4], showing a statistically significant decrease among smokers compared to non-smokers. The mean SFR measured by the MST at the end of the 1st, 2nd, and 3rd minutes was presented in [Table/Fig-5], demonstrating a statistically significant decrease among smokers compared to non-smokers at all time intervals.

Pearson's correlation analysis revealed a strong positive correlation of 0.88 between the MST and spitting method [Table/Fig-6,7]. The association between xerostomia and hyposalivation, as determined by the MST method, was also evaluated [Table/Fig-8].

Group-I	Group-II	p-value
0.18±0.11	0.29±0.08	**0.001***

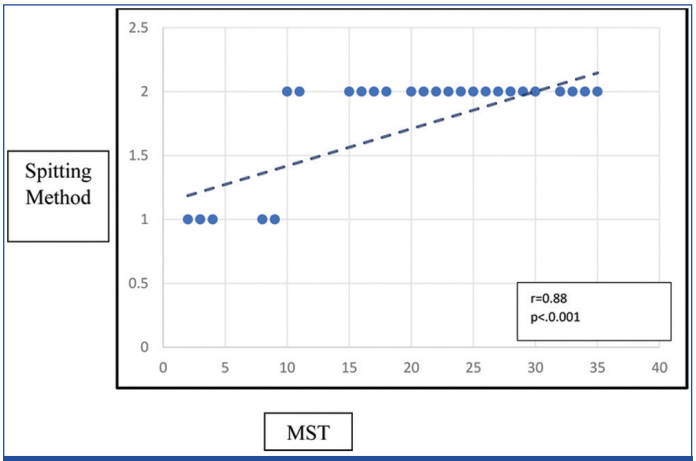
[Table/Fig-4]: Spitting method scores (mL/min) among the study subjects.
*significant difference

Time interval	Group-I	Group-II	p-value
1st min	6.76±3.94	9.73±2.58	**0.001***
2nd min	12.5±7.39	19.19±4.76	**0.001***
3rd min	19.03±10.28	29.59±6.75	**0.001***

[Table/Fig-5]: MST scores (mm) among the study subjects.
*significant difference

Subjects	Spitting	MST	r value	p-value
Group-I	0.18±0.11	19.03±10.28	r=0.873	**0.001***
Group-II	0.29±0.08	29.59±6.75	r=0.805	**0.001***
Total Sample	0.23±0.11	24.31±10.16	r=0.886	**0.001***

[Table/Fig-6]: Correlation between the spitting method and MST.
*significant difference



[Table/Fig-7]: Correlation graph between MST and spitting method.

	Group-I		Group-II	
	Hyposalivation		Hyposalivation	
Xerostomia	Present	Absent	Present	Absent
Present	33 (33%)	12 (12%)	9 (9%)	5 (5%)
Absent	40 (40%)	15 (15%)	1 (1%)	85 (85%)

[Table/Fig-8]: Association of xerostomia and hyposalivation by MST.
Unpaired t-test was applied

Among the 45 subjects in Group-I who complained of xerostomia, 33 (73%) had hyposalivation. Among the 14 subjects in Group-II who complained of xerostomia, 9 (64%) had hyposalivation. In Group-I, 40 (40%) subjects had hyposalivation but did not complain of xerostomia, whereas in Group-II, only 1 (1%) subject had hyposalivation without complaining of xerostomia [Table/Fig-8].

In Group-I, xerostomia was present in 45 subjects (45%), while in Group-II, it was present in 14 subjects (14%). Hyposalivation was found in 73 subjects (73%) in Group-I and 10 subjects (10%) in Group-II. A higher number of subjects in the smoking group exhibited both xerostomia and hyposalivation compared to the healthy group [Table/Fig-9].

Groups	N	Xerostomia	Hyposalivation
I	100	45 (45%)	73 (73%)
II	100	14 (14%)	10 (10%)

[Table/Fig-9]: Prevalence of xerostomia and hyposalivation.

DISCUSSION

Saliva is an essential fluid in the oral cavity that plays a crucial role in defence mechanisms. Its secretion can be influenced by various systemic conditions, drugs, and habits. The daily saliva secretion ranges from 0.75 to 1.5 L, with a typical total SFR of 0.3-0.5 mL/minute [16]. Xerostomia, or the feeling of dry mouth, is a subjective sensation that varies based on individual perception. It may not always accurately reflect actual salivary gland functioning. Sometimes, individuals may experience dryness despite having normal salivary flow, while others may have decreased flow without perceiving dryness. Previous studies have also indicated that dry mouth does not always correlate with hyposalivation [8]. Therefore, it is important to evaluate both objective and subjective measures of salivary flow to draw conclusions. In this study, the authors measured salivary flow using both objective and subjective methods and assessed the association between them. The questionnaire developed by Fox PC et al., [9] was used as a simple screening tool to assess xerostomia. The study revealed that 45 subjects (45%) in the smokers group and 14 subjects (14%) in the non-smokers group reported experiencing xerostomia. These findings were consistent with a study conducted by Dyasanoor S and Saddu SC [14].

Resting whole saliva is a mixture of secretions that enter the mouth without external stimuli. Unstimulated whole saliva reflects the basal SFR and is present for approximately 14 hours a day, providing oral tissue protection. Stimulated saliva is produced in response to stimulation, such as when eating, and lasts for up to two hours. The measurement of unstimulated saliva is an accurate method for analysing the status of salivary glands, while stimulated saliva is useful for studying functional reserve [17]. Therefore, the present study assessed hyposalivation by measuring the Unstimulated SFR (USSFR). Various methods, such as volumetric and gravimetric analysis (such as spitting method, draining methods, etc.), can be used to measure USSFR. However, these techniques are time-consuming, cumbersome, and require additional training. They are commonly used in research but impractical for clinical use [18]. In the search for an alternative method that is easy, rapid, and feasible for chair-side use, the MST emerged as a better choice. Many authors have performed MST and correlated its results with gravimetric and volumetric measurements. They have found that MST is a simple, practical, inexpensive, standardised, and easy-to-perform method in clinical practice [10,11,16,19]. Therefore, MST was included in the present study. Based on the experience from the present study, subjects were more comfortable performing the MST compared to the spitting method.

Among all habits, smoking is the one that exposes the entire oral cavity to various carcinogens, toxins, and chemicals, with saliva being the first to be exposed. Nicotine, the main constituent of tobacco smoke, is highly addictive and alters neural activation, leading to changes in salivary secretion. Carbon monoxide, a toxin present in smoke, has a destructive effect on the salivary gland parenchyma, resulting in reduced salivary flow [20]. The effects of smoking on salivary flow are not clear. Previous studies have reported a transient increase in salivary flow in the initial stages of smoking. However, long-term use can lead to tolerance, resulting in a reduction in SFR. It has been found that smoking is a risk factor associated with xerostomia and dry mouth [15,17].

In the present study, the SFR was significantly lower in smokers compared to non-smokers using both estimation methods. These results were consistent with previous studies conducted by Rad M et al., Dyasanoor S and Saddu SC, Ameer S et al., and Singh M et al., [1,14,16,17]. The correlation analysis with an r-value of 0.88 indicated a strong positive correlation between the MST and the gold standard volumetric spitting method. This suggests that MST can be routinely used in day-to-day clinical practice as a less cumbersome alternative. Similar results were observed in previous studies by Kumar NN et al., which measured SFR using the MST [19].

The study results revealed that 73 subjects (73%) in the smokers group and 10 subjects (10%) in the non-smokers group had hyposalivation, as indicated by an MST value of <25 mm at three minutes. These values are higher than those reported in the study conducted by Dyasanoor S and Saddu SC [14]. This difference may be attributed to the duration of smoking, as the previous study included individuals with a smoking history of more than six months, while the present study included individuals with a smoking history of 10 years. This suggests that chronic, long-term smoking has a greater impact on salivary gland functioning.

Interestingly, out of the 73 (73%) subjects who showed hyposalivation in the smokers group, only 33 (45%) subjects complained of xerostomia. This implies that many patients are unaware of the actual reduced functioning of their salivary glands, which can have implications for their oral health. Therefore, early screening of subjects using the MST for hyposalivation, even if they are asymptomatic, along with a detailed history of long-term smoking habits, may improve their quality of life and help prevent the deleterious effects associated with smoking by providing counselling to quit the habit.

Limitation(s)

The present study did not correlate the type of smoking, frequency, and duration of the habit with salivary flow, which could have provided further insight into the short-term and long-term effects of smoking. Additionally, the sample size was limited, which may have impacted the generalisability of the findings. Furthermore, the study did not evaluate the potential side effects on the oral cavity resulting from decreased SFR.

CONCLUSION(S)

The SFR was found to be significantly lower in smokers compared to non-smokers, indicating the negative impact of smoking on salivary gland function. This decrease in salivary flow has deleterious effects on the oral cavity. Both the MST and spitting methods yielded similar results, with the MST showing a strong and positive correlation with the gold standard volumetric spitting method. This suggests that the MST can be routinely used in day-to-day clinical practice as a reliable, objective, inexpensive, and easy-to-perform test for assessing hyposalivation. It is well-tolerated by patients.

Early detection of hyposalivation using the MST in smokers can lead to improved overall oral health and prevention of long-term complications. The immediate implication of this study is that hyposalivation can be readily assessed using the MST, thereby preventing the deleterious effects on the oral cavity and improving the quality of life.

Hence future studies are recommended with larger sample sizes to document the relationship between smoking and SFR along with consideration of factors like type and duration of smoking habit, thus analysing consequences of same on SFR and oral health.

REFERENCES

[1] Rad M, Kakoie S, Niliye Brojeni F, Pourdamghan N. Effect of long-term smoking on whole-mouth salivary flow rate and oral health. J Dent Res Dent Clin Dent Prospects. 2010;4(4):110-14.
[2] Sreebny LM. Saliva in health and disease: An appraisal and update. Int Dent J. 2000;50(3):140-61.
[3] Dawes C. Salivary flow patterns and the health of hard and soft oral tissues. J Am Dent Assoc. 2008;139(Suppl):18S-24S.
[4] Zappacosta B, Persichilli S, De Sole P, Mordente A, Giardina B. Effect of smoking one cigarette on antioxidant metabolites in the saliva of healthy smoker. Arch Oral Biol. 1999;44(6):485-88.
[5] Mandel ID. The diagnostic use of saliva. J Oral Pathol Med. 1990;19(3):119-25.
[6] Sreebny LM, Valdini A. Xerostomia. Part I: Relationship to other oral symptoms and salivary gland hypofunction. Oral Surg Oral Med Oral Pathol. 1988;66(4):451-58.
[7] Villa A, Connell CL, Abati S. Diagnosis and management of xerostomia and hyposalivation. Ther Clin Risk Manag. 2014;11:45-51. Doi: 10.2147/TCRM.S76282. PMID: 25653532; PMCID: PMC4278738.
[8] So JS, Chung SC, Kho HS, Kim YK, Chung JW. Dry mouth among the elderly in Korea: A survey of prevalence, severity, and associated factors. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110(4):475-83.
[9] Fox PC, Busch KA, Baum BJ. Subjective reports of xerostomiaand objective measures of salivary gland performance. J Am Dent Assoc. 1987;115(4):581-84.
[10] Chen A, Wai Y, Lee L, Lake S, Woo SB. Using the modified Schirmer test to measure mouth dryness: A preliminary study. J Am Dent Assoc. 2005;136(2):164-70.
[11] Fontana M, Zunt S, Eckert GJ, Zero D. A screening test forunstimulated salivary flow measurement. Oper Dent. 2005;30(1):03-08.
[12] Johnson N. Tobacco use and oral cancer: A global perspective. J Dent Educ. 2001;65(4):328-39.
[13] Rad M, Kakoie S, Brojeni FN, Pourdamghan N. Effect of long-term smoking on whole-mouth salivary flow rate and oral health. J Dent Res Dent Clin Dent Prospect. 2010;4(4):110-14.
[14] Dyasanoor S, Saddu SC. Association of xerostomia and assessment of salivary flow using modified schirmer test among smokers and healthy individuals: A preliminary study. J Clin Diagn Res. 2014;8(1):211-13.
[15] Khan GJ, Mehmood R, Salah-ud-Din, Ihtesham-ul-Haq. Effects of long-term use of tobacco on taste receptors and salivary secretion. J Ayub Med Coll Abbottabad. 2003;15(4):37-39.
[16] Ameer S, Mamatha B, Chikte D, Damera A, Kumar YP, Shreya Reddy C. Comparative assessment of salivary flow rates among reverse smokers and smokers using modified Schrimer test: A randomized prospective trial. J Indian Acad Oral Med Radiol. 2022;34(2):203-07.
[17] Singh M, Ingle NA, Kaur N, Yadav P, Ingle E. Effect of long-term smoking on salivary flow rate and salivary pH. J Indian Assoc Public Health Dent. 2015;13(1):11-13.
[18] Humphrey SP, Williamson RT. A review of saliva: Normal composition, flow, and function. J Prosthet Dent. 2001;85(2):162-69.
[19] Kumar NN, Panchaksharappa MG, Annigeri RG. Modified schirmer test--A screening tool for xerostomia among subjects on antidepressants. Arch Oral Biol. 2014;59(8):829-34.
[20] Alaee A, Azizi A, Valaei N, Moeini SH. The correlation between cigarette smoking and salivary flow rate. J Res Dentomaxillofac Sci. 2017;2(3):05-09.

PARTICULARS OF CONTRIBUTORS:
1. Lecturer, Department of Diagnostic Sciences and Oral Biology, King Khalid University, ABHA, Aseer, Saudi Arabia.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Saeed Abdullah Arem,
King Fahad Street, ABHA, Asir, Saudi Arabia.
E-mail: sareem@kku.edu.sa

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 17, 2023
- Manual Googling: Jun 17, 2023
- iThenticate Software: Sep 11, 2023 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Apr 02, 2023**
Date of Peer Review: **Jun 09, 2023**
Date of Acceptance: **Sep 13, 2023**
Date of Publishing: **Dec 01, 2023**