INFLUENCE OF RESTING TONGUE POSTURE ON MANDIBULAR ARCH WIDTH AND VERTICAL DIMENSIONS OF FACE

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ABSTRACT

Objective: To evaluate the influence of tongue posture on the arch width of the mandible and the facial proportions in the vertical dimension.

Methodology: A cross-sectional analysis was carried out utilizing lateral cephalograms and dental molds from 120 participants (45 males, 75 females). The participants were classified into three categories based on the dimensions of their vertical facial structure: Normodivergent, Hyperdivergent, and Hypodivergent. The posture of the tongue was ascertained by measuring the distance from the tongue to the palate using the technique introduced by Graber and colleagues. The widths of the mandibular dental arches were assessed using the study molds. Differences among the groups were evaluated using one-way ANOVA. Relationships between mandibular arch widths and six distinct tongue-to-palate measurements were investigated using Pearson's correlation. A p-value of ≤ 0.05 was deemed to indicate a statistically significant result.

Results: The comparison of the tongue to palate distances (D1, D2, and D3) at 0, 30, and 60 degrees among study groups showed statistically nonsignificant differences, however, the tongue to palate distances (D4, D5, and D6) showed statistically significant differences amongst all groups. Statistically significant differences were found in intercanine and intermolar width among the three study groups. The correlation of tongue posture with mandibular intercanine width and intermolar width at all six tongue-to-palate distances was weak.

Conclusion: In hyperdivergent patients, the tongue posture was lower as compared to hypodivergent and norm divergent patients, especially at the mid-dorsum, anterior dorsum, and tongue tip regions. A weak correlation was found between mandibular arch width and tongue posture.

Keywords: Dentofacial Deformities; Malocclusion; Mandibular Arch Width; Orofacial Muscles; Resting Tongue Posture; Vertical Dimensions

INTRODUCTION

Orofacial musculature involving the muscles of the tongue, lips, and cheeks behave as a determinant in the harmony of occlusion, and its dysfunction influences dentition and the morphology of dental arches. Teeth and supporting alveolar arches are constantly under the effect of muscles of the face and neck[1]. Functional matrix theory of growth by Melvin Moss[2] states that soft tissues dictate the size and shape of bony structures and the growth of facial bones is controlled by environmental factors and functional needs mediated by soft tissues.

The imbalance between resting postural and active functional forces can be a primary causative factor leading to the development of malocclusion or can aggravate an existing malocclusion as a result of an increase in compensatory muscle activity. Open bite malocclusion is related to thumb or finger sucking habits and compensatory tongue thrusting to create an oral seal[3]. Leptoprosopic facial form is associated with mouth breathing[4] while Class III malocclusion is associated with a short upper lip, redundant lower lip, and low tongue posture[5].

The tongue is one of the strongest oral musculatures and it plays the role of the primary taste organ along with functions of mastication, swallowing, speech, breathing, and maintaining the equilibrium of dentition[6]. The tongue is a mighty flexible muscular organ and any discrepancy in its size[7], posture[8], and activity[9] is labelled as the hallmark of causing various dentofacial deformities. Macroglossia can cause difficulty in breathing, deglutition, and speech as well as the development of generalized tooth spacing and open bite[10]. Literature review shows that habitual abnormal tongue posture can be a contributing factor in the establishment of malocclusions such as anterior open bite, mandibular prognathism, and spacing between

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teeth[11,12].

Furthermore, the assessment of soft tissue relations clinically bears primary diagnostic importance. The modern treatment goals of orthodontic therapy are now primarily focused on establishing the ideal soft tissue proportions and improved esthetics rather than Angle's paradigm of ideal occlusion[13]. Treatment planning is done to predict the future soft tissue profile and then place teeth in a position to achieve desired esthetic outcome based on soft tissue favorability and balance[14].

Moreover, the stability of results of orthodontic tooth movement is based particularly on soft tissue pressures and equilibrium. The concept of neutral zone refers to the zone of equilibrium between tongue and lip and cheek musculature[15]. Moving teeth out of the neutral zone will alter the neuromuscular balance and result in a tendency of orthodontic relapse[16].

Studies have been done previously to determine the relation of resting tongue posture with skeletal sagittal dimensions such as in Class III patients there is a significantly lower tongue posture as compared to Class I and II patients[5]. The rationale of this study is to investigate the influence of resting tongue posture on the dental arch width of the mandible and the vertical dimensions of the face. It will contribute to the field by adding to our understanding of the impact of soft tissue factors on the development of dentofacial deformities and malocclusion and can help clinicians develop more comprehensive treatment plans that address not only the teeth but also the surrounding soft tissues. By identifying and addressing abnormal tongue postures or other functional habits, clinicians can improve treatment outcomes and reduce the likelihood of relapse.

METHODOLOGY

This cross-sectional study was carried out at the Armed Forces Institute of Dentistry (AFID) Department of Orthodontics Rawalpindi after taking ethical approval from the ethical review committee of AFID Rawalpindi (Ref letter no: 905/Trg-ABP1K2). A sample size of 120 was calculated using the G Power software, the value of Effect size was kept at 0.8, Alpha error was 0.05, Beta error was 0.2, and the Probability and power were 0.8. Patients fulfilling our inclusion criteria were included in the sample using a non-probability consecutive pattern. Subjects with a complete set of permanent dentition including second molars and good visibility of tongue in cephalogram were selected. Whereas, exclusion criteria involved a history of previous orthodontic treatment, trauma and surgery affecting orofacial musculature, deleterious habits, missing teeth, any craniofacial or dental anomaly/syndromes and neuromuscular disorders.

Pretreatment digital lateral cephalograms and dental casts were recorded for all the subjects. Based on the maxillomandibular plane angle evaluated on lateral cephalogram, patients were divided into three groups i.e. Hypodivergent (MMA <21°), Normodivergent (MMA = 25±4°) and Hyperdivergent (MMA >29°)

For the evaluation of tongue posture, Digital cephalostat (Carestream 8000C, model DFBD040, France) with a tube voltage of 80kV and tube current of 10mA was used to record pretreatment lateral cephalograms of all subjects at 170 cm film to x-ray source distance as shown in Figure 1. Patient's heads were positioned at the natural head position as they looked straight into their eyes in the mirror at the front. After explaining to the patient about centric occlusion and resting lip posture, records of resting tongue posture were obtained by instructing the patients to swallow and then relax. Tongue posture was evaluated on lateral cephalograms by constructing a template using the method developed by Graber et al[17]. Assessment of tongue posture requires measuring the distance between the superior tongue surface and the roof of the mouth. The outlines of the superior surface of the tongue and the palatal roof were delineated. A horizontal reference line connecting the incisal tip of the most prominent lower incisor and the cervical third on the distal side of the lower second molar was drawn on the template. The distal surface's cervical region of the lower second molar served as the focal point, and from this center, vertical lines were drawn at angles of 30°, 60°, 90°, 120°, and 150°. The distances between the tongue's dorsal surface and the palate's contours, labeled as D1 to D6, were quantified at six distinct angles (0°, 30°, 60°, 90°, 120°, and 150°).

Data was analyzed using SPSS version 25.0. Frequencies and percentages were calculated for age and gender. Using the Shapiro-Wilk test normality of data was tested and since the data showed normality of distribution, one-way ANOVA was used to differentiate resting tongue posture and mandibular arch widths among the three study groups. To compare statistically significant groups, a Tukey post hoc test was applied. Using Pearson's correlation, mandibular intercanine and intermolar widths were correlated with six tongue to palate distances. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of the sample (N=120) was 16.43 ± 4.3 years (Table 1). Out of a total of 120 patients, there were 45 males and 75 females (Table 2) which were divided into hypodivergent, normodivergent and hyperdivergent groups (Table 3). Statistically non-significant differences were found among study groups by comparison of the tongue to palate distances (D1, D2, and D3) however the tongue to palate distances (D4, D5, and D6) showed statistically significant differences among normodivergent, hypodivergent and hyperdivergent groups (Table 4). Moreover, statistically significant differences were found in mandibular intercanine and intermolar width among the three study groups (Table 4). A Tukey post hoc test suggested statistically significant differences (p-value < 0.05) in resting tongue posture at D4, D5 and D6 between hyperdivergent and hypodivergent groups (Table 5). Comparison between normodivergent and hyperdivergent groups showed statistically significant results at D4 and D5. However, there were no differences between normodivergent and hypodivergent groups at D4, D5 and D6. Differences in mandibular intercanine width were significant between normodivergent and hyperdivergent groups. Mandibular intermolar widths were significantly different between both normodivergent-hyperdivergent and hyperdivergent-hypodivergent pairs (Table 5). A weak correlation was found between mandibular arch width and tongue posture (Table 6).

Table 1: Age

	N	Minimum	Maximum	Mean	Std. Deviation
Age	120	10	32	16.43	4.311
Valid N (listwise)	120				

Table 2: Gender Statistics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	45	37.5	37.5	37.5
	Female	75	62.5	62.5	100.0
	Total	120	100.0	100.0	

Table 3: Vertical proportions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normodivergent	49	40.8	40.8	40.8
	Hyperdivergent	37	30.8	30.8	71.7
	Hypodivergent	34	28.3	28.3	100.0
	Total	120	100.0	100.0	

Table 4: ANOVA analysis

	Hyperdivergent n=37	Normodivergent n=49	Hypodivergent n=34	P value
Tongue to palate distance at 0o (D1)	3.13 ± 1.52	2.91 ±1.65	3.50 ±2.13	0.340
Tongue to palate distance at 30o (D2)	3.06± 1.67	2.83 ±1.69	2.79 ±1.57	0.745
Tongue to palate distance at 60o (D3)	4.54 ±1.78	3.88 ±1.96	3.51 ±1.81	0.067
Tongue to palate distance at 90o (D4)	7.54 ±2.16	5.71 ±2.64	4.67 ±2.87	0.001*
Tongue to palate distance at 120o (D5)	10.37 ±3.47	7.30 ±3.06	6.00 ±3.04	0.001*
Tongue to palate distance at 150o (D6)	10.08 ±4.73	9.14 ±3.57	7.72 ±3.55	0.045*
Mandibular Intercanine Width (IC)	26.16 ±2.38	27.94 ±3.38	27.28 ±2.92	0.025*
Mandibular Intermolar Width (IM)	45.60 ±5.24	48.54 ±5.55	48.88 ±3.02	0.007*

*p-value <0.05

Table 5: Tukey post hoc test

Dependent Variable	(I) Vertical proportions	(J) Vertical proportions	Mean Difference (I-J)	Sig.
Tongue to palate distance at 90º (D4)	Normodivergent	Hyperdivergent	-1.82625*	.004*
		Hypodivergent	1.03782	.173
	Hyperdivergent	Hypodivergent	2.86407*	.000*
Tongue to palate distance at 120º (D5)	Normodivergent	Hyperdivergent	-3.07226*	.000*
		Hypodivergent	1.30612	.163
	Hyperdivergent	Hypodivergent	-1.71514*	.004*

DISCUSSION

The facial and masticatory musculature is of utmost value in the causation and management of malocclusions and craniofacial deformities, as well as for the retention of achieved orthodontic treatment.[18] Forces of soft tissue and associated musculature act on dentition exerting variable magnitude and duration of forces during rest and activity. Resting postural forces of oral musculature are continuous and are of long duration. The such light magnitude and long-duration forces can cause teeth to move while forces exerted during activity i.e., swallowing, mastication and speech are intermittent and short duration thus, unable to achieve tooth movement.[19] Resting postural forces of the tongue have a paramount role in the development of arch dimensions and stability of dentition.

Tongue to palate distance at 150° (D6)	Normodivergent	Hyperdivergent	-.93822	.524
		Hypodivergent	1.42227	.246
	Hyperdivergent	Hypodivergent	-2.36049*	.036*
Mandibular Intercanine Width (IC)	Normodivergent	Hyperdivergent	1.78837*	.018*
		Hypodivergent	.66242	.581
	Hyperdivergent	Hypodivergent	-1.12595	.253
Mandibular Intermolar Width (IM)	Normodivergent	Hyperdivergent	2.94660*	.017*
		Hypodivergent	-.34021	.947
	Hyperdivergent	Hypodivergent	-3.28681*	.015*

*p-value <0.05

Table 6: Pearson's correlation

Tongue to palate distances	Mandibular intercanine width (IC)	Mandibular intermolar width (IM)
D1	0.263	0.180
D2	0.144	0.067
D3	0.032	0.105
D4	0.029	0.178
D5	0.039	0.111
D6	0.084	0.154

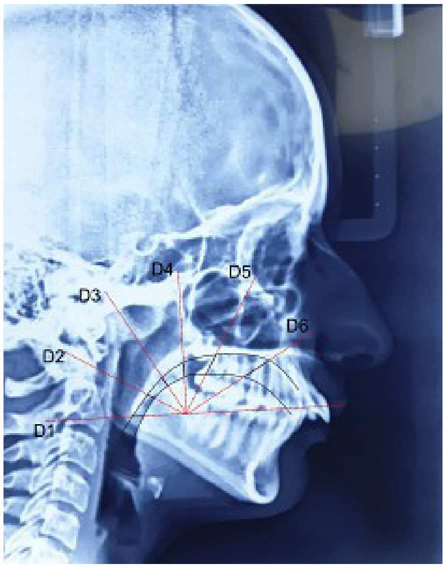

Figure 1: Template for assessment of tongue posture on lateral cephalogram

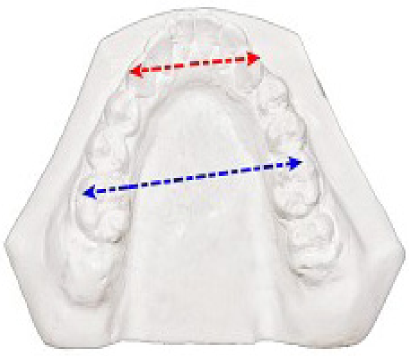

Figure 2: Measurement of mandibular intercanine and intermolar width on a dental cast

It is a well-known fact that the facial skeleton exhibits various vertical growth patterns and it can grow towards a more vertical or horizontal growth pattern. The ultimate choice of treatment mechanics, extraction decisions, and treatment timing are based on underlying vertical patterns. Any treatment approach or philosophy without consideration of the vertical facial pattern would appear to be insufficient thus, the orthodontist should have a comprehensive knowledge and cognizance of the craniofacial musculature and its interrelation with the growth and development of the dentofacial complex and orthodontic treatment and stability.[20] The present study investigates the influence of resting tongue posture on facial proportions in the vertical dimension and arch width of the mandible.

The tongue to palate distances D4, D5 and D6 showed statistically significant differences (p-value <0.05) among normodivergent, hypodivergent, and hyperdivergent groups. In hyperdivergent patients, the tongue posture was found to be lower (greater tongue-to-palate distances), as compared to hypodivergent and normodivergent patients, especially at mid-dorsum(D4), anterior dorsum(D5), and tongue tip regions(D6) (Table 4). Results reported by Valdés et al[21] were also similar, he found significantly greater vertical facial dimensions with the resting position of the tongue on the floor of the mouth when compared with the resting position of the tongue against the palate. This association is likely due to the weight of the tongue in contact with the mandible leading to greater eruption of posterior teeth and the concomitant downward and backward mandibular rotation. The lower resting position of the tongue creates mandibular descending action which consequently increases the vertical dimensions of the face. Long face patients with the anterior open bite may experience a lower tongue posture due to a reduced airway space, which can cause a lower mandibular resting position and an extended head posture[22,23]. In addition to tongue posture, studies have suggested that both genetic and environmental factors may play a role in the aetiology of hyperdivergent facial pattern[24].

A significant relation was found between mandibular intercanine and intermolar widths and vertical dimensions of the face (Table 4). Mandibular dental arch widths were narrower in hyperdivergent subjects as compared to hypodivergent and normodivergent subjects. Hwang et al reported comparable results, as the mandibular plane angle increased, transverse mandibular width at the midroot level decreased[25]. This occurrence is explained by the difference in the functional activity of masticatory muscles and the association of masticatory muscles with the growth of jawbones. In the case of brachyfacial individuals, muscles have increased functional activity hence the jaws are subject to increased mechanical loading that may, in turn, enhance bone apposition and transverse growth in the dentofacial regions, whereas, in dolicofacial patients, weak musculature and smaller biting forces lead to more constricted dental arches with deficient transverse growth[26].

Postnatal alterations in the dental arch form might occur by size, activity, and posture of the tongue acting as one of the environmental factors. The correlation of tongue posture with mandibular intercanine width and intermolar width at all six tongue-to-palate distances was weak (Table 6). Similar results of weak correlation of tongue posture with mandibular arch widths were reported by Fatima et al[27]. These results were in accordance with the study conducted by Primozi et al[5], in which weak to no correlation was seen between tongue posture and the intermolar/intercanine widths, probably due to dental compensations.

Results of the study indicate that vertical proportions of the face are related to the resting tongue posture and arch width of the mandible. As clinical inference, an abnormal resting posture of the tongue, neuromuscular disturbances and soft tissue imbalances can be contributing factors in the development of malocclusion and instability of orthodontic treatment results. Therefore, the examination of tongue posture and movements particularly in hyperdivergent patients would be endorsed and comprehensive treatment should include the modification of improper tongue posture to improve treatment outcomes and to enhance post-treatment stability of orthodontic treatment.

Limitations of this study include the use of lateral cephalogram for evaluation of tongue posture which is a two-dimensional imaging technique thus tongue volume could not be taken into account. Furthermore, maxillary and mandibular widths should be ideally taken from basal bone levels[25] as molars and canines may show compensations for various malocclusions, which is possible from CBCT scans but due to high radiation dosage we avoided taking CBCT scans for study purposes only.

CONCLUSION

In conclusion, this study illuminates the intricate relationships between facial structure, dental configuration, and tongue posture. Our findings suggest that tongue-to-palate distances increase progressively from the root to the tip of the tongue, with a higher posture at the posterior dorsum. Notably, facial vertical patterns, specifically hyperdivergent structures, significantly influence the resting tongue posture and the mandibular dental arch width. Even though a weak positive correlation was observed between the resting tongue posture and the mandibular arch width, likely due to dental compensations, it highlights the complex dynamics of these anatomical elements.

REFERENCES

1. Sarver DM. Interactions of hard tissues, soft tissues, and growth over time, and their impact on orthodontic diagnosis and treatment planning. Am J Orthod Dentofacial Orthop. 2015;148(3):380-6. DOI:10.1016/j.ajodo.2015.04.030.
2. Moss ML, Salentijn L. The primary role of functional matrices in facial growth. Am J Orthod. 1969;55(6):566-77. DOI:10.1016/0002-9416(69)90034-7.
3. Meng M, Xie Y, Cao J, Yu Y, Zhou X, Zou J. Effects of bonded spurs, fixed and removable palatal crib in the early treatment of anterior open bite: A systematic review and meta-analysis. Am J Orthod Dentofacial Orthop. 2023;163(3):298-310. DOI:10.1016/j.ajodo.2022.10.017.
4. Zhao Z, Zheng L, Huang X, Li C, Liu J, Hu Y. Effects of mouth breathing on facial skeletal development in children: a systematic review and meta-analysis. BMC Oral Health. 2021;21(1):108. DOI:10.1186/s12903-021-01458-7.
5. Primozic J, Farcnik F, Perinetti G, Richmond S, Ovsenik M. The association of tongue posture with the dentoalveolar maxillary and mandibular morphology in Class III malocclusion: a controlled study. Eur J Orthod. 2013;35(3):388-93. DOI:10.1093/ejo/cjs015.
6. Doyle ME, Premathilake HU, Yao Q, Mazucanti CH, Egan JM. Physiology of the tongue with emphasis on taste transduction. Physiol Rev. 2023;103(2):1193-1246. DOI:10.1152/physrev.00012.2022.
7. Liu ZJ, Shcherbatyy V, Gu G, Perkins JA. Effects of tongue volume reduction on craniofacial growth: A longitudinal study on orofacial skeletons and dental arches. Arch Oral Biol. 2008;53(10):991-1001. DOI:10.1016/j.archoralbio.2008.05.010.
8. Lowe AA, Takada K, Yamagata Y, Sakuda M. Dentoskeletal and tongue soft-tissue correlates: a cephalometric analysis of rest position. Am J Orthod. 1985;88(4):333-41. DOI:10.1016/0002-9416(85)90133-2.
9. Lowe AA. Correlations between orofacial muscle activity and craniofacial morphology in a sample of control and anterior open-bite subjects. Am J Orthod. 1980;78(1):89-98. DOI:10.1016/0002-9416(80)90042-1.
10. Topouzelis N, Iliopoulos C, Kolokitha OE. Macroglossia. Int Dent J. 2011;61(2):63-9. DOI:10.1111/j.1875-595X.2011.00015.x.
11. D'Onofrio L. Oral dysfunction as a cause of malocclusion. Orthod Craniofac Res. 2019 May;22 Suppl 1(Suppl 1):43-48. DOI:10.1111/ocr.12277.
12. Yamaguchi H, Sueishi K. Malocclusion associated with abnormal posture. Bull Tokyo Dent Coll. 2003;44(2):43-54. DOI:10.2209/tdcpublication.44.43.
13. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 1. Evolution of the concept and dynamic records for smile cap-

ture. Am J Orthod Dentofacial Orthop. 2003;124(1):4-12. DOI:10.1016/s0889-5406(03)00306-8.

14. Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res. 1999;2(2):49-52. DOI:10.1111/ocr.1999.2.2.49.
15. Beenu V, Kattak AKS, Pattath VS, Nair SJ, Das R, Sreelekshmi MS. Is Neutral Zone, Patients Comfort Zone? A Feedback Review. J Pharm Bioallied Sci. 2020;12(Suppl 1):S2-S5. DOI:10.4103/jpbs.JPBS_56_20.
16. Littlewood SJ. Evidence-based retention: Where are we now? Semin Orthod. 2017;23:229–36.
17. Graber TM, Petrovic AG. Dentofacial orthopedics with functional appliances. St. Louis Mosby; 1997.
18. Kim TH, Kim CH. Correlation between mandibular morphology and masticatory muscle thickness in normal occlusion and mandibular prognathism. J Korean Assoc Oral Maxillofac Surg. 2020 Oct 31;46(5):313-20. DOI:10.5125/jkaoms.2020.46.5.313.
19. Proffit WR. Contemporary orthodontics. 6th ed. Philadelphia: Elsevier; 2018.
20. Pepicelli A, Woods M, Briggs C. The mandibular muscles and their importance in orthodontics: a contemporary review. Am J Orthod Dentofacial Orthop. 2005;128(6):774-80. DOI:10.1016/j.ajodo.2004.09.023.
21. Valdés C, Gutiérrez M, Falace D, Astaburuaga F, Manns A. The effect of tongue position and resulting vertical dimension on masticatory muscle activity. A cross-sectional study. J Oral Rehabil. 2013 Sep;40(9):650-6. DOI:10.1111/joor.12080.
22. Gill D, Naini F. Preadjusted Edgewise Fixed Orthodontic Appliances: Principles and Practice. 1st ed. Wiley; 2023.
23. Gutiérrez DAR, Garzón JS, Franco JQ, Botero Mariaca P. Anterior open bite and its relationship with dental arch dimensions and tongue position during swallowing and phonation in individuals aged 8-16 years: A retrospective case-control study. Int Orthod. 2021;19(1):107-116. DOI:10.1016/j.ortho.2020.12.005.
24. Buschang PH, Jacob H, Carrillo R. The morphological characteristics, growth, and etiology of the hyperdivergent phenotype. Semin Orthod. 2013;19(4):212–26. DOI:10.1053/j.sodo.2013.07.002.
25. Hwang S, Jeong S, Choi YJ, Chung CJ, Lee HS, Kim KH. Three-dimensional evaluation of dentofacial transverse widths of adults with various vertical facial patterns. Am J Orthod Dentofacial Orthop. 2018;153(5):692-700. DOI:10.1016/j.ajodo.2017.08.026.
26. Mastroianni D, Woods MG. 3D-CT assessment of mandibular widths in young subjects with different underlying vertical facial patterns. J World Fed Orthod. 2019;8(2):78–86. DOI:10.1016/j.ejwf.2019.02.005.
27. Fatima F, Fida M. The assessment of resting tongue posture in different sagittal skeletal patterns. Dental Press J Orthod. 2019;24(3):55-63. DOI:10.1590/2177-6709.24.3.055-063.oar.

Author's Contribution

QAT conceived the idea, collected the data and analysed the data, and drafted the manuscript. AJ supervised the study and reviewed the manuscript for proofreading and technical errors. NA and ZBN helped in data collection and data analysis and drafting of the manuscript. Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest

Authors declared no conflict of interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.