Original Article

DOI: 10.7860/JCDR/2026/80052.22451

Physiotherapy Section

Effectiveness of Otago Exercise Programme on Balance and Prevention of Fall in Post-stroke Patients: A Quasi-experimental Study from Assam, India

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ABSTRACT

Introduction: A stroke is the sudden loss of nerve cells caused by a shortage of oxygen due to an arterial rupture or a blockage in blood flow to the brain. Stroke occurs when the blood supply to the brain is interrupted, resulting in an abrupt loss of neurological function. The Otago Exercise Program (OEP), an evidence-based fall-prevention program composed of muscle strengthening, balance training, and walking, was implemented in this study.

Aim: To determine the efficacy of OEP on balance and fall prevention in post-stroke patients.

Materials and Methods: A quasi-experimental study was conducted at the Pews Group of Institution, Bonda, Guwahati, Assam, India, over the period of six months from March 2019 to August 2019. The study involved 30 post-stroke patients irrespective of the underlying vascular territory, who could walk independently without an assistive device and were classified as grade 4 on the functional ambulation category (able to ambulate independently on level surfaces but requiring supervision to negotiate). Participants had no cardiovascular disease, were at Brunnstrom recovery stage 4 (indicating voluntary movements outside synergy patterns and decreasing spasticity), and had no visual or auditory impairment, limb loss, bone impairment in the past years, or cognitive dysfunction. Patients with visual defects, vestibular dysfunction, hypertension, or an inability to follow commands and concentrate on the experiment were excluded. A two-stage sampling method was used: first stratified sampling, followed by simple random sampling. The intervention was administered for eight weeks, three times per week. The first part of the exercise program consisted of strengthening the muscles in the front and back of the knees, hip abductors, calf muscles, and toe extensors. Outcome measures—including the Berg Balance Scale (BBS), Timed Up and Go Test (TUGT), and Falls Efficacy Scale (FES)—were recorded before and after the exercise program to evaluate balance and fall prevention. Using Statistical Package for the Social Sciences (SPSS) software, statistical analyses were carried out, and results were presented in terms of mean, standard deviation (SD), and p-value.

Results: A total of 30 post-stroke patients participated (23 males and 7 females). A paired t-test revealed a statistically significant improvement in all variables with a p-value <0.001. Significant differences were observed in the BBS mean and SD values (–2.400±–1.773), TUGT (1.5833±1.3646), and FES (4.233±2.315). These findings indicate that OEP improved balance ability, enhanced confidence levels, and reduced fear of falling during activities.

Conclusion: The OEP helped participants maintain confidence in performing routine activities without fear of falling while also improving muscle strength and balance. The program demonstrated improvements in all three parameters—BBS, TUGT, and FES—indicating a beneficial effect of OEP on post-stroke patients.

Keywords: Berg balance scale, Cerebrovascular accident, Fall efficacy scale, Strength training, Time up and go test

INTRODUCTION

Stroke is a neurological disorder characterised by the blockage of blood vessels. Clots may form in the brain and interrupt blood flow, clogging arteries and causing blood vessels to rupture, resulting in bleeding [1]. Stroke occurs when the blood supply to the brain is interrupted, leading to an abrupt loss of neurological function. It is a major health issue associated with high rates of mortality and morbidity [2]. Stroke is one of the leading causes of death and disability worldwide. In India, stroke ranks as the fourth leading cause of death and the fifth leading cause of disability. The burden of stroke is increasing, with incidence rising from 76 per 100,000 population in 1990 to 88 per 100,000 in 2021 [3,4]. Ischaemic stroke, accounting for 70-80% of cases, occurs when a blood clot obstructs blood flow, depriving the brain of essential nutrients and oxygen. Haemorrhagic stroke results from the rupture of blood vessels and bleeding around the brain. Clinical manifestations may include changes in consciousness and sensory, motor, cognitive, perceptual, and language impairments. Neurological deficits must persist for at least 24 hours to be classified as stroke. Motor impairments commonly include haemiplegia or haemiparesis on the side opposite the lesion. Strokes are categorised based on aetiology, vascular territory, and management groups [2].

Stroke presentations vary depending on the location and extent of the lesion. In haemiplegic patients, postural instability is commonly observed, leading to dependence and significant balance impairment. Factors such as weight-bearing asymmetry, muscle weakness, increased visual dependency, and altered ankle proprioception contribute to postural instability and ultimately increase fall risk [5]. An unstable posture leads to restricted range of motion, muscle weakness, and standing instability—all of which increase the likelihood of falls and reduce gait capacity [6]. Compared to individuals of the same age or gender, stroke survivors are twice as likely to fall. Falls are among the most common complications in stroke patients, with reported incidence ranging from 7% in the first week after stroke to 73% during the first year after hospital discharge. Falls can result in fractures, brain injury, or other secondary complications, which

may further impair muscle strength and physiological functioning. Several social, environmental, and personal factors contribute to fall risk. Exercise-based fall prevention has been extensively studied in the elderly population [7].

Falling is a common complication after stroke, where both physical and psychological impairments contribute to repeated falls, as reported by Larén A et al., 2018 [8]. Studies by Weerdesteyen V et al., (2008) [9], Melillo P et al., (2015) [10], and Wei TS et al., (2017) [11] indicate that ischaemic stroke patients are often prescribed antiplatelets or anticoagulants for secondary stroke prevention, which may increase bleeding risk following a fall. Falls are known to be seven times more prevalent in this population compared to healthy individuals [8]. According to Blennerhassett JM et al., (2012) [12], Tilson JK et al., (2012) [13], and Yoshimoto Y et al., (2016) [14], approximately half of all stroke patients experience at least one fall within the first year after stroke [15]. When standing, weakened knee muscles may cause instability and sway. Therefore, patients must continue strengthening their muscles through exercise and physical activity to prevent falls [16].

Various exercise programs—including balance training on stable and unstable surfaces, muscle-strengthening exercises with elastic bands, endurance exercises on a stationary bicycle, yoga for flexibility and posture, Tai Chi, and the Otago Exercise Program (OEP)—have been designed to prevent falls. The OEP, first implemented at the Otago Medical School, is an evidence-based fall-prevention program developed by physical therapists and designed for home use. It is a well-tested intervention targeting deficits in strength and balance.

The OEP was selected for this study because it effectively addresses the needs and conditions of post-stroke patients and has demonstrated positive outcomes in improving balance, health-related quality of life, and reducing fall risk in older adults. It enhances physical performance, functional balance, and muscle strength through three components: locomotion, balance training, and muscle strengthening exercises. Previous research has shown that older adults participating in the OEP exhibit improved balance and muscle strength and a reduced frequency of falls [7,17]. The most modifiable risk factors for falls include strength, flexibility, balance, and reaction time. The OEP was specifically developed to target these factors. The program lasts approximately 30 minutes and includes progressively challenging leg strengthening and balance exercises, along with a walking schedule. Participants are encouraged to perform the exercises at least twice a week and engage in physical activity three times a week. Adequate leg strength and balance are essential to achieving stability [17]. Overall, the OEP has been shown to reduce the number of falls and fall-related injuries by 35%, with similar effectiveness in both men and women. Participants in earlier studies gained strength and balance and reported increased confidence in performing daily activities without falling.

The present research was conducted to evaluate the benefits of the OEP on balance and fall prevention in post-stroke patients. Although the OEP has been widely used in elderly populations and stroke patients in other regions, its application in post-stroke patients in Assam has not been extensively studied. This study fills a regional research gap and provides new evidence regarding the program's effectiveness in this population. Therefore, the aim of the present study was to determine the effectiveness of the OEP on balance and fall prevention among post-stroke individuals residing in Assam. Specifically, the study sought to determine whether the OEP could improve postural stability and reduce fall risk in post-stroke patients. It was hypothesised that participation in the OEP would lead to significant improvements in the BBS, a reduction in TUGT duration, and improvements in the FES among post-stroke patients.

MATERIALS AND METHODS

The present study was a quasi-experimental study which involved a single-group design; complete assessor blinding was not possible. The physiotherapist who delivered the intervention also conducted the assessments. However, standardised assessment protocols were followed to minimise measurement bias. An experimental study was conducted at Pews Group of Institution, Bonda, Guwahati, over six months from March 2019 to August 2019. Ethical clearance from the Institutional Review Board was obtained (reference number CPMS/DVSSUHS/1508/OCT/18).

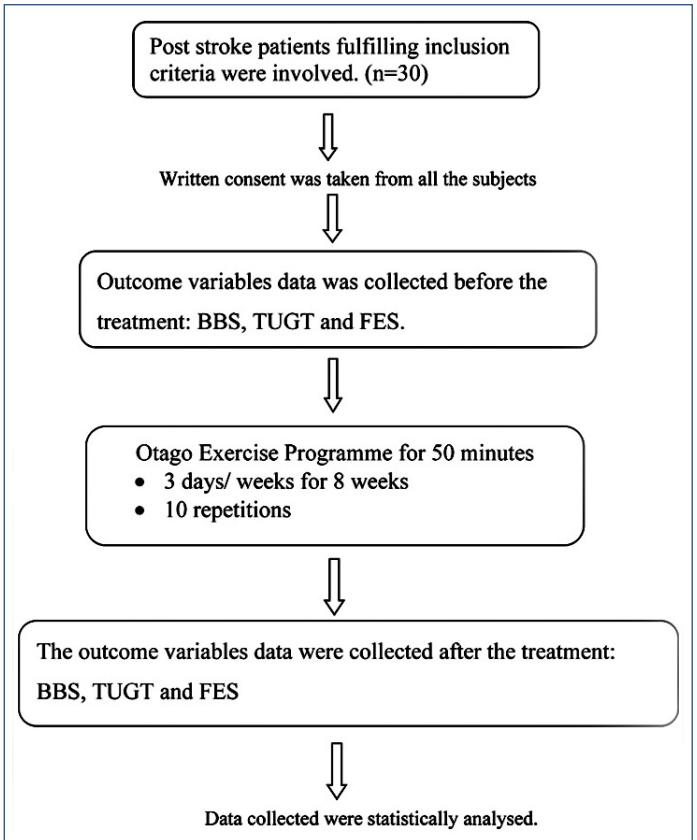
Sample size: A stratified sampling (1st stage) was used to divide the target population of post-stroke patients in Assam based on a relevant factor, specifically Brunnstrom Stroke Recovery Stage 4. Adults aged 45 to 65 years of both genders were included. Simple random sampling (2nd stage) was then used to select participants from each stratum, ensuring equal representation and reducing selection bias. A total of 30 subacute post-stroke patients were recruited, including 23 males and 7 females. For sample size determination, a one-group pre-post design was considered. As the pre-post correlation (rho) was not reported in previous studies, rho=0 was assumed as a conservative approach, as it yields a larger estimate of the standard deviation of change scores and prevents underestimation of the required sample size. Using a two-sided significance level of 5% and 80% power, the minimum required sample size was calculated to be nine participants. After accounting for a 20% dropout rate, the number increased to 12 participants. However, to enhance the robustness, generalisability, and protection against data variability, 30 participants were recruited. This larger sample ensured adequate power and reliability.

Inclusion criteria: Individuals who could walk independently without an assistive device and met Functional Ambulation Category grade 4 (indicating independence on level surfaces with supervision required for negotiating obstacles) were included. Participants were required to have no cardiovascular disease (to minimise exercise-related risks), Brunnstrom Recovery Stage 4 (indicating voluntary movements outside synergy patterns and reduced spasticity), and no visual or auditory impairments essential for maintaining balance. Additional criteria included absence of limb loss, absence of bone impairment in the past year, and adequate cognitive function to safely participate in standing, walking, or strengthening exercises.

Exclusion criteria: Patients with visual defects, vestibular dysfunction, uncontrolled hypertension, or inability to follow commands or concentrate on the experiment were excluded. These criteria ensured participant safety and reduced confounding factors affecting balance and mobility outcomes. Obesity was not listed as a specific exclusion criterion because it is a heterogeneous condition and does not uniformly hinder participation in balance or fall-prevention programs. However, obese individuals with functional limitations interfering with exercise were naturally excluded under general safety considerations. Body Mass Index (BMI) was not considered a primary determinant because the study's focus was on neurological status and ability to safely participate in the OEP.

Data collection: Selected subjects provided written informed consent before participation. The treatment was conducted ethically, following all necessary guidelines and ensuring patient safety. Thirty stroke patients who met the inclusion and exclusion criteria were enrolled. All participants were informed about the goals and methodology of the study. Outcome measures—BBS, TUGT and FES—were recorded before initiating the OEP. Schubert TE et al., reported that after completing the OEP for six months, participants demonstrated substantial improvements in all functional and physical performance evaluations [18].

The BBS is a highly valid and reliable tool used to measure balance. It assesses fall risk and helps predict length of stay during inpatient rehabilitation [19]. The TUGT is a simple, quick, and widely used clinical measure of lower-extremity function, mobility, and fall risk [20]. The FES measures perceived confidence in performing everyday activities without falling [21] [Table/Fig-1] shows treatment protocol of the study.



[Table/Fig-1]: Treatment protocol.

The Otago Exercise Programme (OEP): The OEP is a progressive training regimen specifically designed for older adults, emphasising exercises that target balance and strength to reduce fall risk by improving physical stability [22]. The initial components of the OEP include head, back, neck, ankle, and trunk movements. Muscle-strengthening exercises include toe and calf raises, side hip strengthening, and front and rear knee strengthening. Balance training activities consist of knee bends, backward walking, walk-turns, sideways walking, heel-to-toe stands, one-leg stands, heel-to-toe walking, backward heel-to-toe walking, sit-to-stand, and stair-walking [Table/Fig-2] [23].

STATISTICAL ANALYSIS

Statistical analysis was conducted using SPSS software version 20.0. A paired t-test was performed to evaluate the effectiveness of the OEP on balance and fall prevention in post-stroke patients. Statistical significance was set at p-value <0.001 for all measurements, while p-value>0.05 was considered non significant. The confidence interval was set at 95%.

RESULTS

A total of 30 post-stroke patients participated in the study (23 males and 7 females). Following the OEP, as shown in [Table/Fig-2]. The preassessment mean value of TUGT was 28.8767±3.9663, while the postassessment mean value was 27.2933±4.5869 with p-value <0.001 [Table/Fig-3]. This indicates that participants required less time to complete the TUGT, reflecting improved ability to rise from a standard chair, walk 3 meters, turn, and return to sit.

The preassessment mean BBS score was 44.1333±3.646, and the postassessment mean score was 46.5333±3.037 with p-value <0.001 [Table/Fig-4]. This demonstrates that the OEP improved balance abilities. The preassessment mean FES score was 39.9333±1.285, and the postassessment mean score was 35.7000±2.830 with p-value <0.001 [Table/Fig-5], indicating improved confidence and reduced fear of falling during daily activities.

[Table/Fig-6] presents the results of the paired sample t-test showing the mean difference, standard deviation and standard error of the mean for the paired observations along with the 95% confidence interval of the difference.

Overall, the findings indicate that the OEP is highly effective in enhancing balance and reducing fall risk in stroke patients. Although the BBS score suggests a low fall risk, the FES and TUGT results indicate higher concerns regarding balance and functional mobility. This discrepancy may arise because the BBS assesses balance under controlled conditions, whereas the FES and TUGT are more sensitive to fear of falling and mobility limitations in real-life situations. Therefore, patients may demonstrate good balance in standardised tests yet still experience fear of falling and reduced mobility in daily activities.

S. No.	Exercises name			
	Initial movements			
1.	Head movements			
2.	Neck movements			
3.	Back extension			
4.	Trunk movements			
5.	Ankle movements			
	Strengthening exercise	**Sets**	**Repetitions**	**Weeks**
1.	Front knee strengthening	3	10	8
2.	Back knee strengthening	3	10	8
3.	Side hip strengthening	3	10	8
4.	Toe raises	3	10	8
5.	Calf raises	3	10	8
	Balance training			
1.	Knee bends	3	10	8
2.	Backwards walk	3	10	8
3.	Walk and turn	3	10	8
4.	Sideways walk	3	10	8
5.	Heel toe stand	3	10	8
6.	Heel toe walk	3	10	8
7.	One leg stand	3	10	8
8.	Heel walking	3	10	8
9.	Toe walking	3	10	8
10.	Heel toe walk backwards	3	10	8
11.	Sit to stand	3	10	8
12.	Stair walking	3	10	8
	Walking (as an essential component because it improves endurance, mobility and confidence in daily activities)	Twice a week for 30 minutes		

[Table/Fig-2]: Otago Exercise Programme (OEP) [23].

Group	Mean±Standard deviation
Pretest	28.876667±3.9663
Post-test	27.29333±4.5869

[Table/Fig-3]: Comparison of pre- and post-test values of the Timed Up and Go Test (TUGT).

Group	Mean±Standard deviation
Pretest	44.13333±3.646
Post-test	46.53333±3.037

[Table/Fig-4]: Comparison of pre and post-test values of the Berg Balance Scale (BBS).

Group	Mean±Standard deviation
Pretest	39.93333±1.285
Post-test	35.70±2.830

[Table/Fig-5]: Comparison of pre- and post-test values of the fall efficacy scale.

Paired samples test									
		Paired differences							
		Mean±Std. deviation	Std. error mean	95% confidence interval of the difference		T	Df	p-value	Effect size
				Lower	Upper				
Pair 1	TUG pre - TUG post	1.5833±1.3646	0.2491	1.0738	2.0929	6.355	29	<0.001	1.16
Pair 2	BBS pre - BBS post	-2.400±1.773	0.324	-3.062	-1.738	-7.413	29	<0.001	1.35
Pair 3	FES pre - FES post	4.233±2.315	0.423	3.369	5.098	10.018	29	<0.001	1.83

[Table/Fig-6]: Paired differences.

DISCUSSION

This study aimed to determine the effectiveness of the OEP in improving balance and preventing falls in post-stroke patients. The study demonstrated a significant increase in BBS scores from pre- to postintervention, with a mean difference of -2.400 (p-value <0.001), indicating improved balance performance. A significant reduction in TUGT scores was observed, with a mean difference of 1.5833 (p-value <0.001), suggesting improved functional mobility and dynamic balance. Additionally, FES scores improved significantly from pre- to postintervention, with a mean difference of 4.233 (p-value <0.001), reflecting enhanced confidence in performing daily activities without fear of falling.

Youngju P and Young CM (2016) reported that the OEP significantly improved fall efficacy, activities of daily living, and quality of life in elderly stroke patients [6]. The significant p-values (<0.001) across all variables confirm that the intervention was effective in improving balance and reducing fall risk in post-stroke patients. Faria-Fortini I et al., stated that the FES-I demonstrates good discriminatory ability to classify individuals with chronic stroke into fallers and non fallers. The use of the established cut-off score of 28 points is recommended, as it may assist in clinical reasoning and decision-making in stroke rehabilitation [24]. The effect of the OEP showed a 35% reduction in the number of falls and a 35% reduction in fall-related injuries. The program was more effective for individuals aged 80 years and above than for those aged 65 to 79 years, particularly in preventing injurious falls [9].

Wang C and Kim SM, reported that the OEP effectively improves balance, gait, and lower limb strength, especially in older adults with compromised health. However, it does not significantly impact physical function or upper limb strength [2]. Youngju P and Young CM, further claimed that the OEP significantly increased fall efficacy, quality of life (QOL), and Activities of Daily Living (ADL) scores, indicating that the program is highly beneficial for improving fall efficacy in older stroke patients [6]. According to Shubert TE et al., the OEP significantly reduced the risk of death over a 12-month period and substantially decreased the rate of falls [18]. Numerous exercises have been developed to reduce fall risk, such as yoga poses that improve flexibility and static posture, balance exercises on stable and unstable surfaces, and muscle-strengthening exercises using elastic bands and stationary bicycles [7]. Additionally, the OEP incorporates aerobic exercise, which helps enhance functional balance, muscle strength, and physical performance in stroke patients. It also includes progressive-resistance strength exercises and balance activities relevant to daily life [7].

The strengthening exercises primarily target major lower limb muscles such as the hip abductors, knee extensors, and knee flexors, which are essential for walking and other functional activities. The plantar flexors and dorsiflexors of the ankle are also crucial for balance recovery [16]. This study demonstrates the effectiveness of the OEP in stroke patients using the variables TUGT, BBS, and FES. The TUGT is a commonly used clinical test to evaluate functional mobility [7,15]. Patients with chronic stroke and those receiving geriatric day care have shown varying levels of cross-rater reliability with the TUGT. Furthermore, the TUGT is reliable in determining fall risk in community-dwelling older adults and stroke survivors. Only a limited number of previous studies have examined TUG awareness in stroke patients, and these involved small sample sizes (n=50 and 44). In one study, patients with the most severe disabilities were excluded from data interpretation [20,21].

Improving balance is crucial in stroke rehabilitation, as older adults post-stroke are at higher risk of sustaining hip fractures and losing independence compared to the general population. It is recommended that treatment plans be tailored to individual needs, guided by comprehensive assessments that identify specific impairments such as deficits in body structure and function [5,20,21]. The BBS is the most widely used standardised balance assessment among physiotherapists in neurological settings. More than 90% of neurological physiotherapists consider the BBS valuable for planning treatment strategies for balance impairments. However, treatment decisions often incorporate the physiotherapist's clinical observations in addition to the BBS score [25]. Falls are a serious complication after stroke, significantly affecting rehabilitation outcomes and functional recovery [26]. Physical and psychological factors may contribute to the falls experienced by stroke patients. Self-efficacy related to falling is an important psychological component. Balance, cognition, and activities of daily living have been shown to have a moderate correlation with fall efficacy. In this study, the OEP was found to increase the level of confidence of stroke patients and reduce their fear of falling, as reflected in the FES scores [27].

The OEP is an exercise regimen designed to prevent falls among older adults. It includes a variety of exercises involving head, neck, back, trunk, and ankle movements [3,7]. The muscle-strengthening exercises include side hip strengthening, back knee strengthening, front knee strengthening, and toe and calf raises. Balance training consists of stair walking, sit-to-stand, backward heel-toe walking, toe walking, heel walking, one-leg standing, heel-to-toe standing, walk-and-turn, sideways walking, backward walking, and knee bends. These exercises were performed for 50 minutes, three days per week, for eight weeks [15,16]. Strengthening exercises were performed using weight cuffs. To date, these exercises have primarily been applied to elderly individuals and stroke patients to evaluate daily activity performance, quality of life, and fall efficacy. However, in the present study, the OEP was used specifically to assess balance and fall prevention using three outcome measures: TUGT, BBS, and FES. Following the OEP intervention, stroke patients showed improvements in balance, reduced fear of falling, and increased confidence [15,16].

Upon completion of the study, authors examined whether eight weeks of OEP would be useful in treating stroke patients with balance deficits and fall risk. The OEP enhanced muscle strength, improved postural balance, increased confidence levels, and reduced the need for assistance. Maintaining balance requires continuous postural adjustments that demand coordination. Exercises targeting the foot and ankle muscles were found to be essential components of an effective fall-prevention program. The study primarily focused on postural muscle and lower-limb strengthening. To achieve results, moderately intense walking, minimal upper extremity activity, and balance retraining were incorporated. The OEP demonstrated significant improvements in lower-limb strength and balance through exercises such as heel-to-toe walking and stair walking. As a result, participants increased their activity levels—both socially and physically.

Increased activity may have contributed to greater confidence, thereby reducing fall risk. The findings of this study suggest that the OEP may help reduce post-stroke falls and can be effectively implemented in clinical rehabilitation settings. Because the exercise program is low-cost and can be administered by trained physiotherapists, it is feasible for both outpatient and community-based rehabilitation.

Limitation(s)

The limitations of this study include the absence of a control group and the lack of follow-up assessments. Additionally, the study included only 30 subjects, which was a relatively small sample size. The intervention targeted only the lower limbs.

CONCLUSION(S)

The OEP was specifically implemented to reduce both the incidence of falls and fall-related injuries. Participants demonstrated improved strength and balance, and their confidence in performing daily activities without falling was maintained. The program was equally effective in both males and females. The present study demonstrated that the OEP is an effective intervention for improving balance, mobility, and confidence in post-stroke individuals, as evidenced by improvements in BBS, TUGT, and FES scores, with p-value <0.001. Thus, this study shows that the OEP has a beneficial effect on stroke patients. The findings also indicate that a progressive, home-based program such as the OEP can serve as a feasible and low-cost strategy for post-stroke balance rehabilitation.

Acknowledgement

The authors would like to thank all the participants and the institutional director for their support, guidance, and for allowing the development of the foundation for this study.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 13, 2025
- Manual Googling: Nov 15, 2025
- iThenticate Software: Nov 18, 2025 (15%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

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 20, 2025**
Date of Peer Review: **Aug 06, 2025**
Date of Acceptance: **Nov 20, 2025**
Date of Publishing: **Feb 01, 2026**