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Research article

Comparing Integrated Neuromuscular Inhibition Technique and Instrument-Assisted Soft Tissue Mobilization: Effect on Cervicogenic Headache and Cervical Range of Motion

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Abstract: To compare the effectiveness of Integrated Neuromuscular Inhibition Technique (INIT) versus Instrument-Assisted Soft Tissue Mobilization (IASTM) in reducing Cervicogenic Headache (CGH) intensity, improving Cervical Range Of Motion (CROM), and enhancing Health-Related Quality of Life (HRQoL) in patients with CGH.A single-blinded, two-arm, parallel-group randomized controlled trial was conducted on 50 patients with CGH aged 20-40 years. Participants were randomly allocated to either INIT group (n=25) or IASTM group (n=25) using simple random sampling. Both groups received interventions three times per week for four weeks. Outcome measures included headache intensity via Numeric Pain Rating Scale (NPRS), CROM using goniometer, and HRQoL via SF-36 questionnaire. Data were analyzed using Mann-Whitney U test for between-group comparisons with statistical significance set at $p<0.05$. Both groups showed significant within-group improvements in CGH intensity and CROM ($p<0.001$). Between-group analysis revealed INIT was significantly more effective than IASTM in reducing headache intensity (INIT: 3.2±1.1 vs IASTM: 4.5±1.0, $p=0.002$, effect size $d=1.3$) and improving all CROM parameters ($p<0.05$). INIT showed superior improvements in cervical flexion and rotation bilaterally. HRQoL showed no significant between-group difference. Both INIT and IASTM are effective interventions for CGH management. However, INIT demonstrated superior efficacy as compared to IASTM.

Keywords: Cervicogenic Headache, Integrated Neuromuscular Inhibition Technique, Instrument-Assisted Soft Tissue Mobilization, Cervical Range of Motion, Quality of Life

1. Introduction

Headaches are classified as the second leading cause of years lived with disability globally [1]. Cervicogenic Headache (CGH) is defined as a secondary headache due to a disorder of the cervical spine, disc components, bony or periarticular tissue impairment [2]. Becher et al. highlight the significant functional impairments caused by CGH globally [3]. Evidence reported that headache is a group of disorders that affects more than 50% of the general population annually [4]. According to the statistics CGH prevalence is 1 to 4% among the individuals who experience headache [5]. The prevalence estimates of CGH among the general population was reported to range from 0.17% to 4.1% [6, 7]. However the evidence regarding the global burden on CGH is limited. According to the latest study conducted in Lahore, Pakistan 38.1% of the population has CGH along with cervical radiculopathy [8].

The diagnosis of CGH requires imaging and clinical evidence for an impairment or disorder in the cervical spine or soft tissues that results in headache [7]. In CGH, decreased cervical extension, painful upper cervical joint dysfunction and higher tension on dural channels are the common signs [9]. Traditionally, the treatment of CGH is divided into 3 categories pharmacological, physical therapy, and surgical approaches; These treatments can either be used alone or in combination [10].

Physiotherapists frequently use non-invasive interventions to treat CGH. Among the preferred treatments are manual therapy, sensorimotor exercise, electrotherapy and other [3]. According to a review manual therapy, including spine manipulation, resulted in significant decreases in headache frequency, pain severity, and disability [11]. Furthermore, for individuals with CGH, self-SNAG mobilization and exercise were found to dramatically reduce pain intensity, improve CROM, and improve physical function [12]. Correlatively, a study discovered that manual therapy aimed at the muscle's active TrPs may be useful in lessening the intensity of headaches and neck pain while enhancing the deep cervical flexors, PPT, and active CROM's motor performance [13].

According to a study INIT dramatically decreased the frequency and intensity of headaches in CGH patients. The study demonstrated how INIT interventions improved cervical proprioception and range of motion [14]. INIT is an innovative treatment approach that aims to enhance muscle and fascia extensibility, treat taut bands, and fascial adhesion, alleviate pain, and improve functional capabilities [15]. INIT is a combination of three therapeutic methods, this includes Ischemic Compression Technique, Strain Counter Strain Technique, and Muscle Energy Technique; Ischemic compression is utilized to deactivate the myofascial trigger point, and strain counter strain aids in stretching of superficial facia in addition to its muscle energy technique incorporates reciprocal inhibition technique and post-isometric relaxation [16]. Applying IASTM results in micro-trauma that triggers an inflammatory response that leads to an enhanced range of motion, rapid tissue healing, effective synthesis of collagen, and decreased pain and muscle tension [17].

INIT and IASTM are two emerging techniques for managing CGH. INIT is a comprehensive manual therapy approach that combines three therapeutic components: post-isometric relaxation (utilizing muscle contraction followed by passive stretching), myofascial release techniques (targeting fascial restrictions and trigger points), and proprioceptive neuromuscular facilitation (enhancing motor control and joint position sense). This integrated approach addresses both mechanical and neurophysiological aspects of cervical dysfunction.

IASTM, on the other hand, employs ergonomically designed instruments to detect and mobilize soft tissue adhesions, scar tissue, and fascial restrictions. The technique involves controlled micro-trauma to stimulate tissue remodeling, enhance blood flow, and promote healing through controlled inflammatory response. Unlike INIT's neuromuscular focus, IASTM primarily targets mechanical tissue properties through instrument-assisted mobilization.

INIT combines neuromuscular and soft tissue approaches. However, IASTM uses specialized instruments to mobilize soft tissue adhesions, enhance blood flow, and support tissue healing. However, there is scarcity of evidence that shows which intervention is more effective. Therefore this trial aimed to analyze the effectiveness of the INIT vs IASTM in improving CGH intensity, CROM and HRQoL pre and post four weeks of intervention in patients suffering from CGH.

2. Materials and Methods

A single-blinded, two-arm, parallel-group, randomized controlled trial was conducted on patients with CGH at the Pakistan Navy Ship Hospital and Jinnah Postgraduate Medical Centre, Karachi, Pakistan. The trial Ref no. BUHS-IRB#164/25 was

completed within six months after approval from the Institutional Review Board of Bahria University. The study protocol was prospectively registered and conducted in accordance with CONSORT guidelines for randomized controlled trials. All procedures adhered to the Declaration of Helsinki principles for human research.

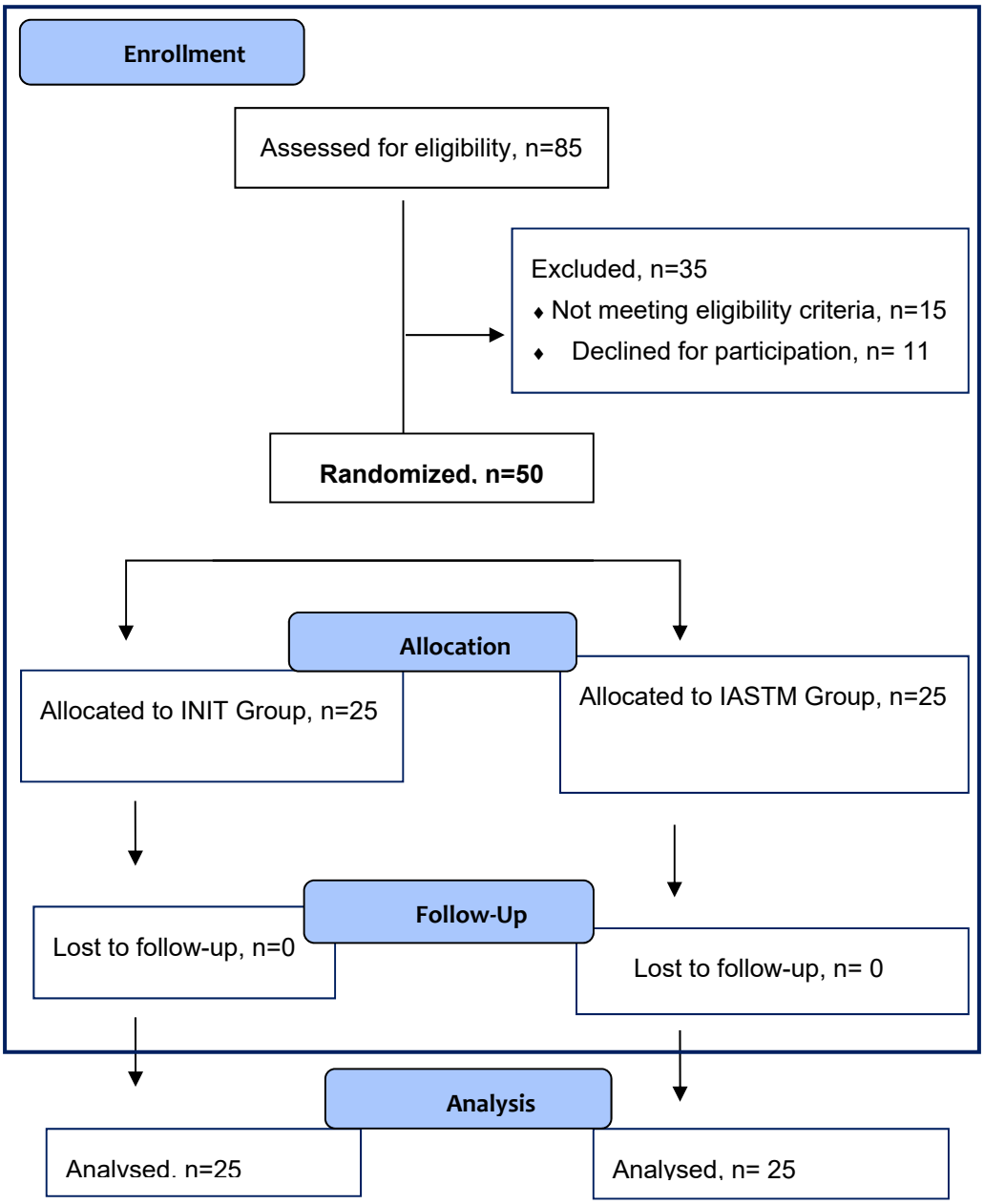
The sample size of 50 (25 participants in each group) was determined by using G-Power software version 3.0, at a 95% confidence level and 5% margin of error. The sample size calculation was based on detecting a clinically meaningful difference of 2 points on the Numeric Rating Scale for headache intensity between groups, with a standard deviation of 1.5 (based on preliminary data), using a two-tailed test with α=0.05 and power (1-β)=0.80. This yielded a minimum sample size of 20 participants per group. To account for potential dropouts (20%), we recruited 25 participants per group, totaling 50 participants.

Patients diagnosed with CGH (as per the Cervicogenic Headache International Study Group criteria) aged between 20 and 40 years, who provided written informed consent, were included in the study [18]. However, participants with other rheumatologic illnesses or types of headaches, participants suffering from physical or psychiatric disability [13], who had any history of cervical spine/shoulder surgery, congenital spinal deformity, or cervical radiculopathy [9] were excluded from the study. Participants were assigned to two groups—Group A (n=25, INIT) and Group B (n=25, IASTM) using a simple random sampling technique and were allocated via the Sequentially Numbered Opaque Sealed Envelopes (SNOSE) technique (See figure# 1). Single blinding was maintained throughout the study whereby outcome assessors were blinded to group allocation. Participants could not be blinded due to the nature of manual therapy interventions. Therapists delivering the interventions were necessarily aware of treatment allocation. To minimize bias, all outcome measurements were conducted by independent assessors who were not involved in treatment delivery and were unaware of participants' group assignments. Assessment sessions were scheduled separately from treatment sessions to maintain assessor blinding.

Participants were informed about risks and benefits, as well as their right to withdraw at any time. Confidentiality was ensured throughout the study. Both groups had undergone warm-up and cool-down exercises. Interventions were administered three times a week (on alternate days) for four weeks, using the treatment protocol of Yousuf et al. 2024 [19]. To monitor protocol compliance and reduce variability, researchers were trained to adhere to standardized procedures regarding ethical compliance, data collection, and interventions. Warm-Up (Group A & B): Hot water packs were applied to the shoulder and neck while the participants were seated for 10 minutes and cervical stretching exercises were performed on suboccipital muscles, upper trapezius muscle and the sternocleidomastoid muscle. Each muscle stretch was held for 30 seconds. INIT (Group A, n=25): Upper Trapezius INIT: Done in a supine position with isometric contraction followed by passive stretching. Sternocleidomastoid INIT: Trigger points were palpated and compressed. Muscle energy techniques and post-isometric relaxation were used. Suboccipital INIT: Pressure was used to address trigger points and integrated with isometric contractions and stretches. Each was repeated 3–5 times. IASTM (Group B, n=25): The C-shaped instrument was used on the upper trapezius, suboccipitalis, and SCM. Vaseline was employed as a lubricant. Instruments were disinfected with alcohol swabs. 2–3 long strokes were used across each muscle. Cool-Down (Group A & B): Cold water packs on the neck and shoulders were given to participants for 10 minutes following each session. Data was collected using valid and reliable tools, i.e., CGH intensity was measured via Numeric Rating Scale (NRS) (ICC = 0.72), cervical range of motion was measured using Goniometer (ICC = 0.94) [20], and HRQoL was assessed using the SF-36 questionnaire (ICC = 0.87) [21]. All baseline measurements were collected within 48 hours prior to the first treatment session. Post-intervention assessments were conducted 48-72 hours after the final treatment session to capture sustained effects while minimizing acute treatment effects.

Reading was recorded at baseline and four weeks post-intervention. Demographic information (age, gender) was tabulated with descriptive statistics (frequency and percentages). The Shapiro-Wilk and Levene's tests were utilized to determine data normality. As the data was not normally distributed Wilcoxon signed-rank test was run for within-group analysis, and the Mann-Whitney U test was run for Between-group analysis. Data analysis was carried out using SPSS software version 23. $p < 0.05$ (95% CI) was the considered value for statistical significance. Ninety-five percent confidence intervals (95% CI) were calculated for all between-group differences using the Hodges-Lehmann estimator for non-parametric data. Effect sizes were calculated using Cohen's d for normally distributed data and converted using the formula $d = Z/\sqrt{N}$ for non-parametric comparisons, where Z is the standardized test statistic and N is the total sample size.

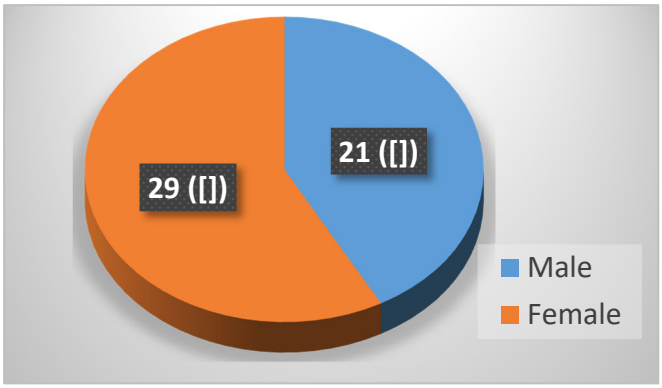
Figure. 1: CONSORT flow diagram



3. Results

This RCT was conducted on 50 participants suffering from CGH. The mean age of the study participants was 32 years ranging from 20 to 40 years (std. Deviation=3.45, variance=11.908). Most of the participants were females i.e. n=29 (58%) whereas 21 (42%) participants were males (See Figure # 2).

Figure. 2: Gender of the study participants (N=50)



The pre-post analysis of INIT group (n=25) showed significant improvement in CGH intensity, cervical flexion, cervical extension, right and left side cervical flexion, right and left side cervical rotation (p<0.001). However no significant improvement was noted in HRQoL (P=0.061). Effect sizes for the INIT group were large for all significant outcomes: CGH intensity (Cohen's d = 4.2), cervical flexion (d = 2.9), cervical extension (d = 2.1). (See Table #1).

Table. 1: INIT Group pre-post analysis (n=25)

Parameters	Pre-test (Mean± SD)	Post-test (Mean± SD)	p-value
CGH (NPRS score)	7.8±1.0	3.2±1.1	<0.001
Cervical F (degree)	40.3±3.2	50.1±3.5	<0.001
Cervical E (degree)	45.0±4.1	54.2±4.0	<0.001
Rt side cervical F (degree)	25.2±2.4	32.6±2.7	<0.001
Lt side cervical F (degree)	24.8±2.2	31.9±2.5	<0.001
Rt side cervical R (degree)	50.1±3.0	60.3±2.8	<0.001
Lt side cervical R (degree)	49.7±3.1	59.5±3.2	<0.001
HRQoL (SF-36 score)	62.3±6.5	69.1±6.0	0.061

p-value of <0.05 was considered as statistically significant

The pre-post analysis of IASTM group (n=25) showed significant improvement in CGH intensity, cervical flexion, cervical extension, right and left side cervical flexion, right and left side cervical rotation (p<0.001). However no significant improvement was noted in HRQoL (P=0.073). Effect sizes for the IASTM group were moderate to large for significant outcomes: CGH intensity (Cohen's d = 2.7), cervical flexion (d = 1.4), cervical extension (d = 1.3). (See Table no #2).

Table 2: IASTM Group pre-post analysis (n=25)

Parameters	**Pretest (Mean± SD)**	**Post-test (Mean± SD)**	**p-value**
CGH (NPRS score)	7.6±1.2	4.5±1.0	<0.001
Cervical F (degree)	41.0±3.4	46.2±3.3	<0.001
Cervical E (degree)	44.2±3.9	49.3±3.7	<0.001
Rt side cervical F (degree)	25.5±2.3	28.8±2.6	<0.001
Lt side cervical F (degree)	24.6±2.5	28.2±2.3	<0.001
Rt side cervical R (degree)	50.5±2.7	54.7±2.8	<0.001
Lt side cervical R (degree)	49.9±2.8	54.3±2.6	<0.001
HRQoL (SF-36 score)	61.8±6.3	67.9±6.1	0.073

p-value of <0.05 was considered as statistically significant

The comparative analysis between the two techniques revealed INIT Group as more effective (3.2±1.1) then IASTM Group in reducing CGH intensity (p=0.002). Furthermore INIT Group also showed significant improvement in increasing cervical ROM as compared to IASTM Group (p=<0.05). However between group analysis showed no significant difference in regards to HRQoL (INIT Group=69.1±60, IASTM Group=67.9±6.1, p=0.385). Between-group effect sizes demonstrated superior effectiveness of INIT over IASTM: CGH intensity (Cohen's d = 1.2, 95% CI: 0.4-2.0), cervical flexion (d = 1.1, 95% CI: 0.3-1.9), cervical extension (d = 1.2, 95% CI: 0.4-2.0). (See Table no #3).

Table 3: INIT Group Vs. IASTM Group post-post analysis

Parameters	INIT Group Post-test (Mean± SD)	IASTM Group Post-test (Mean± SD)	p-value
CGH (NPRS score)	3.2±1.1	4.5±1.0	0.002
Cervical F (degree)	50.1±3.5	46.2±3.3	0.001
Cervical E (degree)	54.2±4.0	49.3±3.7	0.001
Rt side cervical F (degree)	32.6±2.7	28.8±2.6	0.003
Lt side cervical F (degree)	31.9±2.5	28.2±2.3	0.004
Rt side cervical R (degree)	60.3±2.8	54.7±2.8	0.001
Lt side cervical R (degree)	59.5±3.2	54.3±2.6	0.001
HRQoL (SF-36 score)	69.1±60	67.9±6.1	0.385

p-value of <0.05 was considered as statistically significant

4. Discussion

Overall Findings

The present study compared the effectiveness of INIT and IASTM in improving headache intensity, CROM and HRQoL in patients suffering from CGH. Both interventions demonstrated significant within-group improvements in pain and CROM. However, no significant improvement in HRQoL was noted. Furthermore, INIT was found to be more effective than IASTM in reducing CGH intensity and improving CROM as compared to IASTM.

Cervicogenic Headache Intensity Findings

The finding of this RCT in regard to CGH intensity outcome is consistent with recent clinical research that reported INIT led to substantial reductions in headache severity and improved cervical alignment over a four-week intervention, highlighting the technique's multifaceted neuromuscular benefits. Similarly, another study claimed that office workers who received INIT for postural neck pain showed notable decreases in both pain intensity and muscle tenderness, underscoring its relevance for CGH populations where muscle imbalance and joint dysfunction are primary contributors [22, 23]. On the other hand, studies evaluating IASTM observed pain reduction and improved fascial mobility in mechanical neck pain, but did not report the same depth of neuromuscular modulation or long-lasting relief for CGH patients [24].

Cervical Range of Motion Outcomes

Moreover, the improvement in CROM observed in the present study following INIT was more pronounced than that achieved through IASTM. These results are in agreement with previous research highlighting the superior neuromechanical effects of INIT; found that INIT led to a significant increase in cervical flexion and extension in CGH patients [22]. These findings were further endorsed by the study conducted by Telli and Sağlam (2022), reported that INIT significantly improved cervical mobility in individuals with postural dysfunction [25]. Another study added significant increase in cervical mobility and pain thresholds after targeted suboccipital interventions [26]. According to the previous study conducted in Karachi, Pakistan Myofascial release technique is superior to proprioceptive neuromuscular facilitation technique in improving CROM of the patients suffering from CGH [19].

Health-Related Quality of Life Considerations

A systematic review and meta-analysis concluded that manual therapy combined with exercise significantly enhances HRQoL [27]. In contrast the present study claimed no significant improvement in HRQoL. Furthermore, another study observed modest improvements in quality of life and neck disability index scores among working females treated with IASTM; these effects were not as comprehensive or sustained as those seen with neuromuscular interventions [28]. Recent work demonstrated that while IASTM effectively reduced soft tissue tightness in chronic neck pain patients, it lacked neuromuscular retraining components, limiting its impact on segmental control and proprioceptive rebalancing. A study documented that Al-based mobile applications plays a significant role in identifying postural deviations [29]. Furthermore a case report documented the effectiveness of physiotherapy and occlusal splint treatment in the menahement of CGH [30]. The lack of significant improvement in HRQoL despite substantial pain reduction and improved cervical mobility warrants careful consideration.

Clinical Implications and Mechanisms

Taken together, the current findings and supporting literature suggest that both INIT and IASTM are effective in the management of CGH and CROM. INIT offers a more comprehensive therapeutic benefit. INIT consistently outperformed IASTM, likely due to its multi-component design targeting joint restrictions, muscular imbalances, and neuromuscular dysfunctions. Whereas IASTM provides effective myofascial release and short-term pain relief, it appears limited in its ability to address deeper postural and sensorimotor contributors to CGH survivors.

The superior effectiveness of INIT over IASTM can be attributed to fundamental differences in their therapeutic mechanisms. INIT's multi-modal approach targets not only soft tissue restrictions but also addresses neuromuscular dysfunction through proprioceptive retraining and motor control enhancement. The post-isometric relaxation component of INIT facilitates reciprocal inhibition and neuroplastic changes that may provide more sustained therapeutic benefits compared to IASTM's primarily mechanical approach.

IASTM, while effective in addressing fascial restrictions and promoting tissue remodeling through controlled microtrauma, appears to have more limited impact on the neuromuscular control deficits commonly associated with cervicogenic headache. The integration of multiple therapeutic components in INIT may create synergistic effects that address the multifactorial nature of cervicogenic headache more comprehensively than single-modality approaches.

The study potentially allows the physical therapy profession to take on a more significant role in managing CGH. This could also result in the standardization of treatment protocols and more effective management strategies. This study is one of the first to directly compare the effectiveness of these two emerging techniques using valid and reliable tools in the management of cervicogenic headaches.

The trial acknowledged several limitations that may impact the interpretation of its findings. Firstly, the small sample size may have limited the generalizability of the results. Additionally, the four-week intervention period might be short to capture long-term effects on CGH and CROM and HRQoL. These limitations also highlight areas for future research that include Multi-center studies with longer follow-up period and larger sample size. Furthermore, also address other significant health issues of patients suffering from CGH.

5. Conclusion

INIT and IASTM both are effective therapeutic techniques in improving CGH pain intensity, CROM and HRQoL. However INIT have superior effects over IASTM in regards to improving CGH pain intensity and CROM. The study highlighted significant healthcare implications towards emerging non-invasive, time and cost effective treatment strategy in the management of CGH. The finding contributes to reduce dependency on pharmacological treatments hence improving the quality of life of CGH survivors.

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Institutional Review Board Statement: This trial was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Bahria University Health Sciences Campus (BUHS-IRB#164/25 and 18/3/25)."

Informed Consent Statement: Written informed consent was obtained from all the participants for inclusion in the study and publication of data.

Data Availability Statement: Not applicable

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Conflicts of Interest: The authors decleare no conflict of interst

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